

The 26th Asian-Pacific Weed Science Society Conference

— Weed Science for People, Agriculture, and Nature —

Programme Book




Supporters

The Weed Science Society of Japan

The Kyoto University Foundation

The Japan World Exposition 1970 Commemorative Fund

KYOTO
TRADITION MEETS INNOVATION
Your Japan is Here

19-22 September, 2017
Kyoto, Japan

The 26th Asian-Pacific Weed Science Society Conference

— Weed Science for People, Agriculture, and Nature —

Welcome Message

As a representative of the Asian-Pacific Weed Science Society and a chairperson of the local organizing committee, it is indeed a great honor to host the 26th APWSS Conference in Kyoto, Japan.

APWSS was founded in 1967 at the first conference in Hawaii. The society exists for 50 years and this year 2017, the conference reached 26 in number. I would like to celebrate 50 years anniversary of the society with you.

On hosting the conference, we have received cooperation from many supporters and sponsors. Especially, I would like to extend my heartfelt gratitude to our Supporters the Weed science Society of Japan, the Kyoto University Foundation, the Japan World Exposition 1971 Commemorative Fund and Kyoto Convention & Visitors Bureau. I also appreciate our Platinum Sponsor, Bayer Crop Science, Gold Sponsors, BASF Japan, Kumiai Chemical Industry, Syngenta Japan and SDS Biotech, Silver Sponsors, Dow AgroSciences and Kyoyu Agri, and Bronze Sponsors, Mitsui Chemicals Agro, Sumitomo Chemical, Ishihara Sangyo Kaisha, Nissan Chemical Industries, Nihon Nohyaku and Hokko Chemical Industry for their generous contribution.

I look forward to good discussions during the conference with great anticipation, and wish this conference a great success. Your contribution and cooperation are highly appreciated.

Hiroshi Matsumoto, PhD
President of the Asian-Pacific Weed Science Society
Chairperson, 26th APWSS Conference

Conference Information A-Z

Abstracts

All abstracts for Invited, Oral and Poster sessions are available on our website.
To view, download, and print abstracts, you will be asked to enter the password as follows:

APWSS2017 Oral and Poster Awards

Abstracts that scored highly in our oral and poster presentations are awarded with APWSS 2017 Oral and Poster Awards. Awards will be announced and given at the closing ceremony.

Badges

Each participant is required to wear a name badge at all times in order to enter session rooms or other events.

Certificates

Certificate of Attendance:

Certificate of Attendance is provided at registration desk.

Certificate of Presentation:

Please visit our Inquiry desk, 4th Floor in the East Area Bldg #1, Kyoto Research Park.

Cloak

Please note that we do not have cloak room to check-in your luggage. We ask all participants to leave your luggage at your hotel.

Data Preview

The data preview desk is located on the B1 Floor in the West Area Bldg #4, Kyoto Research Park.
All oral presenters are asked to check in your data at least 30 minutes before the session starts.

Dress Code

Dress code for the conference is business casual.

Events

Name badges are strictly required for all events.
The 26th APWSS Conference invites attendees to participate in the following events:

Welcome Reception

5:00-7:30 pm, Tuesday, September 19
Venue: Atrium, 1st floor in the East Area Bldg #1, Kyoto Research Park

Conference Dinner

6:00-8:00 pm, Thursday, September 21
Venue: Aoi-no-ma, 2nd Floor, Kyoto Tokyu Hotel

Exhibition

Our sponsor exhibitions will take place on the following dates & times and are located in various areas within the Kyoto Research Park.

Exhibition 1: Foyer area, 2nd Floor in the West Area Bldg #4
Exhibition 2: Session Room "Oral-2" Foyer area, B1 Floor in the West Area Bldg #4
Exhibition 3: Foyer area, 4th Floor in the East Area Bldg #1

Handouts:

Conference handouts will be provided at the registration desk.

Internet Access
Wi-fi access is available in the public area.

Language
The official language of the conference is English.

Lost and Found
Please visit the Inquiry desk, located on the 4th Floor in the East Area Bldg #1, Kyoto Research Park, for any lost and found items.

Lunches
Lunchboxes will be provided on Wednesday, Thursday, and Friday (Sept. 20-22) in the Atrium, 1st floor in the East Area Bldg #1, Kyoto Research Park. *Tickets are strictly required for each lunch.*

Origami Workshop
"Origami Workshop" will be open on 9:00-5:00 pm.
Wednesday and Thursday (Sept. 20-21) in the 4th Floor in the East Area Bldg #1

Payments
On-site Payment can be made by credit card (Visa and MasterCard Only) or cash (Japanese yen).

Session rooms
Oral-1: Buzz Hall, B1 Floor in the West Area Bldg #4
Oral-2: Banquet Hall, B1 Floor in the West Area Bldg #4
Oral-3: Room 1, 2nd Floor in the West Area Bldg #4
Oral-4: Room 2, 2nd Floor in the West Area Bldg #4
Poster Room1: Science Hall, 4th Floor in the East Area Bldg #1
Poster Room2: AV Meeting Room, 4th Floor in the East Area Bldg #1

Refunds
There are no refunds for registration payment.

Registration
Registration is located on the B1 Floor in the West Area Bldg #4, Kyoto Research Park.

Open Hours:

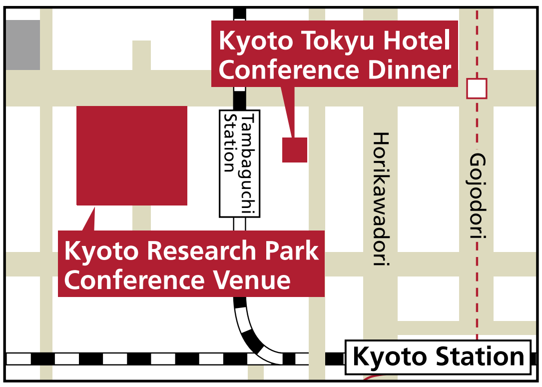
Tuesday, September 19	3:00-6:00 pm
Wednesday, September 20	8:30 am-4:00 pm
Thursday, September 21	8:30 am-4:30 pm
Friday, September 22	8:30 am-2:00 pm

Transportation
We kindly ask all attendees to use public transportations, as parking space is very limited.

Venue
The venue of the 26th APWSS 2017 is Kyoto Research Park (Ltd.) [KRP]

134 Chudoji Minamicho,
Shimogyo-ku, Kyoto city,
Kyoto600-8813, Japan

Please join us at Conference dinner & enjoy the Japanese cultural night!



The 26th APWSS Conference

Kyoto Research Park, 19-22 September 2017

[Day 1: Sept 19]

Venue	West Area Bldg #4				East Area Bldg #1		West Area Bldg #4	Venue
	B1F		2F		4F	1F	B1F	
Room	Buzz Hall	Banquet Hall	Room 1	Room 2	Science Hall/ AV Room	Atrium	Foyer	Room
	Oral-1	Oral-2	Oral-3	Oral-4	Posters 1, 2	Reception	Registration	
12:00								12:00
13:00								13:00
			13:30-17:30 NARO International Symposium *"Weedy Rice, the stranger in our midst. Can we get along?"*	**13:30-17:30** Technical Writing Workshop				
14:00								14:00
15:00					**15:00-17:00** Poster Mounting		**15:00-18:00** Registration	15:00
16:00								16:00
17:00								17:00
						17:30-19:00 Welcome Reception		
18:00								18:00
19:00								19:00
20:00								20:00

[Day 2: Sept 20]

Venue	West Area Bldg #4				East Area Bldg #1			West Area Bldg #4	Venue
	B1F		2F		4F	Various areas	1F	B1F	
Room	Buzz Hall	Banquet Hall	Room 1	Room 2	Science Hall/ AV Room	Foyer	Atrium	Foyer	Room
	Oral-1	Oral-2	Oral-3	Oral-4	Posters 1, 2	Exhibition 1-3	Lunch	Registration	
8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00	(8:30-8:45 Opening Remarks) **8:45-9:30** Keynote Lecture 1 Dr. Duke **9:30-12:30** Golden Jubilee Memorial Lectures **14:45-16:05** Aquatic Weeds 1 **16:25-17:30** Aquatic Weeds 2 **17:50-18:30** Special Lectures	**14:45-16:15** Biological Control 1 **16:35-18:10** Biological Control 2	**14:45-16:35** Weed Problem, Constraint, and Opportunity in different countries 1 **16:55-17:55** Weed Problem, Constraint, and Opportunity in different countries 2	**14:45-16:15** Herbicide 1 **16:35-18:20** Herbicide 2	**9:00-10:00** Poster Mounting **10:00-13:30** Poster Viewing **13:30-14:30** Poster Session (Odd Number e.g. P-001, 003...) **14:30-17:00** Poster Viewing	**9:00-17:00** Exhibition 1: Foyer area, 2^{nd} Fl. West Area Bldg. #1 2: Oral-2 Foyer area B1Fl, West Area Bldg #1 3: Foyer area 4F East Area Bldg. #4	**12:30-13:30** Lunch	**8:30-16:00** Registration	8:00 9:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00

8:30-8:45
Opening Remarks

9:30-9:35
Opening Remarks by Dr. Fujii
9:35-9:40
President Remarks by Dr. Matsumoto
9:40-9:55
Celebratory Volume Book Release by Dr. Chandrasena

9:55-10:25 *Dr. Baltazar*
10:25-10:55 *Dr. Morita*

10:55-11:15 *Morning Break*

11:15-11:25
Rice Weed Management Book Release by Dr. Matsumoto and Dr. Rao

11:25-11:55 *Dr. Adkins*
11:55-12:25 *Dr. Burgos*

12:25-12:30
Closing Remarks and Vote of Thanks by WSSJ President Dr. Yogo

17:50-18:10 *Dr. Zimdahl*
18:10-18:30 *Dr. Charudattan*

[Day 3: Sept 21]

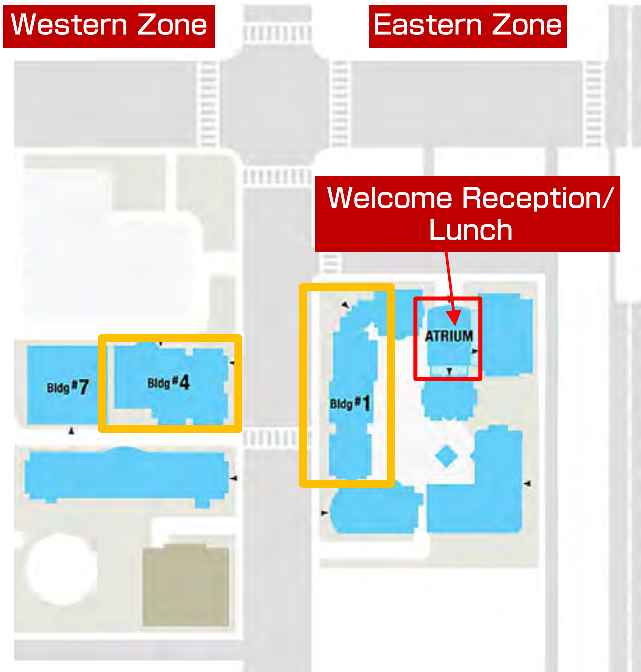
Venue	West Area Bldg #4				East Area Bldg #1			West Area Bldg #4
	B1F		2F		4F	Various areas	1F	B1F
Room	Buzz Hall	Banquet Hall	Room 1	Room 2	Science Hall/ AV Room	Foyer	Atrium	Foyer
	Oral-1	Oral-2	Oral-3	Oral-4	Posters 1, 2	Exhibition 1-3	Lunch	Registration
8:30								**8:30-16:30** Registration
9:00	**9:00-9:35** Plenary Lecture 1 Dr. Hamamura				**9:00-13:00** Poster Viewing	**9:00-17:00** Exhibition 1: Foyer area, 2nd Fl. West Area Bldg. #1 2: Oral-2 Foyer area B1Fl, West Area Bldg #1 3: Foyer area 4F East Area Bldg. #4		
9:35	**9:35-10:10** Plenary Lecture 2 Dr. Kaundun							
10:30	**10:30-12:05** Invasive Alien Species	**10:30-12:00** Non-Chemical Control	**10:30-12:05** Herbicide Resistance (Status)	**10:30-12:00** Herbicide 3				
12:00							**12:00-13:00** Lunch	
13:00					**13:00-14:00** Poster Session (Even Number e.g. P-002, 004...)			
14:00					**14:00-17:00** Poster Viewing			
14:15	**14:15-16:00** Parastic Weeds, Weed Biology and Ecology, Utilization of Weeds	**14:15-16:00** Allelopathy	**14:15-15:45** Herbicide Resistance (Management)	**14:15-16:00** Herbicide Usage 1				
16:15	**16:15-1700** General Assembly Meeting							
18:00	**18:00-20:00** Conference Dinner @KYOTO TOKYU HOTEL							

[Day 4: Sept 22]

Venue	West Area Bldg #4				East Area Bldg #1			West Area Bldg #4	Venue
	B1F		2F		4F	Various areas	1F	B1F	
Room	Buzz Hall	Banquet Hall	Room 1	Room 2	Science Hall/ AV Room	Foyer	Atrium	Foyer	Room
	Oral-1	Oral-2	Oral-3	Oral-4	Posters 1, 2	Exhibition 1-3	Lunch	Registration	
8:00									8:00
8:30								**8:30-14:00** Registration	
9:00	**9:00-9:35** Plenary Lecture 3 Dr. Kim				**9:00-13:00** Poster Viewing	**9:00-16:00** Exhibition 1: Foyer area, 2nd Fl. West Area Bldg. #1 2: Oral-2 Foyer area B1Fl, West Area Bldg #1 3: Foyer area 4F East Area Bldg. #4			9:00
9:35	**9:35-10:10** Plenary Lecture 4 Dr. Fujii								
10:00									10:00
10:30	**10:30-12:05** Weedy Rice	**10:30-12:00** Weed Management (Sustainable System)	**10:30-12:00** Herbicide Resistance (Target-Site Resistance)	**10:30-12:00** Herbicide Usage 2					
11:00									11:00
12:00							**12:00-13:00** Lunch		12:00
13:00					**13:00-15:00** Poster Dismantling				13:00
13:15	**13:15-14:50** Herbicide Tolerant Crops	**13:15-15:00** Management (Integrated Weed Management)	**13:15-15:00** Herbicide Resistance (Non-Target-Site Resistance), Others	**13:15-14:45** Herbicide Usage 3					
14:00									14:00
15:00									15:00
15:05	**15:05-15:35** *Closing Ceremony*								
16:00									16:00

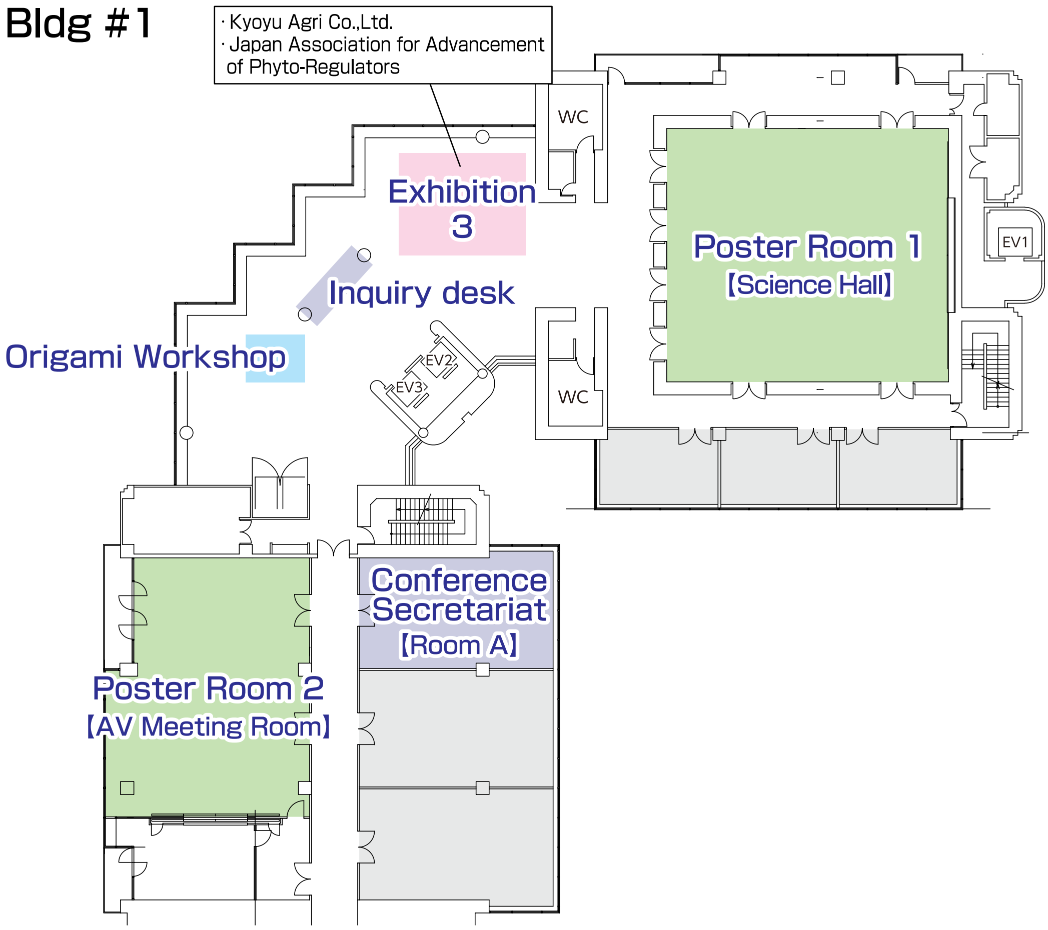
Floor Map

Kyoto Research Park



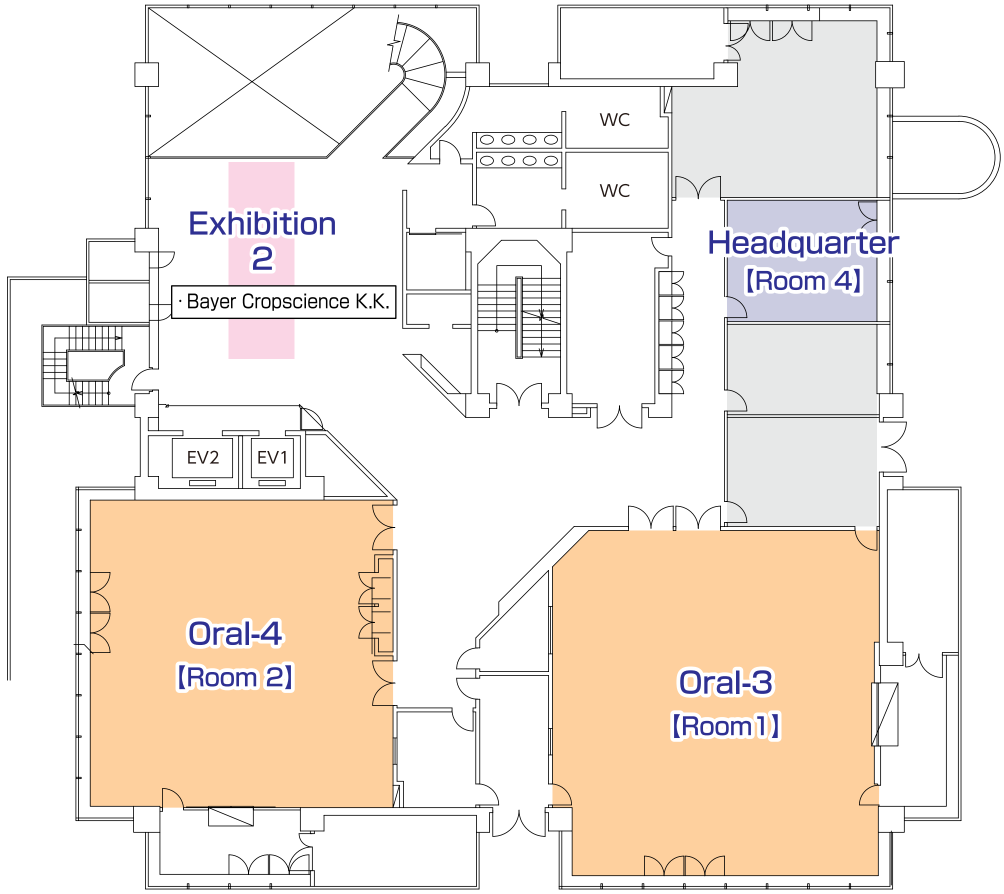
East Area Bldg #1

4F

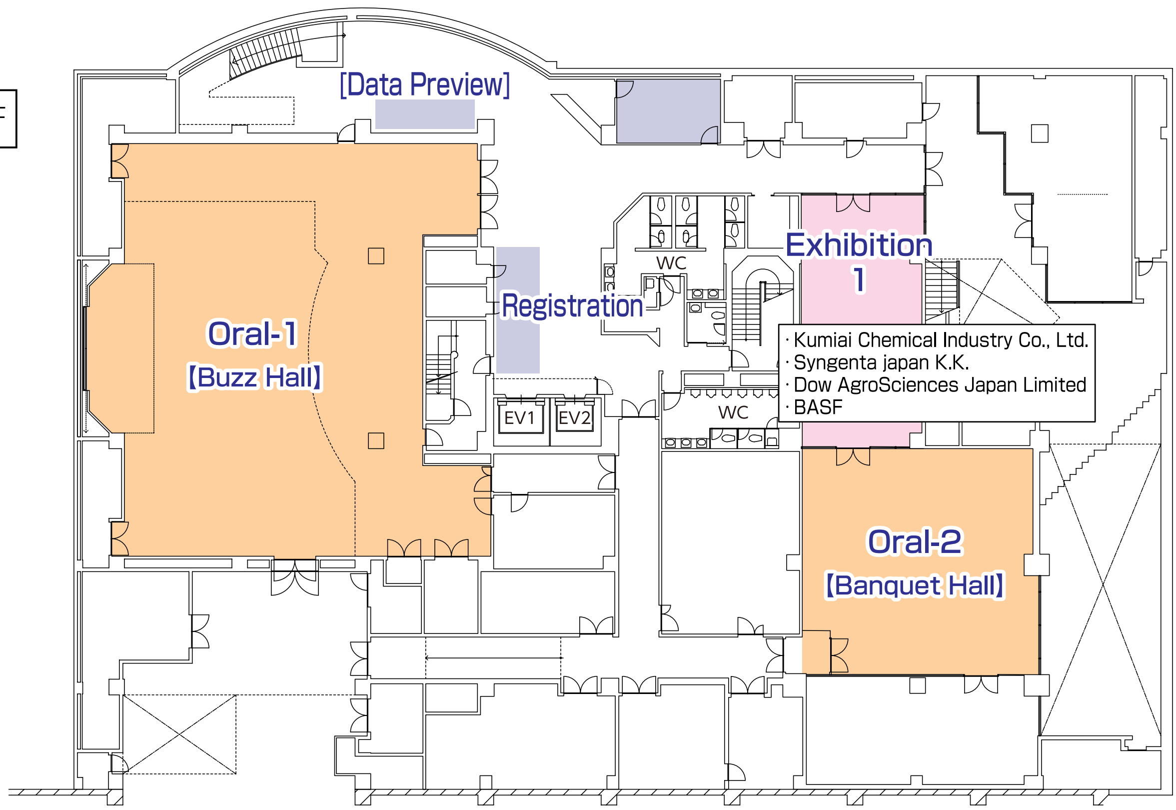


West Area Bldg #4

2F



B1F



Oral 1: Kyoto Research Park West Area Bldg #4, B1F, Buzz Hall

Wednesday, September 20

Keynote Lecture
KL 1

8:45-9:30

Integrated weed management of the future

Stephen O. Duke

Research Leader, Natural Product Utilization Research Unit, USDA-ARS, USA

(Chair: Masanori Morimoto)

Golden Jubilee Memorial Lectures

9:30-12:30

9:30-9:35

Opening Remarks by Yoshiharu Fujii (Vice-Chairperson of the 26th APWSS Conference)

9:35-9:40

President Remarks by Hiroshi Matsumoto (President of APWSS; Chairperson of the 26th APWSS Conference)

9:40-9:55

Celebratory Volume Book Release by Nimal Chandrasena

Former General Secretary of APWSS; Principal Ecologist, GHD Pty Ltd., Australia

(Chair: Hiroshi Matsumoto)

9:55-10:25

Commemorating 50 years of the Asian-Pacific Weed Science Society (1967-2017)

Aurora M. Baltazar

Adjunct Professor, Crop Protection Cluster, University of the Philippines Los Baños, Philippines

(Chair: Tohru Tominaga)

10:25-10:55

Temperature and soil moisture as principal factors on emergence and growth of weeds in rice production in Asian-Pacific Region

Hirohiko Morita

Technical Adviser, Research Institute, Japan Association for Advancement of Phyto-Regulators (JAPR), Japan

(Chair: Yasuhiro Yogo)

10:55-11:15

Morning Break

11:15-11:25

Dr. A. N. Rao

Rice Weed Management in Book Release

Hiroshi Matsumoto[1] and A. N. Rao[2]

[1]University of Tsukuba, Japan

[2]General Secretary of APWSS; Principal Scientist, ICRISAT, India

(Chair: Hiroshi Matsumoto)

11:25-11:55

Weed science in the Asian-Pacific Region: Present status and experiences

Stephen Adkins

Professor, School of Agriculture and Food Sciences, University of Queensland, Australia

(Chair: Tjitrosemito Soekisman)

11:55-12:25

Dr. Nilda Roma-Burgos

Technological advances for weed management

Nilda Roma-Burgos[1], Christopher E. Rouse[2], Vijay Singh[3], Reiofeli Salas-Perez[3], Muthukumar Bagavathiannan[3]

[1]Professor, Department of Crop, Soil, and Environmental Sciences, University of Arkansas, USA

[2]University of Arkansas, USA

[3]Texas A&M University, USA

(Chair: Abdul Shukor Juraimi)

12:25-12:30

Closing Remarks and Vote of Thanks by Yasuhiro Yogo (President of the Weed Science Society of Japan)

Special Lectures

SL-1 17:50-18:10

Ethics, agriculture, and the environment

Robert L. Zimdahl

Emeritus Professor, Colorado State University, USA

(Chair: Nimal Chandrasena)

SL-2 18:10-18:30

Biologically-based methods of weed management: The next 50 years

Raghavan Charudattan

Emeritus Professor, University of Florida-Institute of Food and Agricultural Sciences; President & CEO, BioProdex, Inc., USA

(Chair: A. N. Rao)

Oral 1: Kyoto Research Park West Area Bldg #4, B1F, Buzz Hall

Thursday, September 21

Plenary Lectures

PL1

9:00-9:35

Development of herbicides for paddy rice in Japan

Kenshiro Hamamura

Manager, Research Institute Chiba Branch, Japan Association for Advancement of Phyto-Regulators, Japan

(Chair: Buddi Marambe)

PL2

9:35-10:10

Evolution, mechanism and sustainable control of herbicide resistance in weeds

Deepak Kaundun

Herbicide Resistance Bioscientist, Herbicide Bioscience, Syngenta, United Kingdom

(Chair: Chaoxian Zhang)

Friday, September 22

PL3

9:00-9:35

Genetic diversity of *Echinochloa* species in taxonomic and ecological aspects

Do-Soon Kim

Associate Professor, Department of Plant Science, College of Agriculture and Life Sciences, Seoul National University, Republic of Korea

(Chair: Bhagirath Singh Chauhan)

PL4

9:35-10:10

Research on allelopathy for weed science in Asian-Pacific Region

Yoshiharu Fujii

Executive Professor, Department of Agriculture/Division of International Environmental and Agricultural Sciences, Tokyo University of Agriculture and Technology, Japan.

(Chair: Hisashi Kato-Noguchi)

Oral 4: Kyoto Research Park West Area Bldg #4, 2F, Room 2

Tuesday, September 19

Technical Writing Workshop

13:30-17:30

Nilda Roma-Burgos

Professor, Weed Physiology, Dept. of Crop, Soil, and Environmental Sciences University of Arkansas-Fayetteville, USA

Workshop Outline

I. What is Scientific Writing?
II. The Craft of Naming Your Paper
III. How to Write an Impactful Abstract
IV. That Darn Introduction . . .
V. Common Grammatical Problems in Materials and Methodology
VI. How Do I Present and Explain this Data? What is the story?
   a. Clarity b. Redundancy c. Verbosity d. Common grammatical problems
VII. What it Takes to Write a Good Discussion
VIII. . . . And, so WHAT?

Oral-1 (Kyoto Research Park West Area Building #4, B1F, Buzz Hall)

Oral Sessions

Wednesday, September 20

14:45-16:05

Aquatic Weeds 1

Organizer/Chairperson: Nimal Chandrasena
GHD Pty Ltd., Australia

O-001 Lead

Endothall use in flowing systems for nuisance aquatic weed and algae control

Cody J. Gray

United Phosphorus, Inc., USA

O-002

Control of aquatic weeds in canals and drains in Australasia – a review of methods

William Chisholm[1], Nimal Chandrasena[2], Peter Harper[3]

[1]Aquatic Weed Control Ltd, New Zealand; [2]GHD Pty Ltd., Australia; [3]Bettersafe Pest & Weed Management, Australia

O-003

Fungal metabolites of *Alternaria raphani* in microbial control agents of aquatic weed *Alternanthera phylloxeroides*

Puja Ray, Writuparna Dutta, Jashaswi Basu

Presidency University, India

O-004

Crassulacean acid metabolism in an aquatic weed, a fern-ally: *Isoetes coromandelina* L. f.

Roypim Thananusak, Ornusa Khamsuk, Tassanai Jaruwattanaphan, Srisom Suwanwong

Kasetsart University, Thailand

O-005

Submerged aquatic plant control in Sydney 2000 Olympic lakes with fluridone (Sonar®) –A case study

Nimal Chandrasena[1], Peter Harper[2], Kevin Flynn[3]

[1]GHD Pty Ltd., Australia; [2]Bettersafe Pest & Weed Management, Australia; [3]Sydney International Regatta Centre, Australia

16:25-17:30

Aquatic Weeds 2

Organizer: Nimal Chandrasena
GHD Pty Ltd., Australia

Chairperson: A. N. Rao
International Crops Research Institute for Semi Arid Tropics (ICRISAT), India

O-006 Lead

Translocation of ^{14}C-endothall in *Eurasian Watermilfoil, Curlyleaf Pondweed,* and two *Hydrilla* biotypes

Cody J. Gray[1], Mirella Farinelli Ortiz[2], Scott Nissen[2]

[1]United Phosphorus, Inc., USA; [2]Colorado State University, USA

O-007

Genetic and morphological diversity of *Ludwigia sedioides* in Sri Lanka: a potential invasive aquatic plant

Dinusha Debarawatta, Kapila Yakandawala, Thilak Attanayake

Wayamba University of Sri Lanka, Sri Lanka

O-008 APWSS Travel Grant

Studies on understanding the trends of invasive aquatic plant succession through inter-specific interactions among weeds

Writuparna Dutta, Parbani Chaudhury, Puja Ray

Presidency University, India

O-009

Management of *Hydrocotyle rannunculoides* in the Canning River, Perth: an options review

Nimal Chandrasena[1], Peter Harper[2], Luke McMillan[3], Greer Gilroy[3], Brett Kuhlmann[4], Matt Grimbly[4], Russel Gorton[5]

[1]GHD Pty Ltd., Australia; [2]Bettersafe Pest & Weed Management, Australia; [3]Perth Region NRM, Australia; [4]South East Regional Centre for Urban Landcare (SERCUL), Australia; [5]Wilson Wetlands Action Group Inc., Australia

Oral-1 (Kyoto Research Park West Area Building #4, B1F, Buzz Hall)

Oral Sessions

Thursday, September 21

10:30-12:05

Invasive Alien Species

Organizer: Tjitrosemito Soekisman
BIOTROP, Indonesia

Chairpersons: Steve Adkins
University of Queensland, Australia

Rahayu Sukmaria Sukri
Universiti Brunei Darussalam, Brunei Darussalam

O-010 Lead

A preliminary work to control *Chimonobambusa quadrangularis*, an invasive alien plant species in Gunung Gede National Park, West Java.

Tjitrosemito Soekisman, Mawardi Imam, Bachri Syaiful, Setiabudi Setiabudi, Wahyuni Indah, Tjitrosoedirdjo Sudarmiyati Sri

BIOTROP, Indonesia

O-011

Managing entry of noxious alien weeds in to Sri Lanka: Can DNA barcoding be an effective identification tool?

W. J. Nimanthika, W. L. I. A. Harischandra

National Plant Quarantine Service, Sri Lanka

O-012

What a changing climate may mean for an invasive giant, *Parthenium hysterophorus*?

Ali A. Bajwa, Bhagirath S. Chauhan, Steve Adkins

The University of Queensland, Australia

O-013

The impact of *Acacia* invasion on litterfall production in lowland tropical rain forests of Brunei Darussalam

Salwana Md Jaafar[1], Faizah Metali[1], David F. R. P. Burslem[2], Rahayu Sukmaria Sukri[1]

[1]Universiti Brunei Darussalam, Brunei; [2]University of Aberdeen, Scotland

O-014

Invasive alien plants and policy needs in Turkey

Ahmet Uludağ[1,2]

[1]Düzce University, Turkey; [2]Canakkale Onsekiz Mart University, Turkey

O-015

Medieval and modern volunteer vegetation shift in Jammu and Kashmir Himalayas

Anil Kumar, Jai Kumar, A. P. Singh, Lobzang Stanzen, Vikas Abrol, Sapna Bhagat

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, India

14:15-16:00

Parasitic Weeds, Weed Biology and Ecology, Utilization of Weeds

Chairpersons: Asad Shabbir

University of the Punjab, Pakistan/University of Sydney, Australia

Cumali Özaslan

Dicle University, Turkey

O-016

Screening maize for compatibility with *F. oxysporum* to enhance *Striga Asiatica* (L.) Kuntze. resistance

Admire I.T Shayanowako, Mark D Laing, Hussein Shimelis

University of KwaZulu-Natal, South Africa

O-017

iTRAQ-based differential expression proteomics in roots of sunflowers differing in resistance to *Orobanche cumana*

Na Zhang[1], Chong Yang[1], Ling Xu[1], Xiaopeng Yun[2], Quanjiang Bai[2], Weijun Zhou[1]

[1]Zhejiang University, China; [2]Inner Mongolia Academy of Agricultural & Animal Husbandry Sciences, China

O-018

Inventaritation of weeds in sweet corn (*Zea mays* L Saccarata Strurt) at different fields condition

Uum Umiyati, Denny Kurniadie

Padjadjaran University, Indonesia

O-019

Weed diversity is comparable in Bt-transgenic and conventional cotton fields

Yongbo Liu

Chinese Research Academy of Environmental Sciences, China

O-020

Hyperaccumulator identification from weed species and its phytoremediation potential in Cd contaminated field

Shuhe Wei[1], Huiping Dai[2]

[1]Chinese Academy of Sciences, China; [2]Shaanxi Sci-Tech University, China

O-021

Management of southern blight of bell pepper by soil amendment with dry biomass of *Datura metel*

Arshad Javaid, Nadia Jabeen, Amna Shoaib

University of the Punjab, Pakistan

O-022

Competitiveness of two broad-leaf weeds: sesbania pea (*Sesbania cannabina*) and bladder ketmia (*Hibiscus trionum*) in mungbean (*Vigna radiata*).

Sudheesh Manalil[1,2], Bhagirath Singh Chauhan[1]

[1]The University of Queensland, Australia; [2]Amrita University, India.

Oral-1 (Kyoto Research Park West Area Building #4, B1F, Buzz Hall)

Oral sessions

Friday, September 22

10:30-12:05

Weedy Rice

Organizer: Muhamad Shakirin Mispan
University Malaya, Malaysia

Chairperson: Xing-You Gu
South Dakota State University, USA

O-023 Lead

An ecological genetics study on seed overwintering in weedy rice

Muhamad Shakirin Mispan[1], Jiuhuan Feng[2], Xing-You Gu[2]

[1]University Malaya, Malaysia; [2]South Dakota State University, USA

O-024

Genetic diversity and population differentiation of weedy red rice in Japan

Toshiyuki Imaizumi[1], Kaworu Ebana[1], Maiko Akasaka[1], Ayumi Deguchi[2,3], Atsushi J. Nagano[2], Hiroyuki Kobayashi[1]

[1]NARO, Japan; [2]Ryukoku University, Japan; [3]Chiba University, Japan

O-025

Innovative solution for the management of weedy rice and other weeds in wet-direct seeded rice systems

Virender Kumar, Jhoana Opeña, Katherine Valencia, Ofelia Namuco, Teodoro Migo, Shalabh Dixit, David E Johnson

International Rice Research Institute, Philippines

O-026

Weedy rice management strategies in transplanted aromatic rice in sub-tropical North-Western Himalayas of India

Anil Kumar, Jai Kumar, R. Puniya, B. R. Bazaya, Susheel Rattan

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, India

O-027

Weedy rice: a threat to rice cultivation in Sri Lanka

A.S.K. Abeysekara, H.M.S.D. Kulatunga, D.D. Witharana, W.M.U.B. Wikrama

Rice Research and Development Institute, Sri Lanka

O-028

Spatial distribution pattern of weedy rice (*Oryza sativa* L.) in two rice granaries in Peninsular Malaysia

Muhamad Shakirin Mispan, Fazrul Rahman Yatim, Intan Filzah Mahmod

University Malaya, Malaysia

13:15-14:50

Herbicide Tolerant Crops

Organizers/Chairpersons: David E. Johnson
International Rice Research Institute, Philippines

Virender Kumar
International Rice Research Institute, Philippines

O-029 Lead

Herbicide-resistant crops: A quarter century journey from dominance to diminished utility to diversified weed management practices

Krishna N. Reddy

U. S. Department of Agriculture, Agricultural Research Service, USA

O-030

Sustainability of the Clearfield® production system for rice in Malaysia

M. Azmi[1], T. V. George[1], T. Alex[1], C. Kevin[1], M. Dilipkumar[2], B. Weston[3]

[1]BASF (Malaysia) Sdn Bhd, Malaysia; [2]MARDI Seberang Perai, Malaysia; [3]BASF SE, Germany

O-031

Fifteen years of Clearfield™ rice in Brazil: What we have learned

Luis A. Avila[1], Aldo Merotto Jr.[2], Edinalvo R. Camargo[1]

[1]Federal University of Pelotas, Brazil; [2]Federal University of Rio Grande do Sul, Brazil

O-032

Learning about the Provisia® rice technology

Nilda Roma-Burgos[1], Christopher E. Rouse[1], Vijay Singh[1,2]

[1]University of Arkansas, USA; [2]Texas A&M University, USA

O-033

Provisia™ rice system: efficacy, stewardship and potential

S. Luke Mankin[1], Sudakir Sudakir[2], S. Tan[1], Brigitte Weston[3], Zuhair Zainal Abidin[4]

[1]BASF Corporation, USA; [2]BASF Indonesia, Indonesia; [3]BASF SE, Germany; [4]BASF Malaysia, Malaysia

O-034

Evaluation of herbicide tolerant transgenic corn hybrids in India

Satbir Singh, Punia

CCS Haryana Agricultural University, India

Oral-2 (Kyoto Research Park West Area Building #4, B1F, Banquet Hall)

Oral Sessions

Wednesday, September 20

14:45-16:15

Biological Control 1

Organizers/Chairpersons: Kunjithapatham Dhileepan
Biosecurity Queensland, Australia

Gadi V. P. Reddy
Montana State University, USA

O-035 Lead

Exploration in Asia for biological control agents of *Hydrilla verticillata* a submerged aquatic weed in the United States

Matthew Purcell[1], Nathan Harmes[2], Jialiang Zhang[3], Sun-Hee Hong[4], Hyoung-ho Mo[4], Young Ju Oh[5]

[1]CSIRO Health and Biosecurity, Australia; [2]US Army Corps of Engineers ERDC; [3]Chinese Academy of Sciences; [4]Korea University; [5]Institute for Future Environmental Ecology Co., Ltd

O-036

Biological control of prickly acacia (*Vachellia nilotica* subsp. *indica*) in Australia: prospective agents from Ethiopia and Senegal

Kunjithapatham Dhileepan[1], Boyang Shi[1], Jason T Callander[1], Mindaye Teshome[2], Stefan Neser[3], Nathalie Diagne[4], Anthony King[5]

[1]Biosecurity Queensland, Australia; [2]Central Ethiopia Environment and Forest Research Center, Ethiopia; [3]University of Pretoria, South Africa; [4]National Centre for Agronomic Research, Senegal; [5]Plant Protection Research Institute, South Africa

O-037

The development of biological control of *Chromolaena odorata*, a common invasive alien species in the Southeast Asian region

Tjitrosemito Soekisman, Mawardi Imam, Syaiful Bachri, SETIA BUDI, Sri SUDARMIYATI Tjitrosoedirdjo, Wahyuni Indah

SEAMEO BIOTROP, Indonesia

O-038

An emerging success story of a seed-attacking weevil *Cissoanthonomus tuberculipennis* Hustache (Coleoptera: Curculionidae) released against balloon vine *Cardiospermum grandiflorum* Sw. (Sapindaceae) in South Africa

David O Simelane, Khethani V Mawela

Agricultural Research Council-Plant Protection Research Institute, South Africa

O-039
Biological control programs of the invasive weeds in the Mariana Islands

Gadi V. P. Reddy[1], R. Muniappan[2]

[1]Montana State University, USA; [2]Virginia-Tech, USA

O-040
The adventive pathogen *Cercosporella dolichandrae* and its impact on the biological control of cat's claw creeper, *Dolichandra unguis-cati*, in South Africa

Anthony M. King

Agricultural Research Council, Plant Protection Research, South Africa

16:35-18:10

Biological Control 2

Organizers/Chairpersons: Kunjithapatham Dhileepan
Biosecurity Queensland, Australia

Gadi V. P. Reddy
Montana State University, USA

O-041 Lead
Prioritizing weeds as targets for biological control: a consultative and transparent framework for investing limited resources for weed management

S. Raghu, Louise Morin

CSIRO Health & Biosecurity, Australia

O-042
Biological control of invasive weeds –a potential weed management strategy for Japan

Daisuke Kurose, Marion K. Seier

CABI, UK

O-043
Biological control of parthenium weed (*Parthenium hysterophorus* L.) in China: opportunities from Australia

Boyang Shi, Kunjithapatham Dhileepan

Biosecurity Queensland, Australia

O-044
Enhancing mycoherbicidal potential by combination treatment of fungi for biological control of waterhyacinth

Puja Ray[1], Sushil Kumar[2], Akhilesh Kumar Pandey[3]

[1]Presidency University, India; [2]Directorate of Weed Research, Jabalpur, India; [3]R.D. University, Jabalpur, India

O-045

Genetic variation for tolerance to defoliation in *Cirsium arvense*

M. G. Cripps[1], C. A. Dowsett[1], S. D. Jackman[1], A. D. L. Noble[1], G. J. Houliston[2]

[1]AgResearch, New Zealand; [2]Landcare Research, New Zealand

O-046

Fungi species infesting weed species of lentil in Diyarbakr province, Turkey

Cumali Özaslan

Dicle University, Turkey

Oral-2 (Kyoto Research Park West Area Building #4, B1F, Banquet Hall)

Oral Sessions

Thursday, September 21

10:30-12:00

Non-Chemical Control

Chairpersons: Daizy R. Batish
Panjab University, India

Mohamed Fathy Salem
Genetic Engineering and Biotechnology Research Institute, GEBRI, University of Sadat City, Egypt

O-047

Non-chemical weed management technique for rice

Eagan Somasundaram, Bhavaji Gudi Shoba Rathod, D. Udhaya Nandhini
Tamil Nadu Agricultural University, India

O-048

Utilization of *Chromoleana odorata* integrated with water irrigation on weed control, rice growth and yield

Nawapon Pimthong, Udomporn Pangnakorn, Thanatchasanha Poonpaiboonpipattana
Naresuan University, Thailand

O-049

Effect of *Biden pilosa* L. integrated with water logging on changes of water and soil properties, and its physiological mechanisms to control barnyardgrass

Saiwaree Poolkum, Wipa Homhaul, Udomporn Pangnakorn, Thanatchasanha Poonpaiboonpipattana
Naresuan University, Thailand

O-050

Evaluating of bio efficacy of the aqueous solution of *Michelia champaca* seeds in controlling common weeds in agricultural lands.

P. K. M. Deepani, K. G. Prematilake, A. G. A. W. Alakolanga
University of Sri Lanka, Sri Lanka

O-051

Altering arbuscular mycorrhizal native density has effects on weed suppression in wheat fields

Muhammad Akbar[1], Muhammad Sajjad Iqbal[1], Tayyaba Khalil[1], Aqeel Ahmad[2]
[1]University of Gujrat, Pakistan; [2]University of the Punjab, Pakistan

O-052

Natural herbicides from essential oils: prospects and constraints

Daizy R. Batish, Shalinder Kaur
Panjab University, India

14:15-16:00

Allelopathy

Chairpersons: Yoshiharu Fujii
Tokyo University of Agriculture and Technology, Japan

Hisashi Kato
Kagawa University, Japan

O-053

Competition and allelopathic potential of *Cyperus rotundus* L. on sweet corn

Panwaree Uchaiya, Surasak Thongmuang, Thanatchasanha Poonpaiboonpipattana
Naresuan University, Thailand

O-054

Allelopathic potential of *Ludwigia sedioides*

Dinusha Debarawatta, Kapila Yakandawala, Thilak Attanayake
Wayamba University of Sri Lanka, Sri Lanka

O-055

Two growth inhibitory substances in the leaves of the tree fern, *Cyathea lepifera*

Noriyuki Ida[1], Toshiaki Teruya[2], Arihiro Iwasaki[3], Kiyotake Suenaga[3], Hisashi Kato-Noguchi[1]
[1]Kagawa University, Japan; [2]University of the Ryukyus, Japan; [3]Keio University, Japan

O-056

Bioefficacy and phytotoxicity of Eucalptus leaf oil on wheat and associated weeds under field condition

Ankita Arya, Vipin C. Dhyani, Sumit Chaturvedi
GBPUAT, Pantnagar, India

O-057

Allelopathic potentiality of Bangladesh indigenous rice variety 'Boterswar'

Sheikh Md. Masum[1,2], Md. Amzad Hossain[3], Hikaru Akamine[3], Jun-Ichi Sakagami[1], Takahiro Ishii[3], Shinichi Gima[3], Takara Kensaku[3], Prasanta Chitta Bhowmik[4]
[1]Kagoshima University, Japan; [2]Sher-e-Bangla Agricultural University, Bangladesh; [3]University of The Ryukyus, Japan; [4]University of Massachusetts, USA

O-058

Mechanism action analysis of horseweed (*Conyza canadensis*) subject to botanic caryplic acid stress

Zuren Li[1,2], Qiong Peng[1,2], Lifeng Wang[1,2], Lamei Wu[1,2], Haona Yang[1,2], Xiaomao Zhou[1,2], Qin Yu[1], Lianyang Bai[1,2]
[1]Hunan Acadmy of Agricultural Sciences, China; [2]Collaborative Innovation Center for Field Weeds Control, China

O-059

Administration effect of L-DOPA · allelopathic substance of *Mucuna prurens* on dogs

Hiromi Shimasaki, Taiki Iida, Yoshiharu Fuji
Tokyo University of Agriculture and Technology, Japan

Oral-2 (Kyoto Research Park West Area Building #4, B1F, Banquet Hall)

Oral Sessions

Friday, September 22

10:30-12:00

Weed Management (Sustainable System)

Chairpersons: Makhan S. Bhullar
Punjab Agricultural University, India

Udai Pratap Singh
Banaras Hindu University, India

O-060

Impact of climate change on weed growth and control

Khawar Jabran[1], M. N. Doğan[2]

[1]Duzce University, Turkey; [2]Adnan Menderes University Aydin, Turkey

O-061

Nitrogen scheduling and impact on weed management in aerobic rice

B. Sreedevi, B. Dhanunjaya Reddy, A. Sandhyarani, R. Mahender Kumar, P. Senguttuvel, V. Ravindrababu

ICAR-Indian Institute of Rice Research, India

O-062

Sustainable weed management options for conservation agriculture in eastern Indo-Gangetic Plains of India

U. P. Singh, Yashwant Singh, A. V. Dahiphale, Sanjeev Kumar Kashyap, Sandeep Kumar

Banaras Hindu University, India

O-063

Long term mechanical soil intervention and weed management on yield of irrigated Maize –Sunflower cropping system under semi arid tropics

Murali Arthanari Palanisamy, Chinnusamy Chinnagounder, N. K. Prabhakaran, P. Janaki

Tamil Nadu Agricultural University, India

O-064

Impact of tillage, crop residue, and weed management on crop productivity in a rice-wheat cropping system under conservation agriculture

Makhan S. Bhullar[1], Simerjeet Kaur[1], Navjyot Kaur[1], Pervinder Kaur[1], Tarundeep Kaur[1], Gurjeet Gill[2]

[1]Punjab Agricultural University, India; [2]The University of Adelaide, Australia

O-065

Direct seeded rice in sequence with zero tillage wheat in north-western Indo-Gangetic plains: dealing with increased complexity in weed management

Dharam Bir Yadav[1], Ashok Yadav[2], Dalip Kumar Bishnoi[1], Gurjeet Gill[3]

[1]CCS Haryana Agricultural University, India; [2]IRRI-CSISA Hub, OUAT Campus, India; [3]University of Adelaide, Australia

13:15-15:00

Weed Management (Integrated Weed Management)

Chairpersons: Abdul Shukor Juraimi
Universiti Putra Malaysia (UPM), Malaysia

Abul Hashem
Government of Western Australia, Australia

O-066

Row spacing, herbicides and nitrogen effect on crop-weed competition in cereal-broadleaf crop rotation

A. Hashem[1], W. Vance[2], R. Brennan[1], R. Bell[2]

[1]Department of Primary Industry and Regional Development, Government of Western Australia, Australia; [2]Murdoch University, Australia

O-067

Quantitative sustainable weed management strategy in intensive rice-wheat double cropping fields

Sheng Qiang

Nanjing Agricultural University, China

O-068

Effect of integrated weed management practices on growth, yield and economics of transgenic cotton

Y. R. Aladakatti, Ramesh H. Jatti

University of Agricultural Sciences, India

O-069

Evaluation of eight rice varieties for their weed-suppressive ability under different water regimes

Abdul Shukor Juraimi, Masitah Ab Jalil

Universiti Putra Malaysia (UPM), Malaysia

O-070

A new weed control measure of synchronous seeding and spraying herbicides with the precision rice hill-drop drilling machine

Jianping Zhang, Yongliang Lu, Wei Tang, Xiaoyue Yu

China National Rice Research Institute, China

O-071

Evolving appropriate tillage, weed and nutrient management practices for improving resource use efficiency in Green Manure-Maize-Pulse cropping system for the Semi Arid Tropics

R. Thirumalaikumar, N. S. Venkataraman, K. Balakrishnan, R. Babu, A. Rathinasamy

Tamil Nadu Agricultural University, India

O-143

Response of some summer season crops on weed suppression

Javaid Iqbal, Javeria Muneer, Safdar Hussain, Muhammad Ishaq Asif Rehmani, Shahzadi Mahpara

Ghazi University, Pakistan

Oral-3 (Kyoto Research Park West Area Building #4, 2F, Room 1)

Oral Sessions

Wednesday, September 20

14:45-16:35

Weed Problem, Constraint, and Opportunity in different countries 1

Organizer: Bhagirath Singh Chauhan
The University of Queensland, Australia

Chairpersons: Buddhi Marambe
University of Peradeniya, Sri Lanka

Khawar Jabran
Düzce University, Turkey

O-072 Lead

Issues and opportunities for sustainable weed management in Pakistan: a review

Saima Hashim[1], Hafiz Haider Ali[2], Zarka Hanif[3], Arsalan Masood Peerzada[4], Bhagirath Singh Chauhan[4]

[1]The University of Agriculture Peshawar, Pakistan; [2]University of Sargodha, Pakistan; [3]The Islamia University of Bahawalpur, Pakistan; [4]The University of Queensland, Australia

O-073

Weed research issues, challenges, and opportunities in Cambodia

Robert J. Martin

The University of Sydney, Australia

O-074

Weed research issues and opportunities in China

Jinwen Zhu[1], Jian Wang[1], Chaoxian Zhang[2], Guiping Zheng[1], Wen Liang[1], Faisal Islam[1], Chong Yang[1], Xuexin Chen[1], Weijun Zhou[1]

[1]Zhejiang University, China; [2]Chinese Academy of Agricultural Sciences, China

O-075

Weed research issues, challenges, and opportunities in India

A. N. Rao[1], Ravi G. Singh[2], G. Mahajan[3], S. P. Wani[4], J. K. Ladha[5], Arvind. Kumar[5], B. S. Chauhan[3]

[1]ICRISAT Development Center (IDC) and IRRI, International Crops Research Institute for Semi Arid Tropics (ICRISAT); [2]International Maize and Wheat Improvement Center (CIMMYT), Mexico; [3]The University of Queensland, Australia; [4]International Crops Research Institute for Semi Arid Tropics (ICRISAT), India; [5]International Rice Research Institute (IRRI), Philippines

O-076

Weed problems in Japan

Tohru Tominaga[1], Shunji Kurokawa[2]

[1]Kyoto University, Japan; [2]National Agriculture and Food Research Organization, Japan

O-077

Confirmation of imidazolinone-resistant weedy rice (*Oryza sativa*) in Malaysia

Dilipkumar Masilamany[1], Zuhair Zainal Abidin[2], George Varghese[2], Nilda Roma Burgos[3], Chuah Tse-Seng[4]

[1]Malaysian Agricultural Research and Development Institute (MARDI), Malaysia; [2]BASF (Malaysia), Malaysia; [3]University of Arkansas, USA; [4]University of Malaysia Terengganu, Malaysia

O-078

Current issues related to weeds and weed management in Sri Lanka

Buddhi Marambe

University of Peradeniya, Sri Lanka

16:55-17:55

Weed Problem, Constraint, and Opportunity in different countries 2

Chairperson: Bhagirath Singh Chauhan
The University of Queensland, Australia

O-079

Survey of weed floral composition under aerobic rice (*Oryza sativa* L.) soil condition in Malaysia.

Siti Nur Anisah Aani[1,2], Abdul Shukor Juraimi[1], Muhammad Saiful Ahmad Hamdani[1], Mohd Ridzwan A.Halim[1]

[1]Universiti Putra Malaysia, Malaysia; [2]Universiti Teknologi Mara, Malaysia

O-080

Opportunities for capacity building in weed management - Laos PDR

Deirdre Lemerle

Charles Sturt University, Australia

O-081

The Wild Oat Problem in Wheat Fields in Turkey

Ahmet Uludağ[1,2], Süleyman Türkseven[3], İsmail Can Paylan[3], Mehmet Demirci[4], Deniz Çapkan[3]

[1]Düzce University, Turkey; [2]Çanakkale Onsekiz Mart University, Turkey; [3]Ege University, Turkey; [4]Agrobest Grup, Turkey

O-082

The succession of weed community demanding glyphosate-resistant corn production in China

Xiang-ju Li, Hai-lan Cui, Hui-lin Yu

Chinese Academy of Agricultural Sciences, China

Oral-3 (Kyoto Research Park West Area Building #4, 2F, Room 1)

Oral Sessions

Thursday, September 21

10:30-12:05

Herbicide Resistance (Status)

Organizer/Chairperson: Bodo Peters
Bayer AG, Germany

O-083 Lead

How to manage weed resistance and protect yields —a company perspective

Bodo Peters

Bayer AG, Germany

O-084

Overcoming the resistance to the uptake of integrated weed management tactics in farming systems

Murray Scholz

Scholz Farming Company, Australia

O-085

Seventeen years of continuous application of glyphosate leads to evolution of resistance and shift in weed species

Abul Hashem, Catherine Borger, Mohammad Amjad

Department of Primary Industry and Regional Development, Government of Western Australia, Australia

O-086

Herbicide resistant weeds and their emerging trends in China

Chaoxian Zhang, Hongjuan Huang, Shouhui Wei, Jingchao Chen, Zhaofeng Huang, Cuilan Jiang

Chinese Academy of Agricultural Sciences, China

O-087

Current status and management of herbicide resistance weeds in Sri Lanka

A. S. K. Abeysekara[1], D. D. Witharana[2], T. M. G. H. Tennakoon[1], W. M. U. B. Wickrama[1]

[1]Rice Research and Development Institute, Sri Lanka; [2]Postgraduate Institute of Agriculture, Sri Lanka

O-088

Current and future herbicide resistance challenges in Asia

Vinod Shivrain[1], Florinda Vasquez[2], Xiaolong Jiang[3], Susan Knight[1], Ajit Kumar[4], Gaylene Marsden[1], Sugiyama Minoru[5]

[1]Syngenta Asia Pacific Pte. Ltd., Singapore; [2]Syngenta Philippines Inc., Philippines; [3]Syngenta (China) Investment Co., Ltd, China; [4]Syngenta India Ltd., India; [5]Syngenta Japan, Japan

14:15-15:45

Herbicide Resistance (Management)

Chairpersons: Tse-Seng Chuah
University of Malaysia Terengganu, Malaysia

Roberto Busi
University of Western Australia, Australia

O-089

Outcrossing of herbicide resistance rice with local weedy rice variants in Malaysia

Norida Mazlan, Nur Hidayatul Shuhada Anuar, Engku Ahmad Khairi Engku Arif, Siti Nor Akmar Abdullah, Abdul Shukor Juraimi, Mohd Rafii Yusop

Universiti Putra Malaysia, Malaysia

O-090

Weed control efficacy and herbicide resistance management of Rinskor ™ active in rice fields in Asian countries

Lê Duy[1], Trần Trọng Vinh[1], Mongkol Sripeangchan[2], Bobba Venkata Niranjan Kumar[3], Robert A. Master[4], Richard K. Mann[4], Mauricio Morell[4]

[1]Dow AgroSciences Vietnam, Vietnam; [2]Dow AgroSciences Thailand, Thailand; [3]Dow AgroSciences Malaysia, Malaysia; [4]Dow AgroSciences LLC, USA

O-091

Strategies to manage multiple resistant wheat weeds in India to herbicides of several sites of action

Samunder Singh, Aman Dhillon, Pawan Gowda, Mohammad Irfan, Pradeep Kumar

CCS Haryana Agricultural University, India

O-092

Efficacy of MSMA based premix herbicides on control of goosegrass that evolved multiple resistance across glyphosate, glufosinate and fluazifop in Malaysia

Sim Khay Chuan[1], Anthony Tan Swee Hock[1], Wong Kian Joo[1], Chuah Tse Seng[2]

[1]Ancom Crop Care Sdn. Bhd., Malaysia; [2]University Malaysia Terengganu, Malaysia

O-093

Strategic cultivation for control of glyphosate-resistant weeds in Australian conservation agriculture considering weed ecology and cultivation type

Michael Widderick, Andrew McLean

Queensland Department of Agriculture and Fisheries, Australia

O-094

Identification of paraquat-resistant *Eleusine indica* populations in corn fields across district of Tiga Binanga, Karo, Indonesia

Edison Purba, Kristian Adinata Ginting

Universitas Sumatera Utara, Indonesia

Oral-3 (Kyoto Research Park West Area Building #4, 2F, Room 1)

Oral Sessions

Friday, September 22

10:30-12:00

Herbicide Resistance (Target-Site Resistance)

Chairpersons: Michael Widderick
Queensland Department of Agriculture and Fisheries, Australia

Tae-Seon Park
National Institute of Crop Science, Korea

O-095

A novel EPSPS Thr-102-Ser mutation endows glyphosate resistance in *Tridax procumbens*

Jingbo Li[1,2], Qiong Peng[2,3], Heping Han[2], Qin Yu[2], Stephen B. Powles[2]

[1]Hunan University of Humanities, Science and Technology, China; [2]University of Western Australia, Australia; [3]Hunan Academy of Agricultural Sciences, China

O-096

The dose responses of various sulfonylurea-resistant *Monochoria vaginalis* to ALS inhibitors

Kensuke Ohta, Yoshimi Fujino, Yoshinao Sada

Sumitomo Chemical Co.,Ltd., Japan

O-097

Stacking effects of the mutated ALS genes in SU-resistant *Schoenoplectiella juncoides*

Yoshinao Sada

Sumitomo Chemical Co., Ltd., Japan

O-098 IWSS

Single nucleotide substitution at Asp-376-Glu conferred various resistance patterns to AHAS inhibitors in a problematic rice field weed *Limnocharis flava*

Norazua Zakaria, Muhammad Saiful Ahmad-Hamdani, Mahbod Sahebi, Abdul Shukor Juraimi, Norhayu Asib

Universiti Putra Malaysia, Malaysia

O-099

CRISPR/Cas9-mediated base-editing system efficiently creates point mutations conferring herbicide resistance in Arabidopsis

Linjian Jiang, Yiyu Chen, Zhiping Wang, Hanwen Ni, Yong Xu, Qijun Chen

China Agricultural University, China

O-100

A rapid assay method for detecting ACCase activities of grasses using malachite green

Yoshinobu Jin

Sumitomo Chemical, Japan

13:15-15:00

Herbicide Resistance (Non-Target-Site Resistance), Others

Chairpersons: Shyama R. Weerakoon
The Open University of Sri Lanka, Sri Lanka

Kiyoshi Kawai
Kumiai Chemical Industry Co., Ltd, Japan

O-101

Investigating the glyphosate resistance mechanism in *Conyza canadensis* from Korea

WeiQiang Jia[1], Aung BoBo[1], Ok Jae Won[1], Young Tae Kim[1], Inkon Park[2], Kee Woong Park[1]

[1]Chungnam National University, Korea; [2]Syngenta Korea Limited, Korea

O-102

Enhanced activity of β-cyanoalanine synthase does not confer quinclorac resistance in multiple-herbicide resistant *Echinochloa phyllopogon*

Pattarasuda Chayapakdee[1], Satoshi Iwakami[2], Yoshitaka Kamidate[1], Akira Uchino[3], Longjiang Fan[4], Yukari Sunohara[1], Hiroshi Matsumoto[1]

[1]University of Tsukuba, Japan; [2]Kyoto University, Japan; [3]NARO, Japan; [4]Zhejiang University, China

O-103

Effect of metabolic enzyme inhibitors on herbicides

Bo Tao, Hao Sun, Jingjing Li

Northeast Agriculture University, China

O-104

Multiple-resistance to ACCase- and ALS-inhibiting herbicides in *Polypogon fugax*

Xiaoyue Yu, Wei Tang, Jianping Zhang, Yongliang Lu

China National Rice Research Institute, China

O-105

Tribenuron-methyl resistance in *Myosoton aquaticum*: ALS resistance mutation and P450-mediated enhanced herbicide metabolism

Weitang Liu, Shuang Bai, Lele Zhang, Wei Li, Jinxin Wang

Shandong Agricultural University, China

O-106

Investigation of clomazone resistance mechanism in multiple-herbicide resistant *Echinochloa phyllopogon*

Feng Guo[1], Satoshi Iwakami[2], Takuya Yamaguchi[1], Kiichi Nagai[1], Akira Uchino[3], Yukari Sunohara[1], Hiroshi Matsumoto[1]

[1]Tsukuba University, Japan; [2]Kyoto University, Japan; [3]NARO, Japan

O-146

Studies on germination ecology and interference of *Cleome viscosa* in mungbean (*Vigna radiata* (L.) Wilczek)

Hafiz Haider Ali[1], Muhammad Mansoor Javaid[1], Zaighum Abbas[1], Muhammad Ehsan Safdar[1], Asif Tanveer[2]

[1]University of Sargodha, Pakistan; [2]University of Agriculture, Pakistan

Oral-4 (Kyoto Research Park West Area Building #4, 2F, Room 2)

Oral Sessions

Wednesday, September 20

14:45-16:15

Herbicide 1

Chairpersons: Shinichi Shirakura
Bayer CropScience, Japan

Simerjeet Kaur
Punjab Agricultural University, India

O-107

Discovery and development of novel pesticides by combining biological and chemical rationales with computational technologies

Boaz Inbal

Evogene Ltd., Israel

O-108

Weed control efficacy and crop safety of Rinskor™ active against common weeds in rice fields in Asian countries

Lê Duy[1], Trần Trọng Vinh[1], Mongkol Sripeangchan[2], Marman Maulana[3], Jasmi Aiman Hanis[4], Bobba Venkata Niranjan Kumar[4], Richard K. Mann[5], Mauricio Morell[5]

[1]Dow AgroSciences, Vietnam; [2]Dow AgroSciences Thailand, Thailand; [3]Dow AgroSciences Indonesia, Indonesia; [4]Dow AgroSciences Malaysia, Malaysia; [5]Dow AgroSciences LLC, USA

O-109

Rinskor™ active: biological studies with granule and EC formulations in Japan

Masanori Kobayashi, Shun Nomoto, Ikuo Shiraishi

Dow Chemical Japan Ltd., Japan

O-110

Rinskor™ active + Penoxsulam 3.41% OD: A novel pre-mixture formulation for post-emergence use in transplanted rice in Taiwan

Yi-hsiou Huang, Ta-I Huang

Dow AgroSciences Taiwan Ltd., Taiwan

O-111

A new rice herbicide: cyclopyrimorate

Hiroshi Tamaru[1], Takashi Sakamoto[1], Kosuke Yoshino[1], Nobuko Imamura[1], Soichi Saeki[1], Takuya Ando[1], Sadafumi Koda[1], Yoshihisa Tsukamoto[1], Junji Kadotani[1], Kenta Ikemachi[2], Katsuya Kitahara[2], Chie Furuyama[2], Ryoichi Aoyama[2]

[1]Mitsui Chemicals Agro, INC., Japan; [2]National Federation of Agricultural Cooperative Associations, Japan

O-112

Rinskor™ active control of *Echinochloa spp* and other grasses in rice fields in Jiangsu Province of China

Zhen Wei Yao[1], Jia Xing Yu[2], Li Yao Dong[2]

[1]Dow AgroSciences (China) Ltd., China; [2]Nanjing Agricultural University, China

16:35-18:20

Herbicide 2

Chairpersons: Yoshinao Sada
Sumitomo Chemical Co., Ltd., Japan

Zhen Wei Yao
Dow AgroSciences (China) Ltd., China

O-113

Triafamone (Council®)- A new herbicide for Asia's diverse rice cropping systems

Ramisis Fulgencio[1], Juergen Echle[1], Silke Heibges[1], Hans-Peter Krause[1], Eva-Maria Franken[1], Christopher Rosinger[1], Wolfgang Schulte[1], Shinichi Shirakura[2]

[1]Bayer CropScience AG, Germany; [2]Bayer CropScience K.K., Japan

O-114

Council Complete-Performance on hard-to-control weeds

Tatsuya Yamaoka, Nobuhiro Yamashita, Hidenori Hayakawa, Kenji Sugiura

Bayer CropScience K.K.(Japan), Japan

O-115

The effects of Fenquinotrione on ALS-R broadleaf weeds under flooded conditions

Ken Ueda, Yuta Amano, Atsushi Nagamatsu, Masami Kobayashi

Kumiai Chemical Industry Co., Ltd., Japan

O-116

A new herbicide mixture for early post-emergent application timing in transplanted rice

Vinod Shivrain[1], Ari Budiawan[2], Ruediger Kotzian[3], Ajit Kumar[4], Gaylene Marsden[1], Tiffany Su[1], Pete Tsai[5], Nan Xu[3]

[1]Syngenta Asia Pacific Pte. Ltd., Singapore; [2]PT Syngenta Indonesia, Indonesia; [3]Syngenta Crop Protection AG, Switzerland; [4]Syngenta India Ltd, India; [5]Syngenta Taiwan Limited, Taiwan

O-117

Effectiveness of the rice herbicidal agent, Pyraclonil

Takashi Shigefuji, Yoshio Ushiguchi, Katsuhiro Takahashi, Takuma Sasaki, Takayuki Uchida

Kyoyu Agri Co.,Ltd., Japan

O-118

Metabolism of the novel herbicide fenquinotrione.

Satoshi Usami, Mitsumasa Ikeda, Yudai Hotta, Yuji Ono

Kumiai Chemical Industry Co., Ltd., Japan

O-119

Re-evaluation of the effectiveness of commonly used herbicides in wet seeded rice in Sri Lanka

D. D. Witharana[1], A. S. K. Abeysekara[2], H. M. S. D. Kulatunga[2], W. M. U. B. Wikrama[2]

[1]Postgraduate Institute of Agriculture, Sri Lanka; [2]Rice Research and Development Institute, Sri Lanka.

Oral-4 (Kyoto Research Park West Area Building #4, 2F, Room 2)

Oral Sessions

Thursday, September 21

10:30-12:00

Herbicide 3

Chairpersons: Clair L Keene
North Dakota State University, USA

Ramesh Kumar Singh
Banaras Hindu University, India

O-120

Indaziflam – an innovative base herbicide for plantation crops in Asia

Ramisis Fulgencio[1], Joerg Oeser[1], Anne Helgers[1], Christopher Leake[1], MinSik Park[2]

[1]Bayer CropScience AG, Germany; [2]Bayer (South East Asia) Pte Ltd., Singapore

O-121

Indaziflam – a residual and broad spectrum herbicide for turf

Shin Nakamura, Shigetoshi Obuchi

BayerCropScience K.K., Japan

O-122

Indaziflam (Alion®) – a novel herbicide for weed management in oil palm (*Elaeis guineensis* Jacq.): crop safety and performance

S. H. Ho[1], R. Fulgencio[2], A. Xaviar[1], C. K. Hoe[3]

[1]United Plantations Berhad, Malaysia; [2]Bayer CropScience AG, Germany; [3]Bayer Co. (Malaysia) Sdn. Bhd., Malaysia

O-123

Herbicidal efficacy of tolpyralate under various environmental conditions

Yu Naito, Yoshikazu Satake, Hiroyuki Okamoto, Hiroshi Kikugawa, Shigeru Mitani

Ishihara Sangyo Kaisha, Ltd., Japan

O-124

Biological performance of tolpyralate and tank mixture with atrazine as a post-emergence herbicide application for corn (*Zea mays*) production

Taketo Suganuma, Yoshikazu Satake, Yosuke Kobayashi, Yu Naito, Hiroshi Kikugawa, Shigeru Mitani

Ishihara Sangyo Kaisha, Ltd., Japan

O-125

Control of mixed weed flora in maize with temboptrione and its tank-mix with atrazine and 2,4-D

Simerjeet Kaur, Makhan S. Bhullar, Tarundeep Kaur

Punjab Agricultural University, India

14:15-16:00

Herbicide Usage 1

Chairpersons: Md. Hazrat Ali
Sher-e-Bangla Agricultural University, Bangladesh

Xiangju Li
Chinese Academy of Agricultural Science, China

O-126

Herbicides affect growth and seed germination of broadleaf dock (*Rumex obtusifolius*)

Wiharti Oktaria Purba, Lisa Wasko DeVetter, Chris Benedict, Ian C Burke, Timothy Miller
Washington State University, USA

O-127

Evaluation of weed control measures in combination with seeding rates on chickpea (*Cicer arietinum* L.) weeds under rainfed conditions

Rahamdad Khan[1], Ijaz Khan Ahmad Khan[2], Syed Salim Shah[1]
[1]Bacha Khan University, Pakistan; [2]The University of Agriculture, Peshawar Pakistan, Pakistan

O-128

Bio-efficacy and phyto-toxicity of BAS 835 UB H against weeds in groundnut and its residual effects on succeeding sorghum, wheat and maize crops

Malligawad Lokanath Hemaraddi
University of Agricultural Sciences, India

O-129

Long term application of herbicides on weed shift, weed control, yield and soil properties in transplanted rice-rice system at north western zone of Tamil Nadu

Chinnusamy Chinnagounder, N. K. Prabhakaran, P. Murali Arthanari, P. Janaki
Tamil Nadu Agricultural University, India

O-130

Herbicide combinations for higher productivity and profitability of transplanted rice

M. Madhavi[1], S. Anusha[1], G. Pratibha[2], T. Ramprakash[1]
[1]Professor Jayashankar Telangana State Agricultural University, India; [2]Central Research Institute for Dryland Agriculture, India

O-131

Studies on the efficacy of pre-emergence and post-emergence herbicides on control of weeds in groundnut and soybean and their residual toxicity on succeeding crops

H. D. Shilpa, Lokanath Hemaraddi Malligawad
University of Agricultural Sciences, India

O-144

Growth and yield of soybean as affected by irrigation and weed management method

Md. Hazrat Ali[1], Jannatul Ferdous[1], Md. Shahidul Islam[1], Imtiaz Faruk Chowdhury[1], Md. Nazmul Haque[1], Sheikh Muhammad Masum[1,2]

[1]Sher-e-Bangla Agricultural University, Bangladesh; [2]Kagoshima University, Japan

Oral-4 (Kyoto Research Park West Area Building #4, 2F, Room 2)

Oral Sessions

Friday, September 22

10:30-12:00

Herbicide Usage 2

Chairpersons: **Lokanath Hemaraddi Malligawad**
University of Agricultural Sciences, India

Vinod Shivrain
Syngenta Asia Pacific Pte. Ltd., Singapore

O-132

Bio-efficacy and phytotoxicity evaluation of pendimethalin + metribuzin (RM) for the control of weeds in wheat crop and its residual effect on succeeding crops

Satbir Singh

CCS Haryana Agricultural University, India

O-133

Bio-efficacy of post emergence herbicides alone and as tank mixtures on weed control, growth and yield of roselle(*Hibiscus sabdariffa* L.)

A. S. Rao

Acharya N.G. Ranga Agricultural University, India

O-134

Efficacy of pre-mix formulation of oxyfluorfen + glyphosate on weeds in non-crop areas

Ramesh Kumar Singh, Neelam Bisen

Banaras Hindu University, India

O-135

Troublesome perennial grass weed, dallisgrass (*Paspalum dilatatum*) and cogon grass (*Imperata cylindrica*) control by foramsulfuron in turf.

Shin Nakamura, Shigetoshi Obuchi, Hirohisa Ohtake

BayerCropScience K.K., Japan

O-136

Burn down effect and clorosis of transgenic and conventional corn varieties due to potassium glyphosate 660 g/l at different time of application

Denny Kurniadie, Uum Umiyati, Dedi Widayat

Padjadjaran University, Indonesia

O-137

A new micro emulsion of propaquizafop 2.5%+imazethapyr 3.75% for weed control in Cluster bean (*Cyamopsis tetragonaloba* L.)

Ramesh K. Singh, Vishal Tyagi, Neelam Bisen

Banaras Hindu University, India

13:15-15:00

Herbicide Usage 3

Chairpersons: Camila Ferreira Pinho
UFRRJ - Federal Rural University, Brazil

Chairpersons: C. R. Chinnamuthu
Tamil Nadu Agricultural University, India

O-138

Inhibitory effect of some herbicides on Three Soil borne diseases

Pruchya Ekkathin, Chanya Maneechote, Yurawan Anantanamanee, Suneerat Seemadua, Assiri Klangsawad

Plant Protection Research and Development Office, Department of Agriculture, Thailand

O-139

Sorption and dissipation of pyrithiobac sodium in cotton growing soils of India

T. Ramprakash, M. Madhavi, P. Leela Rani

Professor Jayashankar Telangana State Agricultural University, India

O-140

Nano encapsulated formulations to improve absorption and translocation of herbicide for season long weed control

C. R. Chinnamuthu[1], N. Viji[1], T. Pradeeshkumar[2]

[1]Tamil Nadu Agricultural University, India; [2]Vanavarayar Institute of Agriculture, India

O-141

Alleviation of quinclorac toxicity by salicylic acid in rice seedlings based on visible/near-infrared hyperspectral imaging

Lan Li, Jian Wang, Chong Yang, Su Yang, Weijun Zhou

Zhejiang University, China

O-142

Comparative transcriptome and iTRAQ proteome analyses of rice leaf responses to salicylic acid under quinclorac stress

Jian Wang, Lan Li, Meijuan Long, Mengting Lv, Weijun Zhou

Zhejiang University, China

O-145

Influence of herbicides on plant parasitic nematodes infecting aerobic rice

Nethi Somasekhar, B. Sreedevi, K. Shivakrishna

ICAR-Indian Institute of Rice Research, India

Posters (Kyoto Research Park East Area Building #1, 4F, Science Hall/AV Room)

Poster Sessions

September 20: 13:30-14:30 (Odd Numbers) / September 21: 13:00-14:00 (Even Numbers)

Herbicide 1

P-001

Rinskor™ Active 2.7% NeoEC: a novel formulation of auxin herbicide for post-emergence use in transplanted rice in Taiwan

Ta-I Huang, Yi-Hsiou Huang

Dow AgroSciences Taiwan, Taiwan, Republic of China

P-002

2,4-Di-tertbutylphenol isolated from *Pennisetum purpureum*: a potential natural preemergence herbicide

T. S. Chuah[1], A. H. Naimah[1], W. S. Wan Nur Suzani Sazleen[1], C.M. Mazira[1], M.Z. Norhafizah[2], A.R. Shamsul Bahri[1]

[1]University of Malaysia Terengganu, Malaysia; [2]Universiti Malaysia Kelantan, Malaysia

P-003

Rinskor™ Active GR, a novel herbicide for water injection market in Korea

Jeehwan Yi[1], Kyehwan Lee[2], Won Hur[2], Ikuo Shiraishi[1], Mauricio Morell[1]

[1]Dow AgroSciences LLC, Korea; [2]Kyungnong Corporation

P-004

Herbicidal characteristics of secondary metabolites from *Streptomyces* sp. KRA14-329 and their possible mode of action

Hyun-Suk Yeom[1], Jung Sub Choi[1], Young Kwan Ko[1], Young Sook Kim[1], Hun Tak Sin[2], Kee Woong Park[2]

[1]Korea Research Institute of Chemical Technology, Korea; [2]Chungnam National University, Korea

Herbicide 2

P-005

Council Complete - Field performance (efficacy, selectivity) in rice

Kenji Sugiura, Tatsuya Yamaoka, Masaaki Sase, Shinichi Shirakura

Bayer CropScience K.K., Japan

P-006

Study on the methodology to evaluate weed-control efficacy of rice herbicides against *Paspalum distichum* L. (knotgrass)

Shinichi Shirakura, Rika Matsuura, Tatsuya Yamaoka, Chieko Ueno, Hidenori Hayakawa, Kenji Sugiura

Bayer CropScience K.K. (Japan), Japan

P-007

Bio-efficacy evaluation of herbicides in rice cultivation in Sri Lanka

H. M. S. D. Kulatunga[1], D. D. Witharana[2], A. S. K. Abeysekara[2], U. B. Wickrama[2]

[1]University of Peradeniya, Sri Lanka; [2]Rice Research and Development Institute, Sri Lanka

P-008

Control of weedy-rice in Japan using mixtures including pyrazoxyfen and flucetosulfuron

Yousuke Kobayashi, Taketo Suganuma, Megumi Miyashita, Shigeru Mitani

Ishihara Sangyo Kaisha, Ltd., Japan

P-009

Study on the mode of action and metabolic detoxification of a novel herbicide, fenquinotrione

Shunsuke Yamamoto, Yoshitaka Tanetani, Kiyoshi Kawai

Kumiai Chemical Industry Co., LTD., Japan

Herbicide 3

P-010

Comparison of the physiological effects of five different auxinic herbicides on *Arabidopsis thaliana* mutants

Toshiki Komai[1], Yukari Sunohara[1], Hiroyuki Kawano[1], Satoshi Iwakami[2], Ken-ichiro Hayashi[3], Hiroshi Matsumoto[1]

[1]University of Tsukuba, Japan; [2]Kyoto University, Japan; [3]Okayama University of Science, Japan

P-011

Identification of genes potentially associated with nicosulfuron tolerance in maize via bulked segregant RNA-seq

Xiaomin Liu, Guiqi Wang, Xian Xu, Binghua Li, Huanhuan Zhang, Zhizun Qi

Hebei Academy of Agriculture and Forestry Sciences, China

P-012

Response of soybean applied with flumioxazine 50% soluble concentrate and its residual effect on sunflower and pearl millet

R. Thirumalaikumar, R. Kalpana, N. S. Venkataraman, K. Balakrishnan, R. Babu

Tamil Nadu Agricultural University, India

P-013

Nicosulfuron: a new herbicide for weed control in corn fields in Thailand

Hiroyuki Okamoto, Satoko Fujii, Hiroshi Kikugawa

Ishihara Sangyo Kaisha, Ltd., Japan

Herbicide Usage 1

P-014

Selection of appropriate herbicides for establishment of weed control system and occurrence of invasive exotic weeds in adzuki bean

Jae-Bok Hwang, Tae-Seon Park, Hong-Kyu Park, Hak-Sin Kim, In-Bae Choi, Bon-Il Koo, Hee-Soo Bae

National Institute of Crop Science, Korea

P-015

Assessment of different weed control methods on growth and yield of wheat

Mohammad Shamim Hasan Mandal[1], Md. Hazrat Ali[2], A. K. M. R. Ruhul Amin[2], Sheikh Muhammad Masum[2], Hasan Mehraj[3]

[1]Hiroshima Univeristy, Japan; [2]Sher-e-Bangla Agricultural University, Bangladesh; [3]Ehime University, Japan

P-016

Expanding pre-emergence weed control options in safflower (*Carthamus tinctorious*)

Clair L. Keene[1], Caleb D. Dalley[2]

[1]North Dakota State University, Williston Research Extension Center, USA; [2]North Dakota State University Hettinger Research Extension Center, USA

P-017

Herbicidal efficacy of metamifop granule or emulsifiable concentrate to *Leptochloa chinensis* (L.) Nees

Ken-ichi Sudo[1], Masahiro Akazawa[1], Yoshihiro Asanuma[2], Kentaro Shirouzu[2]

[1]Japan Association for Advancement of Phyto-Regulators, Japan; [2]Kaken Pharmaceutical co., LTD., Japan

P-018

Efficacy of herbicides for weed control and their residues in sweet corn

Amornpan Koysungnoen[1], Avishek Datta[1], Tosapon Pornprom[2]

[1]Asian Institute of Technology, Thailand; [2]Kasetsart University, Thailand

P-019

Effects of formulation and soil moisture conditions on efficacy of soil applied herbicides to a grass weed dominating in rice fields of tropical savanna

Akiko Usui[1], Atsushi Ogawa[1], Chiharu Sone[1], Hirohiko Morita[1,2]

[1]Akita Prefectural University, Japan; [2]Japan Association for Advancement of Phyto-Regulators, Japan

Herbicide Usage 2

P-020

Antagonism of herbicides with different mode of action for the management of *Digitaria insularis*

Camila Ferreira de Pinho, Jéssica Ferreira Lourenço Leal, Amanda Santos Souza, Samia Rayara de Sousa Ribeiro, Gabriella Francisco Pereira Borges de Oliveira, André Lucas Simões Araujo, Joyce de Aguiar Carvalho, Caio Victor Lopes Pereira

UFRRJ - Federal Rural University of Rio de Janeiro, Brazil

P-021

Carryover of diclosulam on corn in crop rotation

Camila Ferreira de Pinho, Samia Rayara de Sousa Ribeiro, Gabriella Francisco Pereira Borges de Oliveira, Amanda dos Santos Souza, Jéssica Ferreira Lourenço Leal, Luane Lima Souza, Marcelo Pereira Sampaio, Alex Sandro da Cruz Damasceno

UFRRJ - Federal Rural University of Rio de Janeiro, Brazil

Herbicide Usage 3

P-022

Effects of benomyl and diuron mixed application on their degradation in tea field soil and impacts on soil bacterial community

Po-Yu Lai, Zhi-Zhan Li, Jui-Hung Yen

National Taiwan University, Taiwan

P-023

Effect of green manure amendment on the dissipation of pendimethalin andchanges in soil microbial communities

Chung-An Tan[1], Wen-Ching Chen[2], Fang-Yu Hsu[1], Jui-Hung Yen[1]

[1]National Taiwan University, Taiwan; [2]National Chung-Hsing University, Taiwan

P-024

Microbial degradation of oxadiazon and thiobencarb by dissimilatory metal reducing bacteria *Shewanella* spp. KR12 under anoxic condition

Yu-Hsin Hsiung, Jui-Hung Yen

National Taiwan University, Taiwan

P-025

Evaluation of paraquat residue in rice fields based on a long-term experiment for 35 years

Naoki Nakamura, Junichi Okuno, Yoshitsugu Odanaka, Ayako Kawata, Shigeo Gonda, Masao Yokoyama

Japan Association for Advancement of Phyto-Regulators, Japan

P-026

Evaluation of leaching of imazapyr+imazapic herbicides considering the different soil moisture

Gabriella Francisco Pereira Borges de Oliveira, Amanda dos Santos Souza, Jéssica Ferreira Lourenço Leal, Samia Rayara Ribeiro, Raíza Ritielle Carvalho Scalzer, Guilherme Araujo Rocha, Eduardo Souza de Amorim, Camila Ferreira de Pinho

Federal Rural University of Rio de Janeiro (UFRRJ), Brazil

P-027

Comparison of transcriptome analysis of japonica and indica type rice (*Oryza sativa* L.) using next generation sequencing (NGS) by benzobicyclon treatment.

Sangsu Kim, Yonghwan Lee, Sungwoo Kim, Yejin Kim

National Academy of Agricultural Science, Korea

P-028

Effects of fluazifop-P-butyl on chlorophyll fluorescence characteristics of *Acanthospermum hispidum* seedlings

Xiaoyong Luo[1], Yuhong Shang[1], Congjun Yang[1], Zhihang Liu[1], Fei Zhou[1], Hiroshi Matsumoto[2]
[1]Qingdao Agricultural University, China; [2]University of Tsukuba, Japan

P-029

Basic research of effect of soil organic matter on glyphosate sorption onto a soil

Hirotatsu Murano, Masayuki Sano, Shiho Orii, Mari Miyata, Toshiyuki Isoi
Meijo University, Japan

P-030 APWSS Student Travel Grant

Influence of cow bonechar addition on reduce bioavailability of aminocyclopyrachlor and mesotrione in an agricultural soil

Kassio Ferreira Mendes, Ricardo Ferraz Silveira, Rodrigo Floriano Pimpinato, Valdemar Luiz Tornisielo
University of So Paulo, Brazil

P-031 APWSS Student Travel Grant

Bonechar as an adsorbent for removing hexazinone, diuron, ametryn and sulfometuron-methyl from drinking water

Kassio Ferreira Mendes, Rosana Maria de Oliveira Freguglia, Rodrigo Floriano Pimpinato, Valdemar Luiz Tornisielo
University of So Paulo, Brazil

Herbicide Resistance (Status)

P-032

Geographical distribution of ALS inhibitor resistant paddy weeds in Gyeonggi and Gangwon provinces of Korea

Soo-Hyun Lim, Minjung Yook, Yeon-Ho Park, Hyejin Yu, Do-Soon Kim
Seoul National University, Korea

Herbicide Resistance (Management)

P-033

Evaluation of different per-emergence herbicides in comparison with glyphosate for effective weed control in glyphosate-resistant cotton

Nadeem Iqbal, Bhagirath S. Chauhan, Sudheesh Manalil, Steve Adkins
The University of Queensland, Australia

P-034

Benefits of narrow-row spacing in weed suppression in glyphosate-resistant cotton

Nadeem Iqbal, Bhagirath S. Chauhan, Sudheesh Manalil, Steve Adkins
The University of Queensland, Australia

P-035

Control and cross-resistance of barnyardgrass to ALS- and ACCase-inhibitors in rice field in Korea

Tae Seon Park, Jae Bok Hwang, Hong Kyu Park

National Institute of Crop Science, Korea

P-036

Penoxsulam resistance in barnyardgrass (*Echinochloa crus-galli*) in rice fields of China

Guoqi Chen, Qiong Wang, Wei Zhang, Jiapeng Fang, Liyao Dong

Nanjing Agricultural University, China

P-037 APWSS Student Travel Grant

Proactive herbicide resistant weed management through synergetic integration of chemical and non-chemical tools in wheat

V. K. Sindhu, Samar Singh, S. S. Punia, Samunder Singh, Anil Duhan

CCS Haryana Agricultural University, India

P-038

Fitness of BC3F2-BC3F4 generations of crosses between two herbicide-resistant transgenic oilseed rape and wild *Brassica juncea*

Xiaoling Song, Xiaolei Wang, Qingling Zhang, Jian Wang, Sheng Qiang

Nanjing Agricultural University, China

P-039

Resistance of *Fimbristylis miliacea* (L.) Vahl populations to acetolactate synthase-inhibiting herbicides

Rudjana Phinyosak, Tosapon Pornprom

Kasetsart University, Thailand

P-040

Responses to several herbicides in multiple herbicide resistant biotypes of *Echinochloa crus-galli* var. *formosensis*

Akira Uchino[1], Satoshi Iwakami[2], Masato Hashimoto[3], Kenshiro Hamamura[3], Ken-ichi Matsushima[4], Hiroaki Watanabe[3]

[1]NARO, Japan; [2]Kyoto University, Japan; [3]The Japan Association for Advancement of Phyto-Regulators, Japan; [4]Tokyo University of agriculture, Japan

Herbicide Resistance (Target-Site Resistance)

P-041

Effects of enantioselective imazapyr on resistant strain *Arabidopsis thaliana* GH90

Bo Y. Liao, Yu-Ling Hsiao, Jui-Hung Yen

National Taiwan University, Taiwan

P-042

Alteration in the *EPSPS* promoter might be involved in the regulation of the expression of *EPSPS* in goosegrass, *Eleusine indica*

Chun Zhang, Li Feng, Xing-shan Tian

Guangdong Academy of Agricultural Sciences, China

P-043

Amino acid substitutions in ALS genes of *Cyperus brevifolius* biotypes resistant to sulfonylurea herbicides from several golf courses, Japan

Junichi Okuno[1], Satoshi Iwakami[2], Akira Uchino[3], Koji Nakamura[4], Ryoya Nakamura[4], Kunio Tsuchida[1], Masao Yokoyama[1]

[1]Japan Association for Advancement of Phyto-Regulators, Japan; [2]Kyoto University, Japan; [3]NARO, Japan; [4]SHIN CHUGOKU Turfgrass Research Institute, Japan

P-044

Copy number variation in acetolactate synthase genes of thifensulfuron-methyl resistant *Alopecurus aequalis* (shortawn foxtail) accessions in Japan

Satoshi Iwakami[1,2,3], Yoshiko Shimono[1], Yohei Manabe[1], Masaki Endo[2], Hiroyuki Shibaike[2], Akira Uchino[2], Tohru Tominaga[1]

[1]Kyoto University, Japan; [2]NARO, Japan; [3]University of Tsukuba, Japan

P-045

The use of molecular genotyping as a tool to manage herbicide resistant ryegrass (*Lolium* spp.) in South Africa

Hestia Nienaber

Agricultural Research Council, South Africa

P-046

The target-site resistance of *Eclipta Prostratain* to acetohydroxyacid synthase inhibitors in China paddy field

Hailan Cui, Dan Li, Xiangju Li

Chinese Academy of Agricultural Sciences, China

P-047

CAPS markers developed for detecting mutatons at 376 and 574 sites of ALS in tribenuron-resistant flixweed

Xian Xu, Xiaomin Liu, Binghua Li, Beibei Shen, Guiqi Wang

Hebei Academy of Agriculture and Forestry Sciences, China

P-048

Tribenuron-methyl resistance and mutation diversity of the AHAS gene in shepherd's purse (*Capsella bursa-pastoris* (L.) Medik.) in Henan Province, China

Jinxin Wang, Lele Zhang, Weitang Liu

Shandong Agricultural University, China

P-049

Sagittaria trifolia resistant to ALS inhibitors and its population dynamics in paddy fields of Korea

Ok Jae Won[1], Jong Chan Won[2], Young Tae Kim[1], Jeongran Lee[3], Jeung Ju Lee[2], Kee Woong Park[1]

[1]Chungnam National University, Korea; [2]Gyeongsang National University, Korea; [3]National Institute of Agricultural Sciences, Korea

Herbicide Resistance (Non-Target-Site Resistance)

P-050

Induction of Glufosinate-resistance in Sri Lankan rice (_Oryza sativa_ L.) varieties via scutellum-derived callus mutagenesis

Shyama R. Weerakoon, R. A. D. Deshani Lakshika, Seneviratne Somaratne

The open University of Sri Lanka, Sri Lanka

P-051

Non-target site resistance to glyphosate in _Lolium multiflorum_ in Japan

Kouhei Kurata, Yoshiko Shimono, Satoshi Iwakami, Masahiro Miyashita, Tohru Tominaga

Kyoto University, Japan

P-052

Investigation of the resistance mechanisms to several ACCase inhibitors in multiple-herbicide resistant _Echinochloa phyllopogon_

Yoshitaka Kamidate[1], Satoshi Iwakami[2], Yukari Sunohara[1], Masaki Endo[3], Seiichi Toki[3], Akira Uchino[3], Hiroshi Matsumoto[1]

[1]University of Tsukuba, Japan; [2]Kyoto University, Japan; [3]NARO, Japan

P-053 IWSS

Salinity-induced redox homeostasis and hormonal modulation reduce herbicide 2,4-D efficacy in _Echinochloa crusgalli_

Faisal Islam, Muhammad A. Farooq, Jian Wang, Theodore M. Mwamba, Weijun Zhou

Zhejiang University, China

P-054

Heterologous production and characterization of CYP81A enzymes from a multiple herbicide-resistant weed, _Echinochloa phyllopogon_

Takuya Yamaguchi[1], Satoshi Iwakami[2], Yukari Sunohara[1], Hiroshi Matsumoto[1]

[1]University of Tsukuba, Japan; [2]Kyoto University, Japan

P-055

Quinclorac resistance in _Echinochloa crusgalli_ var. _zelayensis_

Liyao Dong, Yuan Gao, Jiangyan Xu, Guoqi Chen

Nanjing Agricultural University, China

Biological Control

P-056

Ecological characteristics during growth and dormancy stages in the phytophagous beetle *Gastrophysa atrocyanea* Mots.

Hiroshi Tsuyuzaki, Daiki Goto, Yūsuke Kamata, Miki Ono, Makoto Abe

Akita Prefectural University, Japan

P-057 APWSS Student Travel Grant

Evaluation of fungi, *Paradendryphiella salina* as potential biocontrol agent of aquatic weed, waterhyacinth

Writuparna Dutta, Puja Ray

Presidency University, India

Invasive Alien Species

P-058

Variability and phenotypic plasticity of *Ulex europaeus* seeds in the Hawaiian Archipelago and California, U.S.A: How do they support its invasiveness?

Mika Hozawa[1], James Boyd Friday[2], Eiji Nawata[1], Kanehiro Kitayama[1]

[1]Kyoto University, Japan; [2]University of Hawaii at Manoa, USA

P-059

Weed flora of Timor Leste

John Westaway[1], Sancha de Jesus Marcal[2], Andrew Mitchell[1], Ian Cowie[3]

[1]Australian Department of Agriculture & Water Resources, Australia; [2]National Directorate of Quarantine & Biosecurity, Timor-Leste Ministry of Agriculture & Fisheries; [3]Northern Territory Herbarium (DNA), Darwin

P-060 IWSS

Response of *Parthenium hysterophorus* in terms of phenological, morphological and functional traits upon exposure to variable temperature conditions

Amarpreet Kaur, Daizy R. Batish, Shalinder Kaur, Harminder Pal Singh

Panjab University, India

P-061

Yield losses caused by parthenium weed (*Parthenium hysterophorus*) in maize crop at different competition durations

Ali A Bajwa[1], Tamado Tana[2], Lisanework Nigatu[2], Bhagirath S. Chauhan[1], Steve Adkins[1]

[1]University of Queensland, Australia; [2]Haramaya University, Ethiopia

P-062 APWSS Student Travel Grant

Restricting the species distribution models to regional settings may lead to wrong projections

Shahid Farooq, Huseyin Onen

Gaziosmanpaşa University, Turkey

P-063
Distribution of invasive alien species in Korean croplands

Jin-Won Kim, In-Yong Lee, Jeongran Lee

National Institute of Agricultural Sciences, Korea

P-064
Floating time and longevity for achenes of potentially water dispersed invasive *Parthenium hysterophorus* L.

Runping Mao, Steve Adkins

The University of Queensland, Australia

P-065
Adaptability of malignant invasion plants *Parthenium hysterophorus* L. in different types of soil

Xing-xiang Gao[1], Zuo-wen Sun[2], Mei Li[1], Feng Fang[1], Jian Li[1], Mi-ruo Zhao[3], Hong Zhu[3]

[1]Shandong Academy of Agricultural Sciences, China; [2]Shandong Plant Protection Station, China; [3]Southwest University, China

P-066
Comparative study on the competitive ability of different cytotypes of *Solidago canadensis* L. in a common garden

Jiliang Cheng, Beibei Yao, Xianghong Yang, Jun Li, Sheng Qiang

Nanjing Agricultural University, China

P-067
The effects of *Acacia* invasion on leaf litter and soils of coastal tropical heath forests in Brunei Darussalam

Aiman Yusoff, Kushan Tennakoon, Faizah Metali, Rahayu Sukmaria Sukri

Universiti Brunei Darussalam, Brunei Darussalam

P-068
Host invasive plant species and parasitoids of European corn borer (*Ostrinia nubilalis* (Hubner, 1796) (Lepidoptera: Crambidae) in Black Sea and Marmara Regions of Turkey

Cumali Özaslan[1], Hüseyin Önen[2], Kenan Kara[2], Shahid Farooq[2], Ahmet Bayram[1], Halil Bolu[1]

[1]Dicle University, Turkey; [2]Gaziosmanpaa University, Turkey

P-069
The relationship between the composition of weed seed contaminants of imported grain and the vegetation of international trading ports.

Takeshi Nishi, Yoshiko Shimono, Tohru Tominaga

Kyoto University, Japan

P-070

Palmer amaranth (*Amaranthus palmeri* S. Watson): A new addition to the alien flora of South Eastern Anatolia

Cumali Özaslan[1], Shahid Farooq[2], Hüseyin Önen[2]

[1]Dicle University, Turkey; [2]Gaziosmanpaa University, Turkey

P-071

A survey of alien invasive weed species in Hubei Province, China

Ruhai Li[1], Shihai Chu[1,2,3]

[1]Hubei Academy of Agricultural Sciences, China; [2]Ministry of Agriculture, China; [3]Hubei Key Laboratory of Crop Diseases, Insect Pests and Weeds Control, China

P-072

Alternate of vascular bundles lignification plays a central role in the invasiveness of *Solidago canadensis* L.

Yu Zhang, Sheng Qiang

Nanjing Agricultural University, China

Parasitic Weeds

P-073

Broomrape infestation in lentil crop and farmer knowledge on the management of parasitic weed species in Diyarbakr province, Turkey

Cumali Özaslan[1], Shahid Farooq[2], Hüseyin Önen[2]

[1]Dicle University, Turkey; [2]Gaziosmanpaa University, Turkey

P-074

Herbicidal management of parasaitic *Dendrophthoe* in semi- temperate and temperate fruit crops of Jammu-Kashmir Himalayas

Anil Kumar, R. Punyia, B. R. Bazaya, Amit Mahajan, Lobzang Stanzen, Sunny Raina

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, India

Herbicide Tolerant Crops

P-075

Integration of Provisia® rice into existing rice culture

Sunny Bottoms

Horizon Ag, LLC, USA

P-076

Silencing seed dormancy genes to mitigate risk of escaped transgenes in weedy rice

Xing-You Gu, Alexander Kena, Heng Ye, Luai Muhammad, Ugur Korkmaz, Jiuhuan Feng

South Dakota State University, USA

P-077

Evaluation of weed control efficacy and safety of glyphosate in herbicide tolerant transgenic maize

Huilin Yu, Hailan Cui, Xiangju Li

Chinese Academy of Agricultural Sciences, China

Weedy Rice

P-078

Ethylene and ABA mediated rapid grain filling of weedy rice to promote early maturity

Can Zhao, Lingchao Meng, Xi Chen, Wenrong Xu, Xiaoling Song, Sheng Qiang
Nanjing Agricultural University, China

P-079

Unique effect of paraquat product on weedy rice seed by direct contact of the spray droplet

Shunji Wen, Yoshihiro Arisawa, Toshio Enoyoshi, Minoru Sugiyama
Syngenta Japan K.K., Japan

Weed Problem, Constraint, and Opportunity in different countries

P-080

Rice cultivars response to weed interference period in dry seeded rice system

Manpreet Singh, Makhan Singh Bhullar
Punjab Agricultural University, India

P-081

Weeds: still the fundamental problem in rice

KeeFui Kon, Ben Wu
Syngenta Asia-Pacific Pte. Ltd., Singapore

P-082

Identification of cassava witches broom phytoplasma in some weed species.

Yurawan Anantanamanee, Chanya Maneechote, Pruchaya Ekkatin, Theerawut Wongwarat, Wanlee Amonpon, Supattra Choakongjak, Nimit Wongsuwan
Ministry of Agriculture and Co-operatives, Bangkok, Thailand

P-083

Modelling rice and multiple weed competition under elevated temperatures

Yeon-Ho Park, Jong-seok Song, Ji-Hoon Im, Do-Soon Kim
Seoul National University, Korea

P-084

Weed as reservoirs of some important pests in cassava fields

Supattra Choakongjak
Ministry of Agriculture, Thailand

Non-Chemical Control

P-085

Non chemical weed management in organically grown bhendi + leaf coriander - maize + cowpea cropping system

Murali Arthanari Palanisamy, Chinnusamy Chinnagounder, Somasundaram Eagan

Tamil Nadu Agricultural University, India

P-086

Organic weed management in rice

Eagan Somasundaram, P. Gnanasoundari, D. Udhaya Nandhini

Tamil Nadu Agricultural University, India

P-087

Development of flaming machine for land cleaning on leafy vegetable fields

Li Feng, Xing-shan Tian, Chun Zhang, Ye Cui, Mao-feng Yue

Guangdong Academy of Agricultural Sciences, China

P-088

The effect of essential oil of *Rosmarinus officinalis* L. on several weed and crop species

İlhan Üremiş[1], Soner Soylu[1], Ahmet Uludağ[2,3], Mehmet Arslan[4]

[1]Mustafa Kemal University, Turkey; [2]Düzce University, Turkey; [3]Çanakkale Onsekiz Mart University, Turkey; [4]Erciyes University, Turkey

P-089

Allelopathic effect of *Piper betle* Linn on the germination and seedling growth of barnyard grass and slender amaranth

Thanatchasanha Poonpaiboonpipattana

Naresuan University, Thailand

P-090

Isolation and characterization of *Streptomyces* sp. KRA16-334 producing herbicidal metabolite from soil

Young Kwan Ko[1], Jung Sub Choi[1], Young Sook Kim[1], Jae Deok Kim[1], Surk Sik Moon[2]

[1]Korea Research Institute of Chemical Technology, Korea; [2]Kongju National University, Korea

P-091

Microwave: a novel non-chemical weed management approach in different cropping systems

Muhammad Jamal Khan, Graham Brodie, Dorin Gupta, Jim He

The University of Melbourne, Australia

Allelopathy

P-092
Administration effect of rutin on canine alopecia

Taiki Iida, Hiromi Shimasaki, Yoshiharu Fujii
Tokyo University of Agriculture and Technology, Japan

P-093
Assessment of inhibitory effects, LC50 values and herbicidal activity of Eucalyptus leaf oil on wheat and associated weeds

Sumit Chaturvedi, Ankita Arya, Vipin C Dhyani
GBPUAT, India

P-094
Evaluation of allelopathic potentials in plant species in Mekong Delta Vietnam by sandwich method and dish pack method

Nguyen Thi Hanh Hien[1], Nguyen Thi Hong Nhan[2], Yoshiharu Fujii[1]
[1]Tokyo University of Agriculture and Technology, Japan; [2]Can Tho University, Vietnam

P-095
Ethnobotanical survey as a benchmark for screening for allelopathic species among medicinal plants in Ghana

Kwame Sarpong Appiah[1], Hossein Mardani[1], Sylvia Kpabitey[2], Christiana Adukwei Amoatey[2], Yosei Oikawa[1], Yoshiharu Fujii[1]
[1]Tokyo University of Agriculture and Technology, Japan; [2]University of Ghana, Ghana

P-096
Determination of allelopathic potentiality of *Rosmarinus officinalis*

Kwame Sarpong Appiah[1], Christiana Adukwei Amoatey[2], Yosei Oikawa[1], Yoshiharu Fujii[1]
[1]Tokyo University of Agriculture and Technology, Japan; [2]University of Ghana, Ghana

P-097
Isolation of the growth inhibitory substance from *Heliotropium indicum* (L.) aqueous methanol extracts

Sirinapa Chaipon[1], Arihiro Iwasaki[2], Kiyotake Suenaga[2], Hisashi Kato-Noguchi[1]
[1]Kagawa University, Japan; [2]Keio University, Japan

P-098
Allelopathic volatile compounds from *Callistemon viminalis*: role in weed management

Daizy Rani Batish, Aditi Shreeya Bali
Panjab University, India

P-099
The effect of soil types on allelopathic activity of caffeine from Vietnamese tea (*Camellia sinensis*)

Van Thi Thanh Pham, Maryia Mishyna, Yoshiharu Fujii
Tokyo University of Agriculture and Technology, Japan

P-100

Safranal, the volatile allelochemical of Saffron (*Crocus sativus*) and its effect on biological responses of lettuce (*lactuca sativa*) and some common weeds

Hossein Mardani Korrani, Asma Osivand, Yoshiharu Fujii

Tokyo University of Agriculture and Technology, Japan

P-101

Weed control using herbal medicine extraction residue as natural mulch

Kouki Oyama[1], Masanori Morimoto[1], Sakae Horimoto[2], Kazuhiko Matsuda[1]

[1]Kindai University, Japan; [2]Kyoto Institute of Technology, Japan

P-102

Allelopathic potential of invasive *Acacia mangium* on the germination and radicle growth of selected crops

Nor Amal Nabilah Ismail, Rahayu Sukmaria Sukri, Faizah Metali

Universiti Brunei Darussalam, Brunei Darussalam

P-103

Characterization of plant growth-promoting effect of γ-terpinene and β-caryophyllene in lettuce and maize

Shohei Ebina[1], Yukari Sunohara[1], Yuina Takeuchi[1], Satoshi Iwakami[2], Hiroshi Matsumoto[1]

[1]University of Tsukuba, Japan; [2]Kyoto University, Japan

P-104

Allelopathic potential of mango leaves and an allelopathic substance

Masahiko Suzuki[1,2], Md Sirajul Islam Khan[1,2], Arihiro Iwasaki[3], Kiyotake Suenaga[3], Hisashi Kato-Noguchi[1,2]

[1]Kagawa University, Japan; [2]Ehime University, Japan; [3]Keio University, Japan

P-105

Allelopathic potential of a mushroom, *Cantharellus cinnabarinus*

Asma Osivand[1], Hiroshi Araya[2], Hossein Mardani[1], Yoshiharu Fujii[1]

[1]Tokyo University of Agriculture and Technology, Japan; [2]Meiji University, Japan

P-106

Screening of allelopathic ground cover plants for weed control and analysis of allelochemicals

Hiroko Maeda, Kou Okumura, Riri Nakamura, Takashi Nomura, Yoshiharu Fujii

Tokyo University of Agriculture and Technology, Japan

P-107

Allelopathic activity of *Coccinia grandis*

Krishna Rany Das, Hisashi Kato-Noguchi

Kagawa University, Japan

P-108
Autotoxicity may play an important role in "asparagus decline"

Hisashi Kato-Noguchi[1], Keisuke Nakamura[1], Osamu Ohno[2], Kiyotake Suenaga[2], Nobuyuki Okuda[1]
[1]Kagawa University, Japan; [2]Keio University, Japan

P-109
Allelopathic weed suppression through the use of *Rottboellia cochinchinensis* (Lour.) W.D.Clayton

Apirat Bundit[1], Kosumi Yamada[2], Tosapon Pornprom[3]
[1]Chiang Mai University, Thailand; [2]University of Tsukuba, Japan; [3]Kasetsart University, Thailand

P-110
Allelopathic activity and a growth inhibitory substance in shoots of *Echinochloa crus-galli* (L.) P. Beauv.

Kana Tanaka, Hisashi Kato-Noguchi
Kagawa University, Japan

P-111
Study on competitive ability of hybrid and inbred rice varieties (*Oryza sativa* L.) against weeds

Thang Lam Lun[1], Mar Mar Kyu[1], Hisashi Kato-Noguchi[2]
[1]Yezin Agricultural University, Myanmar; [2]Kagawa University, Japan

Weed Management (Sustainable System)

P-112
Effect of nitrogen fertilizer application method and dosage on weed and weed competition in rice

D. D. Witharana[1], A. S. K. Abeysekara[2], H. M. S. D. Kulatunga[2], W. M. U. B. Wikrama[2]
[1]Postgraduate Institute of Agriculture, Sri Lanka; [2]Rice Research and Development Institute, Sri Lanka

P-113
A *Zoysia* grass net-planting technique for rural levees

Akihide Fushimi[1], Kazuo Naganuma[2]
[1]NARO, Japan; [2]Zoysian Japan Co., Ltd., Japan

P-114
Productivity low land rice on different land preparation and weed control

Dedi Widayat, Yayan Sumekar, Uum Umiyati, Denny Kurniadie
Padjadjaran University, Indonesia

P-115 APWSS Student Travel Grant
The influence of different amounts of nitrogen and weed interference on yield and yield components of corn in two irrigation systems

Rouzbeh Zangoueinejad[1], Seyed Abdolreza Kazemeini[2], Mohammad Taghi Alebrahim[1]
[1]University of Mohaghegh Ardabili, Iran; [2]Shiraz University, Iran

Weed Management (Integrated Weed Management)

P-116

Efficacy of the canopy height-to-row spacing ratio as an onsite index to determine the termination time of *Ipomoea coccinea* control using the soybean mini-core collection

Shunji Kurokawa[1], Akito Kaga[1], Mai Tsuda[2], Daisuke Sekine[1], Tomoko Shibuya[1]

[1]NARO, Japan; [2]University of Tsukuba, Japan

P-117

Weed infestation, yield losses and control methods in maize crop

Khawar Jabran[1], Ahmet Uludag[1,2], Bhagirath Singh Chauhan[3]

[1]Düzce University, Turkey; [2]Canakkale Onsekiz Mart University, Turkey; [3]The University of Queensland, Australia

P-118

Influence of weed management measure on glyphosate resistance and endophyte infection in naturalized Italian ryegrass (*Lolium multiflorum*)

Valentina Dwi Suci Handayani[1], Yuki Tanno[1], Masayuki Yamashita[1], Hiroyuki Tobina[1], Minoru Ichihara[2], Yoshiki Ishida[2], Hitosi Sawada[1]

[1]Shizuoka University, Japan; [2]Shizuoka Prefectural Research Institute of Agriculture and Forest, Japan

P-119

Efficacy of weeding machine composed of steel tines in terms of growth stage of weeds in soybean

Hiroyuki Kobayashi[1], Nozomi Ihara[1], Hiroyuki Kondo[2]

[1]NARO, Japan; [2]QFO Inc., Japan

Weed Biology and Ecology

P-120

Morphological variations, genetics and geographic background of *Echinochloa crus-galli* in China

Yongliang Lu[1], Manyu Zou[2], Liping Yin[3], Shuiliang Guo[2]

[1]China National Rice Research Institute, China; [2]Shanghai Normal University, China; [3]Shanghai Entry-Exit Inspection and Quarantine Bureau, China

P-121

Seed Germination, seedling emergence and response to herbicides of triquetrous murdannia (*Murdannia triquetra*) in rice

Wei Tang[1], Jie Chen[2], Jing Yuan[2], Jianping Zhang[1], Yongliang Lu[1]

[1]China National Rice Research Institute, China; [2]Zhejiang A&F University, China

P-122

Identifying early germination characters that leads to the weediness of a plant: Border regulatory perspectives

W. J. Nimanthika[1,2], S. M. W. Ranwala[2], H. S. Kathriarachchi[2]

[1]National Plant Quarantine Service, Sri Lanka; [2]University of Colombo, Sri Lanka

P-123
Seed germination of *Xyris complanata*, a monocot pioneer plant in burnt tropical peatlands, can be stimulated by a soil *Penicillium* sp.

Yasuyuki Hashidoko[1], Masataka Hane[1], Ryosuke Tamura[1], Yanetri A. Nyon[2], Hanny C. Wijaya[3]

[1]Hokkaido University, Japan; [2]University of Palangka Raya, Indonesia; [3]Bogor Agricultural University, Indonesia

P-124
Population dynamics of *Ipomoea hederacea* Jacq. var. *integriuscula* A. Gray (morning glory)in paddy field levee – relationship between emergence time and fruiting –

Nozomi Ihara, Hiroyuki Kobayashi

NARO, Japan

P-125
Changes of weed flora in wheat fields in the Southeast Anatolia Region of Turkey

Zübeyde Filiz Arslan[1], Ahmet Uludağ[1,2], Ayşin Bilgili[3], Ayçin Aksu Altun[3]

[1]Düzce University, Turkey; [2]Çanakkale Onsekiz Mart University, Turkey; [3]GAP Agricultural Research Institute, Turkey

P-126
Barnyardgrass (*Echinochloa crus-galli*) genome analysis provides insight into its adaptation and invasiveness as a weed

Jie Qiu, Chuyu Ye, Longjiang Fan

Zhejiang University, China

P-127
Response of Se stress on the accumulation of Se and the absorption of mineral elements in alfalfa

Hui-ping Dai[1], Hua Zhao[2], Shuhe Wei[1]

[1]Shaanxi University of Technology, China; [2]Hainan University, China

P-128
A novel gene of seed vernalization in *Conyza canadensis*, which regulates life histories of facultative winter annuals

Yoshihiro Kobayashi, Kohei Kiriyama, Nozomi Aoyama, Satoko Takahashi, Katsuhiro Shiono, Toshihito Yoshioka

Fukui Prefectural University, Japan

P-129
High-throughput sequencing reveals bacterial community composition in the rhizosphere of the invasive plant *Flaveria bidentis*

Zhen Song, Weidong Fu, Guoliang Zhang

Chinese Academy of Agricultural Sciences, China

P-130
Effects of *Solanum rostratum* invasion on soil properties in different soil types

Weidong Fu, Guoliang Zhang, Zhen Song

Chinese Academy of Agricultural Sciences, China

P-131

iTRAQ protein profile differential analysis of dormant and germinated grassbur twin seeds reveals ribosomal synthesis and carbohydrate metabolism promote germination possibly through the PI3K pathway

Guoliang Zhang, Weidong Fu, Zhen Song

Chinese Academy of Agricultural Sciences, China

P-132

Biology and Distribution of Chickenweed purslane (*Portulaca quadrifida* L.)

J. Pinsupa, S. Zungsontiporn

Plant Protection Research and Development Office, Thailand

P-133

Population dynamics of black-grass (*Alopecurus myosuroides*) in winter wheat fields and its effect on wheat yield

Mei Li, Feng Fang, Xingxiang Gao, Jian Li, Ligui Zhu

Shandong Academy of Agricultural Sciences, China

P-134

Evidence of adaptation of *Setaria viridis* to intensive salt splash from typhoon in sandy seashore

Matsuo Itoh[1], Yoshitaka Nakashima[2], Yoko Oki[2]

[1]Shikoku Gakuin University, Japan; [2]Okayama University, Japan

P-135

Heavy metal tolerance of Japanese knotweed (*Reynoutria japonica* Houtt.) growing on mine site and effects of the endophytic fungi

Yuki Hojo, Keiko Yamaji

University of Tsukuba, Japan

P-136

Germination and seedling growth of *Sagittaria pygmaea*

Yumiko Hori, Yoshiko Shimono, Tohru Tominaga

Kyoto University, Japan

P-137

Dramatic shift of flowering phenology of intraspecific hybrids in *Imperata cylindrica* makes an F1-dominated hybrid zone

Yasuyuki Nomura[1], Yoshiko Shimono[1], Nobuyuki Mizuno[1], Kazuhiro Sato[2], Tohru Tominaga[1]

[1]Kyoto University, Japan; [2]Okayama University, Japan

P-138

Comparisons of morphological and genetic variations between native and alien *Artemisia indica* populations used for revegetation in Japan

Satoshi Wagatsuma[1], Yoshiko Shimono[1], Junichi Imanishi[1], Yoshihisa Suyama[2], Chika Mitsuyuki[2], Yoshihiro Tsunamoto[2], Tohru Tominaga[1]

[1]Kyoto University, Japan; [2]Tohoku University, Japan

P-139

***Echinochloa* response to osmotic stress induced by PEG and salt.**

Hyejin Yu, Minjung Yook, Do-Soon Kim

Seoul National University, Korea

P-140

Emergence behavior and seasonal variation in emergence of seedlings in carolina dayflower (*Commelina caroliniana* Walter)

Mitsuhiro Matsuo[1], Taira Sakai[1], Shuji Kurihisa[1], Yoshiki Kawano[2]

[1]University of Miyazaki, Japan; [2]Oita Prefectural Agriculture, Forestry and Fisheries Research Center, Japan

P-141

Comparisons of germination characteristics and seedling growth of *Bromus species* between widespread and non-widespread aliens

Emi Kawamata, Yoshiko Shimono, Tohru Tominaga

Kyoto University, Japan

P-142

Does *Penicillium rolfsii*, a fungus that stimulated germination of *Xyris complanata* seeds, stimulate germination of dormant seeds in a soil seed bank?

Masataka Hane[1], Ryosuke Tamura[1], Yanetri A Nyon[2], Hanny C Wijaya[3], Yasuyuki Hashidoko[1]

[1]Hokkaido University, Japan; [2]University of Palangka Raya, Indonesia; [3]Bogor Agricultural University, Indonesia

P-143

Plant communities around *Spiranthes sinensis* in urban green spaces

Satoru Tanaka, Kou Inoue

Tokyo University of Agriculture, Japan

P-144

Relationships of leaf age and plant height in *Panicum dichotomiflorum* and in *Eragrostis pilosa* had become the problem weeds at dry-seeded rice in Tohoku, Japan

Maiko Akasaka, Soichi Nakayama

NARO, Japan

P-145

Aquatic weed community dynamics of Dal Lake in temperate valley of Kashmir Himalayas

Anil Kumar[1], P. Puniya[1], Ashu Sharma[1], Neetu Sharma[1], Quazi Tassaduq Mueen[2]

[1]Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, India; [2]Department of Horticulture, Rajbagh Srinagar, India

Utilization of Weeds and Uses as Bio-Resources

P-146

Zinc tolerance in four *Medicago sativa*

Hui-ping Dai[1], Shuhe Wei[1,2]

[1]Shaanxi University of Technology, China; [2]Institute of Applied Ecology, Chinese Academy of Sciences, China

New Technology

P-147

The utility evaluation of aerial high resolution images taken from a low latitude with a small drone in the detection of *S. angulatus* community

Osamu Watanabe

Shinshu University, Japan

P-148

A labor saving method for raising *Zoysia japonica* vegetation on paddy field levees using plug shoot, growth retardant and herbicide

Tetsuro Muraoka, Jin-ichi Hashimoto, Akiu Tsuruya, Akihiko Matsuo

Japan Association for Advancement of Phyto-Regulators (JAPR), Japan

P-149

Labor-saving applications of rice herbicide with throw-in type jumbo formulation (granule pack) containing pyraclonil from levees in 1 ha scale paddy rice fields in Japan

Seok Weon Seo, Ryoichi Nishihara, Masashi Hamaya, Hitohisa Takahashi, Yoshiharu Ikeda, Satoru Andou

Kyoyu Agri Co.,Ltd., Japan

Others

P-150

A review of the herbarium of Institute of Plant Science and Resources, Okayama University

Jun Yamashita

Okayama University, Japan

P-151

Soil- and weed-related problems following farmland decontamination post the Fukushima Daiichi nuclear power plant accident

Namiko Yoshino, Motoaki Asai, Hiroyuki Kobayashi

NARO, Japan

P-152
Effect of orthosulfamuron on sugarcane ripening

Kyosuke Miyamoto[1], Angelo Stasievski[2], Tiago Oliveira[2], Shuji Kumata[1]
[1]Nihon Nohyaku CO., LTD., Japan; [2]Nichino do Brasil AGROQUÍMICOS LTDA, Brazil

P-153
Seed characteristics related to weedy risk of hybrids between GM soybean and wild soybean

Minjung Yook, Hae-Rim Park, Jung Hyo Kim, Do-soon Kim
Seoul National University, Korea

P-154
Bioherbicidal potential of *Typha angustifolia* L. extract

Srisom Suwanwong, Udomsap Chanthanet, Ornusa Khamsuk
Kasetsart University, Thailand

P-155
Growth response of poplar (*Populus deltoides*) entire transplants to weed interference

Navneet Kaur, H. Kaur, R. I. S. Gill, M. S. Bhullar
Punjab Agricultural University, India

P-156 [Herbicide Usage 2]
Effectiveness of several selective herbicides in controlling general weeds in *Cassia cobanensis*, *Antigonon leptopus*, *Turnera subulata* and *Euphorbia heterophylla* beneficial plants establishment in oil palm plantation

Meor Badli Shah Ahmad Rafie, Samsudin Amit
Sime Darby Research Sdn Bhd, Malaysia

P-157 [Herbicide Resistance (Status)]
Herbicide use and herbicide resistance in *Cyperus difformis* L. in Sri Lanka

H. M. S. Herath[1], R. F. Hafeel[1], R. S. K. Keerthisena[2], A. P. Bentota[2], A. M. Baltazar[3], V. Kumar[4], D. E. Johnson[4]
[1]Rice Research Station, Sri Lanka; [2]Rice Research and Development Institute, Sri Lanka; [3]University of the Philippines Los Baños, Philippines; [4]International Rice Research Institute, Philippines

P-158 [Weedy Rice]
Weedy rice: An expanding problem in direct seeded rice production in the Philippines

Leylani M. Juliano[1], Edwin C. Martin[1], Dindo King M. Donayre[1], Jesusa C. Beltran[1], Roberto Busi[2]
[1]Philippine Rice Research Institute, Philippines; [2]University of Western Australia, Australia

P-159 [Weed Management (Sustainable System)]
Performance of upland rice (*Oryza sativa.* L) as affected by weed control treatments, poultry manure and stand density

O. Danmaigoro[1], D. B. Ishaya[2], J. A. Y. Shabayan[2]
[1]Federal University Dutse, Nigeria; [2]Ahmadu Bello University, Nigeria

P-160 [Non-Chemical Control]

Smart Biofumigation as a new and innovative technology for aggressive weed control under Organic and Global GAP Standards

Mohamed Fathy Salem

University of Sadat City, Egypt.

P-161 [Invasive Alien Species]

Evidence for rapid evolution in *Parthenium hysterophorus* L.

Asad Shabbir[1], Sadaf Rafiq[1], Sana Amin[1], Steve Adkins[2]

[1]University of the Punjab, Pakistan; [2]The University of Queensland, Australia

P-162 [Herbicide Usage 1]

Does phylogenetic similarity among upland weed species influence susceptibility to pre-emergence herbicides, pendimethalin, trifluralin, and flumioxazin?

Naomi Hosaka, Tetsuro Muraoka, Hirokazu Takahashi

Japan Association for Advancement of Phyto-Regulators, Japan

P-163 [Herbicide Resistance (Management)]

Bispyribac sodium-resistant sedges in rice fields of Sri Lanka

R. M. U. S. Bandara[1], B. Marambe[2], A. P. Bentota[1], R. S. K. Keerthisena[1], A. S. K. Abeysekara[1], H. M. S. Herath[1], V. R. Kumar[3], H. M. M. K. K. H. Dissanayaka[1], Y. M. S. H. I .U. De Silva[1], D. M. C. B. Dissanayake[1]

[1]Rice Research and Development Institute, Sri Lanka; [2]University of Peradeniya, Sri Lanka; [3]International Rice Research Institute, Philippines

P-164 [Weed Biology and Ecology]

Occurrence characteristics of weed flora in arable fields of Korea

In-Yong Lee[1], Young-Ju Oh[2], Sun-Hee Hong[2], Su-Jeoung Heo[3], Chae-Young Lee[4], Kee-Woong Park[5], Seng-Hyun Cho[6], Oh-Do Kwon[7], Il-Bin Im[8], Sang-Kuk Kim[9], Deok-Gyeong Seong[10], Young-Jae Chung[11], Chang-Seog Kim[12], Jeongran Lee[1], and Hyun-A Seo[1]

[1]National Institute of Agricultural Sciences, Korea; [2]Institute for Future Environmental Ecology, Korea; [3]Gangwon-do Agricultural Research & Extension Services, Korea; [4]Chungchengbuk-do Agricultural Research & Extension Services, Korea; [5]Chungnam National University, Korea; [6]Jeollabuk-do Agricultural Research & Extension Services, Korea; [7]Jeollanam-do Agricultural Research & Extension Services, Korea; [8]Bio-Plant Environment Research Center, Korea; [9]Gyeongsangbuk-do Agricultural Research & Extension Services, Korea; [10]Gyeongsangnam-do Agricultural Research & Extension Services, Korea; [11]Shingyeong University, Korea; [12]National Institute of Crop Science, RDA, Korea

P-165 [Herbicide Usage 3]

The effect of herbicides on physiological and biochemical responses in oil palm roots correlate with *Ganoderma* disease incidence.

Mohd Hefni Rusli, Idris Abu Seman

Malaysian Palm Oil Board. No.6, Persiaran Inst

P-166 [Non-Chemical Control]

Herbicidal characteristics of crude extracts from soil bacteria *Streptomyces* sp. G0299

Choi Jung Sub[1], Young SookKim[1], Jae Deok Kim[1], Young KwanKo[1], Kee Woong Park[2]

[1]Korea Research Institute of Chemical Technology, Korea; [2]Chungnam National University, Korea

P-167 [Weed Management (Sustainable System)]

Effect of rice establishment methods on weed shifts

V. Pratap Singh, Arunima Paliwal, S.P. Singh, Tej Pratap and A. Kumar

Govind Ballabh Pant University of Agriculture & Technology, India

KL 1

Integrated Weed Management of the Future

Stephen O. Duke[1]

[1]Research Leader, Natural Product Utilization Pesearch Unit, USDA-ARS, USA

Charles Darwin would have predicted that reliance on the use of a single method of pest management would result in evolution of pests to avoid that control measure. This has occurred relatively quickly during the 70 years that humans have largely relied on herbicides for weed management, with evolved herbicide resistance becoming a costly problem in terms of lost crop yields and increased chemical inputs. Much of this problem could have been prevented through implementation of integrated weed management (IWM) approaches. IWM is an approach that focuses on long-term (sustainable) prevention and management of weeds through the use of combinations of techniques such as herbicides, modification of cultural practices, and mechanical control. Within each of these general management technologies, variety (*e.g.*, rotation of herbicide modes of action) can further the diversity of management technologies that a weed species will encounter, thus minimizing evolution of resistance or avoidance. In other words, diversification of effective weed management approaches in time and space equals optimal integrated weed management.

With no new herbicide modes of action being introduced in over the past 30 years and rampant and growing cases of multiple herbicide resistance, the need for widespread implementation of IWM to preserve what herbicides that are still effective on most weed species is urgent. Herbicides with new modes of action will eventually be introduced. Robotic weeding, both mechanically and with herbicides, will become robust in the near future. Biotechnology may make sprayable RNAi, gene-edited herbicide-resistant crops, microbial biocontrol, and allelopathic crops major weed management tools in the future. Utilization of negative cross resistance to herbicides may play a role in making future use of some herbicides more durable. Our hard-learned lesson from not using IWM with herbicides in the past must not be forgotten when these effective new technologies become available.

Golden Jubilee Memorial Lectures

Commemorating 50 years of the Asian-Pacific Weed Science Society (1967-2017)

Aurora M. Baltazar[1]

[1]Adjunct Professor, Institute of Weed Science, Entomology and Plant Pathology
University of the Philippines Los Banos
College, Laguna 4031 Philippines

The Asian-Pacific Weed Science Society was founded in June 22, 1967 during the First Asian-Pacific Weed Control Interchange held in Hawaii, USA through the vision, planning and hard work of three founding fathers, Roman Romanowski, William Furtick and Donald Plucknett. Its primary objective is to promote weed science, in particular in the Asian and Pacific regions, by pooling and exchanging information on all aspects of weed science. Its activities include holding of conferences every two years, organizing and sponsoring symposia, workshops and training courses in weed science, publishing proceedings of conferences, symposia, and workshops, a newsletter, books and other special publications about weeds and their control in tropical agriculture. It has about 300 members and is affiliated with 18 national weed science societies in the Asian-Pacific region. APWSS has played a highly significant role in bringing together the scientists, researchers, extension and industry workers in weed science in the region and providing a forum for exchange of weed science information. This exchange and collaboration is extremely important in finding solutions and strategies to manage weeds that continually challenge farmers and agricultural workers in their objective of obtaining high crop yields. This paper was written to commemorate the 50th anniversary year of APWSS to reflect on the activities and achievements for the past 50 years and to provide us with the insight, past experiences and lessons learned to help us move into the future and set the directions of the Society for the next 50 years.

Temperature and soil moisture as principal factors on emergence and growth of weeds in rice production in Asian-Pacific Region

Hirohiko Morita[1]

[1]Japan Association for Advancement of Phyto-Regulators (JAPR)
Professor emeritus, Akita Prefectural University
860 Kashiwada, Ushiku, Ibaraki 300-1211, Japan
morita@japr.or.jp

Further development of effective weed management technologies is still significant target in the rice production, particularly in the direct sown fields and the rainfed fields distributed in the temperate and the tropical, sub-tropical regions, respectively in Asian-Pacific region. Since the emergence and the early growth of weeds are affected by the meteorological factors, with the different way, mainly by the temperature in the temperate region and by the soil moisture in the tropical and sub-tropical regions. As examples of these relationships, analysis of the effects of temperature on the leaf emergence in *Echinochloa* weeds in the temperate region and that of the effect of soil moisture rate on the emergence of weeds from rainfed rice fields of tropical regions are reviewed in order to support the development of the effective and labor-saving utilization technologies of herbicides in the rice production, according to the author's experiences conducted mainly in the Asian-Pacific region.

Key words: air temperature, direct sown rice, Echinochloa weeds, emergence, leaf-stage, herbicides, soil moisture rate

Weed Science in the Asian-Pacific Region: Present Status and Experiences

Stephen William Adkins[1]

[1]University of Queensland, Gatton, Australia

The prevention and management of weeds has been a continuous problem throughout the history of food production and native ecosystem protection in the Asian-Pacific region. Despite improvements in the approaches used, weeds still reduce productivity and profitability by unacceptable amounts, and upset the balance of natural ecosystems. The Asian-Pacific region has considerable strengths in many aspects of weed science technology and training. However various issues, such as the rapidly increasing requirement for food due to an ever growing population, the ever increasing influx of new weeds as international travel and trade increases, the acceptance of climate change and its likely impacts upon weed distribution and abundance, and the advent of special threats such as the evolution of weeds that are resistance to herbicides and to the adoption of reduced tillage agriculture, have all necessitated the re-evaluation of our current approaches to weed management. In this paper I attempt to provide a brief summary of some of the present problems facing food production and environment protection in the Asian-Pacific region and review some of the future approaches we may need use to manage these weed threats. The weed challenges now facing our regions agriculture and land management will require food and land systems that are safe for the community and the environment, sustainable and profitable in both the short- and long-term, and adaptable for use in all situations. In the past the vision and the objective of achieving good weed science outcomes in the Asian-Pacific have been primarily achieved through information exchange at conferences, workshops and training courses, through our newsletter and international journal and some bilateral research collaborations. The time has come for an increased level of international collaboration to meet these new challenges.

Technological Advances for Weed Management

Nilda Roma-Burgos[1], Christopher E. Rouse[2], Vijay Singh[3], Reiofeli Salas-Perez[4], and Muthukumar Bagavathiannan[5]

[1]Professor (Weed Science), Department of Crop, Soil, and Environmental Sciences, University of Arkansas, Fayetteville, AR, USA 72704; E-mail: nburgos@uark.edu
[2]Graduate Assistant, Department of Crop, Soil, and Environmental Sciences, University of Arkansas, Fayetteville, AR, USA 72704; E-mail: cerouse@uark.edu
[3]Postdoctoral Associate, Department of Soil and Crop Sciences, Texas A&M University, College Station, TX, USA 77843; E-mail: vijay.singh1633@gmail.com
[4]Graduate Assistant, Department of Soil and Crop Sciences, Texas A&M University, College Station, TX, USA 77843; E-mail: rasalas@uark.edu
[5]Assistant Professor, Department of Soil and Crop Sciences, Texas A&M University, College Station, TX, USA 77843; E-mail: muthu@tamu.edu

Weeds are oftentimes the major pests of crop fields and farmers often utilize a variety of cultural, mechanical, and chemical methods to manage them. Herbicides have been the most preferred tool for weed management. The rapid growth of the herbicide industry and the industrial revolution in farm mechanization paved the way for large farm operations. Weeds adapt to selection pressure imposed by management tactics. Resistance to herbicides will drive most of what we do henceforth for weed management and will drive future discoveries of novel weed management tools. Breaking the yield ceiling, developing resilient varieties, efficient management of large farms, and improving the sustainability of crop production require a higher level of technological innovations. We are beginning to see such innovations today. The study of genomics, proteomics, metabolomics, bioinformatics, systems biology, molecular biology, and physiology and their applications into biotechnology, crop improvement, weed management, plant identification tools, molecular assays, and others will have the broadest impact on weed science and agriculture. Stacking of traits in crops will become the norm. miRNAs can be utilized more in developing crop traits. NGS technology, coupled with various 'OMICS' technologies, will propel major advances in RNAi technology, gene editing, biotechnology, and discovery of new herbicide targets or novel weed management tools. Nanotechnology applications in agriculture will increase and would likely continue to facilitate the development of novel herbicide formulations and delivery of RNAi agents for nonchemical weed control. Remote sensing and robotics will become more practical, user-friendly, and affordable. This would improve management of large farms, especially detection and monitoring of weed invasion and patch expansion, monitoring invasive species in the landscape, or detection and monitoring spread of herbicide-resistant weeds. The future holds great promise for developing novel tools for weed management in particular and producing crops efficiently in general. Technology is advancing fast; we are limited only by our imagination.

SL 1

Ethics, Agriculture, and the Environment

Robert L. Zimdahl[1]

[1]Emeritus Professor, Colorado State University, Fort Collins, CO 80524, USA

Those engaged in agriculture and environmental study possess a definite but unexamined moral confidence or certainty about the correctness of what they do. The origin of that confidence will be discussed and questions will be raised about its validity. The basis of the moral confidence is not obvious to those who have it, or to the public. In fact the moral confidence that pervades agriculture is potentially harmful because it is unexamined. It is necessary that those engaged in science analyze what it is about their science and their society that inhibits or limits their science. All should strive to nourish and strengthen the aspects that are beneficial and change those that are not. To do this we must be confident to study ourselves, our institutions, and be dedicated to the task of modifying the goals of both.

SL 2

Biologically-based methods of weed management: The next 50 years

Raghavan Charudattan[1]

[1]Emeritus Professor, Plant Pathology Department, University of Florida-Institute of Food and Agricultural Sciences and President & CEO, BioProdex, Inc., Gainesville, FL 32609, USA.
Email: rcharudattan@bioprodex.com

In the coming decades, weed management methods are bound to be influenced by newer scientific and technological advances from several fronts. Rapid changes will ensue from the use of various forms of microprocessor-based technologies in weed control and crop production and from molecular-genetic methods in herbicide discovery and crop improvement. The present generation of younger scientists of the Asian-Pacific Weed Science Society will witness these changes and find themselves making key advances in Weed Science. They will also set the overall scientific philosophy of managing weeds not only to answer the call from the agriculture sector but also to ensure the overall safety and health of people and the environment.

To this end, I beckon this generation to make a concerted effort to develop and incorporate biologically-based methods as a key component. Bio-based methods have been a practical, but only a relatively minor component of overall weed management tactics, in the past 50 years. Now, there is a strong case to be made for utilizing the emerging biotechnological breakthroughs, such as gene silencing and gene editing to improve and incorporate biologically based methods as a mainstream solution to global weed problems.

PL 1

Development of Herbicides for Paddy Rice in Japan

Kenshiro Hamamura[1]

[1]Japan Association for Advancement of Phyto-Regulators, Manager, Chiba Branch, Research Institute

History of development of herbicides for mechanized paddy rice production in Japan can be characterized by a combination of products with several ingredients, by large availability in formulation and by application methods for labor-saving according to natural and social conditions of the country, for instance, around 40% of national land located in hilly and mountainous areas, small size paddy fields consolidated in about 0.3 ha in average and so on. As for combination products, One-shot herbicides which can control both annual and perennial weeds including grass, sedge and broad-leave, mainly with sulfonylureas have been major means for rice production since the 1980s. One-shot herbicides have been improved by using newly developed chemicals with excellent herbicidal efficacy such as ALS, 4-HPPD, PPO and VLCFAE inhibitors and by combining ingredients that are effective against SU-resistant biotypes of lowland weeds. The latest type of One-shot herbicides can control noxious species such as *Eleocharis kuroguwai* as well as other ordinal species. Regarding herbicide formulation, '1 kg-granule', 'Jumbo', 'Flowable', 'Diffusion-granule' and so on, have been developed to save farmers' troubles in applying herbicides. As for application methods, 'at-transplanting application', 'at-irrigation inlet application' and utilization of radio-controlled helicopters or boats were put into practical use as a labor-saving technique using technology. As a result, farmers were saved from the severe hand-weeding work under blazing heat during the summer season. JAPR have promoted and contributed to the development of herbicides through collaboration with Agro-Chemical Companies and Research organizations since it was founded in 1964. In this paper, I explain the development progress of herbicide, using materials on the mode of action, the trend of One-shot herbicides, the feature of a labor-saving formulation and the working hours for weed management in rice production.

PL 2

Evolution, mechanism and sustainable control of herbicide resistance in weeds

Deepak Kaundun[1]

[1]Syngenta, United Kingdom

Herbicides are important tools for the cost-effective control of weeds in modern agriculture. Excessive use, however, has resulted in the evolution of resistance in many weeds and cropping systems worldwide. The most recalcitrant species include *Amaranthus* spp. from Midwestern US corn/soybean production systems and *Alopecurus myosuroides* and *Lolium rigidum* from North-Western European and Australian wheat growing regions.

Whilst resistance can spread from field to field via pollen or seed movement, recent studies have shown that it primarily evolves spontaneously from standing genetic variation within heterogeneous weed populations. Single-site herbicide modes of action are particularly affected compared to multi-site inhibitors. Two major mechanisms are documented, namely, target-site and non-target-site resistance. Target-site resistance can be due to subtle mutations or deletion of a key amino acid for herbicide binding or duplication and over-expression of the herbicide target. Non-target site resistance is often accounted for by enhanced metabolism (favoured by low dose use) of the parent compound into non-toxic entities and, in some cases, due to impaired translocation to meristematic tissues. The precise target-site mutations are relatively easy to determine whilst the complex multi-genes involved in NTSR remain elusive to date in spite of the availability of whole genome/transcriptome sequencing techniques.

Some resistant traits are affected by a fitness penalty and therefore predicted to decrease in the absence of herbicide selection pressure. However, the long-term practical significance at the field level is yet to be established. Computer based-modelling integrating weed biology, genetics of the resistance trait and management practices should allow the design of a diversified management strategy to mitigate the risk of resistance evolution to the ever decreasing herbicide options. Simple in-season resistance detection methods are also required to allow for an informed use of herbicides for effective weed control prior to field application.

PL 3

Genetic diversity of *Echinochloa* species in taxonomic and ecological aspects

Do-Soon Kim[1]

[1]Department of Plant Science, College of Agriculture and Life Sciences, Seoul National University, Seoul 08826, Korea (E-mail: dosoonkim@snu.ac.kr)

Echinochloa species belonging to the genus *Echinochloa* consisting of approximately 50 crop and weedy species have diverse ploidy levels from diploid (2n=2x=18) to hexaploid (2n=6x=54) and inhabits wide climatic zone from tropical to temperate region and broad soil water regimes from flooded paddy to dry upland fields. Among *Echinochoa* species, *E. oryzicola* (2n=4x), *E. crus-galli* (2n=6x), and *E. colona* (2n=6x) are most frequently found as a weed in crop fields, where they threaten crop production due to their high abundance, ecological adaptation and competitive ability against crops. *Echinochloa* species show morphological variation within species and similarity among species, making them hard to distinguish taxonomically. In particular, some of *Echinochloa* species resemble rice morphologically at earlier growth stages, enabling them to escape weeding more easily. Conventional taxonomic investigation based on *Echinochloa* morphology and molecular marker analyses revealed genetic diversity and phylogenetic relationships among *Echinochloa* species. Various plant responses to abiotic stress including flooding and drought stresses revealed ecological adaptive diversity among *Echinochloa* species. *De novo* RNA sequencing and transcriptome analysis of *Echinochloa* species revealed diversity in the gene expression patterns of particular gene ontology (GO) categories and subsequent qRT-PCR of selected genes clarified diversity in differentially expressed genes (DEGs) among *Echinochloa* species in responding to different abiotic stresses. Coexistence of *Echinochloa* species as a crop and a weed in agroecosystem and continuous selection pressures due to man-caused disturbance and natural climate change eventually result in genetic diversity of *Echinochloa* species, which thus endows this grass weed species dominant competitive and adaptive abilities over crops and many other weeds in croplands of broad climatic zones and soil water regimes.

PL 4

Research on Allelopathy for Weed Science in Asian-Pacific Region

Yoshiharu Fujii[1]

[1]Tokyo University of Agriculture and Technology, 3-5-8, Saiwai-cho, Fuchu, Tokyo 183-8509 Japan.

There are three main routes of allelopathy in case of plant-to-plant interactions and are evaluated by specific bioassays. Allelopathy by root exudates; plant box method and rhizosphere soil method, route by leaf leachates: sandwich method, and the route of volatile chemicals; dish pack method and cotton swab method. By these methods, we have evaluated about 2000 to 4000 plant species and the database is currently under construction. Some rules and hypothesis concerning this database of allelopathic species will be explained. Isolated allelochemicals in action are evaluated of by total activity to assess their contribution to plant growth inhibition. There are three faces of total activity for the evaluation, isolation, and contribution of allelochemicals; (1) Total activity as EC_{50}/ Concentration as a judge for total richness of activity in plant. (2) Tool for the isolation of allelochemicals. Fractionation based on this will guide in isolation of allelochemicals.
(3) Evaluation of the contribution of identified candidate by comparison of activity of crude extract and activity by specific candidate chemical. Isolated allelochemicals in action based on this approach including L-DOPA in Mucuna, cyanamide in hairy vetch, durantanin in *Duranta repens*, cis-cinnamic acid in *Spiraea* spp. will be explained. By using these methods, there is a possibility to find more new type of allelochemicals in action. We also introduce bioassay aimed at mode of action and specific screening including; (1) Life cycle assessment for the evaluation of effect in each life stage of targeted plant. This method is not finalized, but we hope to revise and evaluate contribution in life cycle, (2) Protoplast method for the evaluation to discriminate the effect on cell membrane and high-throughput evaluation of allelochemicals, and (3) Transcriptome analysis for the estimation of mode of action of allelochemicals. Finally, we present practical weed control by allelopathy. Some of these practical measures are (1) evaluation of allelopathy of weeds and alien plants for their risk to agriculture or environment. By this method, the true risk of alien plants have been evaluated, (2) weed control by ground cover plants with allelopathic activity. Mucuna, wheat, sorghum, buckwheat, and hairy vetch are practical examples of such crops. (3) and the development of new herbicide with novel mode of actions. A trial for gravitropism as a new target for weed control will be explained.

O-001

Endothall Use in Flowing Systems for Nuisance Aquatic Weed and Algae Control

Cody J. Gray[1]

[1] United Phosphorus, Inc., 11417 Cranston Drive, Peyton, CO 80831, USA

The task of controlling aquatic vegetation in flowing water systems is an extremely important venture, especially in the western United States. The waters supplied by irrigation canals are the primary, and in some locations the only, source of water for irrigating agronomic crops. In other locations, these waters supply industrial water users as well. Therefore, aquatic weed control in irrigation canals becomes extremely critical; however, the tools available to canal managers for weed control are limited. In 2009, two endothall formulations were labeled for use in irrigation canals. Cascade is the dipotassium salt of endothall, and works to control a range of aquatic weed species. Teton is an amine formulation of endothall that can control both submersed plants and algae. Since their introduction in 2010, Cascade and Teton have been successfully incorporated into weed and algae management programs by many irrigation districts. Sago pondweed [*Stuckenia pectinatus* (L.) Börner] and horned pondweed (*Zannichellia palustris* L.) are aquatic species native to the United States yet form dense troublesome infestations in irrigation canals and drainage ditches; thereby, not allowing for proper water delivery or flow. Research has determined to effectively control these species with Cascade, factors consisting of the desired target rate (mg/L or ppm) and length of application (time in hrs) be observed. For example, to achieve sago and horned pondweed control, a factor of 24 and 36, respectively, be implemented. An example of the factor scheme is a 4 mg/L rate being applied for 9 hours to gain the required 36 factor for horned pondweed. During the first three seasons of use, differential susceptibility was identified, with some species being more difficult to control. Elodea (*Elodea canadensis* Michx.) is one species that has been difficult to control. Additional elodea studies have indicated that Teton applied at 2 mg/L, or greater, can significantly reduce elodea biomass, with longer exposure time resulting in greater control. Chara (*Chara spp*.) is a macroalgae species difficult to control in flowing water systems. A trial evaluating chara control using Teton indicated a concentration of 0.5 mg/L for a minimum of 4 hrs will provide excellent control. A non-native species that infests many flowing water and natural pond/lake U.S. water bodies is hydrilla [*Hydrilla verticillata* (L.F.) Royle]. Endothall treatments in the Erie Canal, NY targeting hydrilla resulted in greater than 94% reduction in hydrilla tuber populations after a single season of treatment. Subsequent treatments have reduced the hydrilla tuber populations even further. Results from field applications and these ongoing trials indicate that endothall provides a safer and more effective tool for controlling aquatic weeds and algae in flowing water systems compared to alternative control methods.

O-002

Control of Aquatic Weeds in Canals and Drains in Australasia – a Review of Methods

William Chisholm[1], Nimal Chandrasena[2] and Peter Harper[3]

[1] Aquatic Weed Control Ltd, Chisholm Associates, 67 Selwyn St, Leeston, New Zealand

[2] GHD Pty Ltd., Level 2, 20, Smith Street, Parramatta, NSW, 2150, Australia

[3] Bettersafe Pest & Weed Management, 33, Lagonda Drive, Ingleburn, NSW 2565, Australia

The excessive growth of aquatic weeds, such as Lagarosiphon [*Lagarosiphon major* (Ridley) Moss], Egeria (*Egeria densa* Planch), Hornwort (*Ceratophyllum demersum* L.) and Hydrilla [*Hydrilla verticillata* (L. f.) Royle] can have significant adverse economic and ecological effects in waterways. Excessive growth of such species can reduce the hydraulic capacity, and efficiency of drainage infrastructure, and also displace native aquatic plant species, thereby reducing aquatic species diversity and ecosystem functions. The dominance of these species may also modify the habitat, food sources and diversity of aquatic fauna, and sometimes reduce the general aquatic health of waterways. Drains can filter out sediment and nutrients, and thus limit transfer of these materials from the land to vulnerable freshwater or coastal areas downstream. Maintenance of drains, canal and free-flowing waterways is therefore important for operational purposes (i.e. irrigation, navigation and other uses), and also for maintenance of ecological, recreational and socio-cultural values.

This paper presents an overview of techniques used for management of aquatic plants in drains, discussing advantages, disadvantages and costs in both Australia and New Zealand. These include herbicides, mechanical diggers, manual clearing, weed cutting, shade, and plant-eating fish. Mechanical clearance is the most common method to remove sediment accumulation, along with suction dredging, flushing, and source control using soil conservation measures. Amongst these techniques, herbicides are an invaluable tool to control aquatic plant growth and for drain/canal maintenance. The principal herbicides used for drain and canal maintenance in Australasia are: glyphosate, diquat and endothal. Diquat is the only herbicide with registration permitting it to be broadcast onto water in Australia and New Zealand. Glyphosate is also allowed in both countries for use on drain/canal banks (i.e. near waterways), but the spray must be directed onto vegetation with only limited on-water application allowed. Endothal (Aquathol K) is now registered in New Zealand and is widely used to control submerged aquatic plants. However, it is not yet registered in Australia as an aquatic herbicide. The results of some successful examples of using aquatic herbicides to manage nuisance growth of aquatic weeds are discussed.

Keywords: Aquatic weeds, Lagarosiphon, Egeria, Hornwort, Hydrilla, diquat, glyphosate, endothal, Aquathol

O-003

Fungal metabolites of *Alternaria raphani* J. W. Groves & Skolko in microbial control agents of aquatic weed *Alternanthera philoxeroides* (Mart.) Griseb.

Puja Ray, Writuparna Dutta and Jashaswi Basu
Multitrophic Interactions and Biocontrol Laboratory, Department of Life Sciences, Presidency University, 86/1 College Street, Kolkata-700073, India
email: puja.ray@gmail.com

Microorganisms have been recognized as potential sources of novel natural products for exploitation in medicine, agriculture and industry with more bioactive natural products isolated from the fungi. Herbicidal properties of such toxic metabolites of microorganisms have been exploited in weed management. They are expected to surmount the resistance and pollution that have accompanied the use of synthetic pesticides. In earlier studies using mycelial mat and spore suspension, a potential mycoherbicidal agent *Alternaria raphani* J. W. Groves & Skolko was observed to cause extensive damage to the alligator weed, *Alternenthera philoxeroides* (Mart.) Griseb. by causing necrotic spots followed by the death of the plant. Further host range studies on 12 aquatic and 55 terrestrial plants tested confirmed it to be specific to *A. philoxeroides*. The fungus was observed to produce a reddish brown metabolite both in liquid and solid media. During the present investigations, we evaluated different concentrations (100, 500 and 1000 ppm) of the crude metabolite produced in liquid culture of *A. raphani*, against *A. philoxeroides* under controlled conditions. The metabolite was found to be extremely phytotoxic to *A. philoxeroides*. The bioassay results showed that the metabolite obtained significantly inhibited the growth of the test weed even at 100 ppm concentrations by 7th day of application. The fungi was observed to survive at wide temperature range of 7-35^{o}C which may be useful even for field conditions in India in summer. It was also found safe to a range of arthropods including mites *Orthogalumna terebrantis* Wallwork and insect *Neochetina* buchi (Warner), biocontrol agent of another aquatic weed, water hyacinth *Eichhornia crassipes* [Mart.] Solms, growing in same ecological niche as *A. philoxeroides*. With this study, the fungal metabolite of *A. raphani* gives us hope regarding its possible herbicidal potential against the weed, though lot of studies including identification of the bioactive compounds, their stability under wide range of environmental conditions, impact on non-target organisms, etc, still remains to be done.

O-004

Crassulacean acid metabolism in an aquatic weed, a fern-ally: *Isoetes coromandelina* L. f.

Roypim Thananusak[1], Ornusa Khamsuk[1], Tassanai Jaruwattanaphan[2], Srisom Suwanwong[1*]

[1] Department of Botany, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand
[2] Department of Horticulture, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand
[*] Corresponding author e-mail: fscisss@ku.ac.th

Crassulacean acid metabolism (CAM) is a photosynthetic CO_2 fixation pathway and a plastic response to environmental changes. It can be found in plants which have adapted to survive in particular environments such as xerophyte, epiphyte, lithophyte or hydrophyte. CAM in aquatic plants was first discovered in *Isoetes howellii* Engelmann. *Isoetes* L. is an ancient genus of heterosporous lycopsids, fern-allies, and CAM also found in many species of this genus. In this study, we focus on the only species of *Isoestes* in Thaiand, *I. coromandelina* L. f., because of a little-known about CAM pathway in *I. coromandelina* under different environmental conditions. *I. coromandelina* is an aquatic weed in paddy fields and shallow swamps. These kinds of area often change between aquatic and terrestrial environments. We investigated and compared photosynthetic characteristics in *I. coromandelina* leaves under aquatic condition (AC) and terrestrial condition (TC). Titratable acidity was measured at 6:00 P.M., 12:00 A.M., 6:00 A.M., and 12:00 P.M. Starch and soluble sugar content analysis were measured at 6:00 A.M. and 6:00 P.M. The diurnal fluctuation of total acid content of *I. coromandelina* were opposite to the starch and soluble sugar contents. Under AC, the total acid content increased at night (6:00 P.M. to 6:00 A.M.), and decreased during the day (6:00 A.M. to 12:00 P.M.), while it increased from 6:00 P.M. to 12:00 P.M. in TC. For the starch content, both AC and TC showed a decreasing trend during the night. However, the soluble sugar content was not different between the collecting times. Compared with TC, titratable acidity levels were higher in AC, whereas starch and soluble sugar content were lower in AC. The results support that *I. coromandelina* has CAM photosynthesis under AC and TC, and starch is a carbohydrate reserve for CAM in this species.

Keywords: aquatic plant, aquatic weed, fern-allies, *Isoetes*, photosynthetic plasticity

O-005

Submerged Aquatic Plant Control in Sydney 2000 Olympic Lakes with Fluridone (Sonar®) – A Case Study

Nimal Chandrasena[1], Peter Harper[2] and Kevin Flynn[3]

[1] GHD Pty Ltd., Level 2, 20, Smith Street, Parramatta, NSW, 2150, Australia

[2] Bettersafe Pest & Weed Management, 33, Lagonda Drive, Ingleburn, NSW 2565, Australia

3 Sydney International Regatta Centre, Office of Sports, 153-233, Old Castlereagh Road, Penrith, NSW 2749, Australia

Abstract

Over several years, the submerged macrophytes - Ribbonweed (*Vallisneria gigantea*) and Hydrilla (*Hydrilla verticillata)* dominated the Sydney Olympics 2000 lakes (presently, Sydney International Regatta Centre, SIRC), often growing to reach the upper layers of the water column. To achieve international rowing standards, the lakes require 3.5 m of macrophyte free-water from the surface, so that the rowers could move their oars through the water unobstructed. For many years, SIRC had been implementing aquatic plant harvesting to achieve the required macrophyte-free zones. However, mechanical harvesting has been labour intensive and expensive. Also, harvesting did not prevent the seasonal die off of Ribbonweed, or prevent large beds of Hydrilla from growing to nuisance levels, interfering with rowing events.

Prior to the Olympics 2000, SIRC had used the aquatic herbicide – Fluridone (Sonar®), under an off-label permit, to successfully control submerged, aquatic plants. In 2015, the excessive growth of particularly Hydrilla, reached proportions that could not be curtailed by mechanical harvesting alone. As Fluridone is yet to be registered in Australia, an off-label permit was again obtained from the Australian Pesticides and Veterinary Medicines Authority (APVMA) to use the herbicide. The approval included the implementation of a rigorous environmental and water quality monitoring program, prior to; during; and after the treatment.

The lake to be treated (Rowing Lake) was isolated from the Warm Up Lake, using baffles, and the Fluridone treatment was applied in September 2015 as a split-treatment. Following a first application of ~25 ppb, a second ‘boost’ application was made at 42 days after the first treatment (DAT). Post-treatment environmental monitoring indicated that the Fluridone treatments caused a large-scale collapse of the submerged plant beds within about 60-90 days, and by January 2016, underwater sampling and video-photography revealed a very high degree of control of both Hydrilla and Vallisneria in the Rowing Lake. Fluridone residue monitoring indicated that about half of the maximum dose recorded (~ 16 ppb) remained in the Rowing Lake between about 60 days and 105 DAT. Water quality monitoring through 2016-17 has not indicated any adverse impacts, and the lake has remained free of Hydrilla now for more than 18 months after treatment. Fluridone levels in the treated Lake decreased to nil or negligible levels by the end of about 10 months (318 DAT).

Keywords: Ribbonweed, Hydrilla, Fluridone, Sonar, aquatic plant harvesting

O-006

Translocation of ^{14}C-Endothall in Eurasian Watermilfoil, Curlyleaf Pondweed, and Two Hydrilla Biotypes

Cody J. Gray[1], Mirella Farinelli Ortiz[2], Scott Nissen[2]

[1] United Phosphorus, Inc., 11417 Cranston Drive, Peyton, CO 80831, USA
[2] Colorado State University, 1170 Campus Delivery, Fort Collins, CO 80523, USA

Endothall was first labeled for aquatic weed control in 1960, and the endothall label was expanded to include aquatic weed control in flowing water in 2009. Endothall is generally considered a contact herbicide; however, many field observations suggest that it could have systemic activity. We hypothesize that endothall can translocate in Eurasian watermilfoil (*Myriophyllum spicatum* L.) (EWM), curlyleaf pondweed (*Potamogeton crispus* L.) (CLP) and two hydrilla biotypes [*Hydrilla verticillata* (L.F.) Royle]. Each weed was clonally propagated from apical shoot cutting or turions (CLP). Plants with developed roots and 10 cm of shoot growth were transferred to test tubes containing fine, unwashed sand. A low melting point wax was used to seal each test tube to isolate the root system from the water column. Plants were then transferred to mesocosms filled with 3.5 L of dechlorinated tap water and allowed 48 hours to recover from transplanting. Mesocosms were then treated with 3 mg/L endothall as the dipotassium salt plus 66 KBq ^{14}C-endothall. Plants were exposed to the herbicide for 192 hours after treatment (HAT). At predetermined time points three plants of each species were harvested, divided into shoot and root tissue, dried at 60C for 48 hours, and oxidized. Radioactivity was determined by liquid scintillation spectroscopy. Data were subjected to non-linear regression to determine maximum absorption, absorption rate, and translocation. Hydrilla showed a linear increase in herbicide absorption, while herbicide absorption in EWM and CLP best fit a hyperbolic function. Translocation to EWM and CLP roots was limited, reaching a maximum translocation of 11% and 8% of total absorbed radioactivity, respectively. Monoecious and dioecious hydrilla showed a linear increase without reaching maximum absorption or translocation 192 HAT. The distribution of radioactivity was 72% shoot:28% root for monoecious hydrilla and 75% shoot:25% root for dioecious hydrilla. These data provide strong evidence that endothall is systemic and should be reclassified as a systemic aquatic herbicide.

O-007

Genetic and Morphological diversity of *Ludwigia sedioides* in Sri Lanka: A potential invasive aquatic plant

Dinusha Debarawatta[1], Kapila Yakandawala[1], Thilak Attanayaka[2]

[1]Department of Horticulture and Landscape Gardening, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila, (NWP), 60170, Sri Lanka
[2]Department of Biotechnology, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila, (NWP), 60170, Sri Lanka

Ludwigia sedioides (Humb. & Bonpl.) H. Hara is a popular ornamental aquatic plant used in aquatic landscapes. It is a perennial, herbaceous plant belonging to the family Onagraceae and native to Brazil and Venezuela. A recent study revealed that the plant has invaded water bodies of the Gampaha and Colombo Districts in Sri Lanka. Due to its rapid growth, efficient mode of reproduction and aggressive nature, it has been identified as potential invasive plant in Sri Lanka which could have a negative impact on agriculture, environment and recreational activities in water bodies of the wet zone in the future. The genetic diversity is a key factor for the survival of exotic plants in a non-native ecosystem. Therefore, this study was conducted with the objective of studying the genetic and morphological diversity of *L. sedioides* with the aim of providing information for management of this plant in future.

A total number of 20 samples of *L. sedioides*, from two invaded populations and two populations from ornamental plant nurseries (from Colombo and Kandy) were collected representing five genotypes from each accession. Random Amplified Polymorphic DNA (RAPD) makers were used to detect the genetic diversity of *L. sedioides.* Multivariate statistical analysis was carried out to evaluate the morphological variation among the *L. sedioides* present in Sri Lanka using PAST software.

The DNA extracted using modified CTAB method amplified with 10 random primers selected from 38 random primers resulted 33 polymorphic bands. The RAPDistance software package was used to analyze the data obtained and to construct the dendogram. As revealed by the distance matrix, the average genetic distance between all combinations of germplasm accessions was 0.09, indicating a close genetic relatedness among the genotypes.The morphological analysis also corroborates with the molecular data indicating a close similarity among the individuals. However, the analysis identified two main clusters each corresponding to the invaded and plant nursery populations, except one individual from the invaded population grouping with the individuals of the plant nursery populations. This suggests that the two populations, the invaded and the nursery populations might have originated from two different sources. The distances observed among each individual was less than 15 distance units revealing their close relatedness. Further, genetic similarity among the populations could be supported by the absence of evidences of sexual reproduction and the fact that this species was observed to be propagated through vegetative means. As there is still less genetic variation for the adaptive evolutionary changes required by the new selection pressures to take place, immediate actions should be implemented to control this plant before it spread into other areas.

This project was funded by a grant (SRHDC/RP/04/13-02) received from Wayamba University of Sri Lanka.

KEYWORDS: Alien Invasive Plants, Genetic diversity, *Ludwigia sedioides*, Morphometric Analysis, Random Amplified Polymorphic DNA

O-008

Studies on understanding the trends of invasive aquatic plant succession through inter-specific interactions among weeds

Writuparna Dutta, Parbani Chaudhury and Puja Ray

Multitrophic Interactions and Biocontrol Research Laboratory, Department of Life Sciences, Presidency University, 86/1, College Street, Kolkata-700073, India
email: d.writuparna@gmail.com

Bio-invasion of aquatic ecosystems by non-native weeds is an area of critical concern. Such invasions are influenced by complex interactions and control of one species results in dominance by another. Present study assesses the interspecific-interactions among different pairs of aquatic weeds, collected from the lentic water bodies situated in and around Kolkata, India. Competitive dominance between these invasive species were evaluated based on the percentage coverage, number of plants, biomass or production of daughter plants *in-vitro* depending on the species. *Potamogeton crispus* L. was dominated by both *Pistia stratiotes* L. and *Ceratophyllum demersum* L. Example of 'simple facilitation' was observed in *P. crispus*-*P. stratiotes* and *C. demersum* -*Hydrilla verticillata* (L.f.) Royle combinations, where one of the species dominated, when placed in combination with the other. While inter-specific competitive inhibition was seen between *Lemna minor* - *Spirodela polyrhiza* (L.) Schleid and *C. demersum* -*P. crispus* pairs, where growth of the dominant species was more in case of control than for the interaction. Presence of *Alternanthera philoxeroides* (Mart.) positively influenced the growth of *Eichhornia crassipes* (Mart.) Solms species in an aquatic ecosystem, where daughter plants produced by *E. crassipes* was about thrice in the controls and nearly twice in the combination set-ups as compared to *A. philoxeroides*. Comparative analysis of the diversity of the aquatic weeds with changing seasons showed that dominance or establishment got manifested in the form of allelopathic 'competitive inhibition' or through 'facilitation'. These interactions are often impacted by the nutrient conditions, presence and seasonal dynamics of natural control agents, phenotypic variations in the species population, etc. Elimination of a particular weed might make way for another one. Due to lack of such information, the spread of these invasive weeds get strengthened and the success of weed control is hardly predictable. Thus for effective ecosystem restoration and biodiversity renewal, understanding plant succession with the help of stronger projection models are essential through controlled and field studies.

O-009

Management of *Hydrocotyle ranunculoides* in the Canning River, Perth: An Options Review

Nimal Chandrasena[1], Peter Harper[2], Luke McMillan[3], Greer Gilroy[3], Brett Kuhlmann[4], Matt Grimbly[4] and Russell Gorton[5]

[1] GHD Pty Ltd., Level 2, 20, Smith Street, Parramatta, NSW, 2150, Australia

[2] Bettersafe Pest & Weed Management, 33, Lagonda Drive, Ingleburn, NSW 2565, Australia

[3] Perth NRM, 80 Great Northern Hwy, Middle Swan WA 6056, Australia

[4] South East Regional Centre for Urban Landcare (SERCUL), 69, Horley Road, Beckenham, WA 6107, Australia

[5] Wilson Wetlands Action Group Inc., 12 Hyland Way, Wilson, WA 6107, Australia

The first known infestations of *Hydrocotyle ranunculoides* (Floating pennywort) in Australia occurred in the Canning River in Perth, Western Australia (WA) in the early 1990s. Large infestations covered freshwater sections of the river, lagoons and wetlands and seriously affected recreational uses. These early infestations were successfully controlled, with multiple treatments of Round-up® glyphosate, the extensive use of which led to undesirable impacts on aquatic biota. This led to the registration of Bi-active® glyphosate, an environmentally-benign, glyphosate formulation, for aquatic use in Australia in 1996. The spread of Hydrocotyle remained contained over the next 10 years or so. However, large-scale re-infestation of a wider area occurred around 2008-10.

The main constraint to managing the Hydrocotyle, prior to recent Commonwealth funding, was inadequate coordination of control, across multiple land management boundaries. Although a stakeholder group ("Hydrocotyle Working Group") had been formed in the 1990s, its main focus in the initial period was research on the most appropriate control methods. Individual land managers implemented their own control with little coordination and funding for a holistic approach. Funding from the Australian Government enabled the Working Group to co-ordinate and implement the management of the entire infestation, across jurisdictional boundaries. At the same time, it removed the financial barrier for individual land managers to undertake the control of Hydrocotyle and other associated weeds, which harboured and enabled the continual re-infestation.

A recent review (2015) found that while the use of Metsulfuron, registered for this purpose, was an important component of the program. However, the herbicide alone would not have achieved the high level of control recorded. An integrated approach (i.e. combination of removing other associated weeds; cross-boundary coordination; herbicide treatments by specialist contractors; containment, manual removal; and monthly surveillance) has been successful, reducing the once large infestations to sporadic infestations. The review led to formulating a new Hydrocotyle Weed Management Plan (2016), which is currently being implemented with Commonwealth funding, aiming to reduce Hydrocotyle infestations to negligible levels. The lessons learnt in managing a difficult aquatic weed, through consultation and a community-led program, are presented, so that they can be replicated elsewhere.

Keywords: *Hydrocotyle ranunculoides*, Floating pennywort, metsulfuron, glyphosate, Canning River, Western Australia.

O-010

A preliminary work to control *Chimonobambusa quadrangularis*, an invasive alien plant species in Gunung Gede National Park, West Java.

Soekisman Tjitrosemito[1], Imam Mawardi[2], Syaiful Bachri[2], Setiabudi[2], Indah Wahyuni[2] and Sri Sudarmiyati Tjitrosoedirdjo[1]

[1]Affiliate Scientist, [2] Research Assistance, Research Laboratory of Weeds and Invasive Plant Species, BIOTROP, Jln Raya Tajur, Km 6, Bogor, West Java, Indonesia

Chimonobambusa quadrangularis was found as an invasive alien plant species obtaining the first priority to be eradicated. Therefore, an immediate control mean was experimented . Factorial design was applied consisting of stem cutting as the first factor at 2 levels, i.e. leaving one internode, and three internodes behind after cutting. The second factor were (1).brusing herbicides on the left stump with Triclopyr as GARLON at 10% solution in diesel oil after slashing , (2). letting the stump to grow for 2 months to produce leaves before sprayed with glyphosate at 6 lt ROUNDUP/ha in 400 lt of water/ha, (3). reslashing the regrowth at 2 month interval, and (4) leaving the cut stump uncontrolled. The brushing of stump with triclopyr at 10% Garlon diluted in diesel oil. The treatment combinations 2x4= 8 treatment combinations were replicated 3x randomised in block with plot measuring 2x3 m^2. The plots were relatively uniform having bambu shoot at 39 stems/plot. At 2 months after slashing the surviving number of *C.guadrangularis* decreased to 32.24 stem/plot and 24.8 stem/plot for three internodes and one internode left respectively, while the brushing of cut stump with triclopyr at 10% GARLON dissolved in diesel oil reduced the survival of cut stump into only 6.5 stump/plot irrespetive of the internode left. However 6 months after slashing the new growth of bambu reached a density similar to those before the experiment, although the impact of tryclopyr brushing was still conspicuous on the brushed stump. While the standing stems may be controlled the regrowth from rhizome was more than compensating for the reduction of standing stem, it is the main problem in controlling this invasive alien plant species.

O-011

Managing entry of noxious alien weeds in to Sri Lanka: Can DNA barcoding be an effective identification tool?

Nimanthika W. J., Harischandra, W. L. I. A
[1]National Plant Quarantine Service, Department of Agriculture, Sri Lanka

Some of the alien plant species may become invasive or agricultural weeds in the intriduced geographical region. Therefore, regulating such species is extremely important at the Plant Quarantine activities as the first step of designing appropriate risk management plan. However, when alien plants are introduced as seeds, their taxonomic identification is extremely challenging. This study aimed at evaluating DNA barcoding as a tool to identify alien plant seeds. DNA extraction was performed for the seeds of thirty different taxonomically known plant species detected in crop seed consignments imported to Sri Lanka. The study was performed in triplicate. Extracted DNA was multiplied and then sequenced with primers ITS2 and rbcL. CodonCode Aligner software was used for sequence editing. A cluster analysis was performed and a dendogram was developed to understand the level of species delimitation explained by DNA barcodes. Then the DNA sequences were compared with available DNA sequence databases to confirm their taxonomic identity. The dendogram clearly delimited thirty different species, even though it has not explained their taxonomic relationships. Further, the comparison of DNA with available databases has clarified the species taxonomy with highest comparability to the species used for the study except for six specimens out of the total of 90 specimens used. All the three specimens that are morphologically identified as *Euphobia dentata* were found to be 99% similar to *Euphorbia heterophylla* with the confirmation that the morphological identification was erroneous. The Species identified as *Cuscuta chinensis*, *Chenopodium album* and *Rumex crispu*s were found to have represented by a mixture of *Cuscuta chinensis* / *Cuscuta reflexa*, *Chenopodium album* / *Chenopodium capitatum* and *Rumex crispus* / *Rumex obtusifolius* consecutively.

O-012

What a changing climate may mean for an invasive giant, *Parthenium hysterophorus*?

Ali A Bajwa[1,2], Bhagirath S Chauhan[2], Steve Adkins[1,2]

[1]School of Agriculture and Food Sciences, The University of Queensland, Gatton, QLD 4343, Australia.
[2]The Centre for Plant Science, Queensland Alliance for Agriculture and Food Innovation, The University of Queensland, Gatton, QLD 4343, Australia.

Climate change has been suggested to be a major driver for range expansion of many invasive plant species mainly through increasing their growth, reproductive potential and dispersal ability. However, studies investigating the impact of climate change elements on the biological behavior of invasive weed species are lacking. The present study investigated the effect of two atmospheric carbon dioxide (CO_2) concentrations (ambient, 400 ppm and elevated, 700 ppm) and two soil moisture levels (100 and 50% of soil water holding capacity, WHC) on the growth and biomass production of two Australian parthenium weed biotypes (Clermont and Toogoolawah). The two biotypes chosen for this study are known to have contrasting invasion history, Clermont is highly invasive while Toogoolawah is non-invasive. The study was conducted in two identical controlled environment growth chambers operating at 25/15°C day/night temperatures, 12/12 hours photoperiod and a 50% relative humidity with continuous supply of the predetermined CO_2 levels. Clermont produced significantly more branches, leaves and flowers and attained greater height and biomass as compared with Toogoolawah across all the moisture and CO_2 levels applied, consistent with its high invasiveness. Elevated CO_2 significantly increased all these parameters for both biotypes at both moisture levels as compared with the ambient CO_2 treatment. A 50% WHC reduced the parthenium weed growth and biomass production as compared with the 100% WHC treatment. However, the extent of decline was significantly less for Clermont than for Toogoolawah, and at elevated CO_2 than at ambient CO_2. In conclusion, future projected levels of atmospheric CO_2 and increasing droughts may enhance the growing and dispersal ability of invasive parthenium weed biotypes in the sub-tropical and tropical environments of Australia and presumably in other locations around the world.

O-013

The impact of *Acacia* invasion on litterfall production in lowland tropical rain forests of Brunei Darussalam

Salwana Md Jaafar[1], Faizah Metali[1], David F. R. P. Burslem[2], Rahayu S. Sukri[1]

[1]Environmental & Life Sciences Programme, Faculty of Science, Universiti Brunei Darussalam, Jln Tungku Link, BE 1410, Brunei Darussalam
[2]College of Life Sciences & Medicine, School of Biological Sciences, Cruickshank Building, St Machar Drive, University of Aberdeen, AB24 3UU, Scotland.

Invasive plants from the genus *Acacia* are known to adversely impact biodiversity and ecosystems services, often resulting in landscape degradation and economic losses. Invasive *Acacia* species significantly impact nutrient cycling through their effects on litterfall production. Acacias were introduced into Brunei Darussalam in the 1990s as roadside vegetation and to supplement timber production, but soon become invasive in Brunei's coastal landscapes and disturbed forest areas. This study investigated the impact of invasive *Acacia* on litterfall production in Mixed Dipterocarp and heath forest habitats in Brunei Darussalam. We studied litterfall production in four contrasting habitats: primary and *Acacia*-invaded Mixed Dipterocarp forests, and primary and *Acacia*-invaded heath forests. Our results indicate that the presence of *Acacia* significantly increased litterfall production, particularly leaf fall production. Our findings highlight the negative influence of invasive *Acacia* species on litterfall production one of the most important processes in nutrient cycling. We suggest that the ability of Acacias to alter litterfall production in these lowland tropical forests may be crucial mechanisms that enable Acacias to establish and invade these ecosystems.

O-014

Invasive Alien Plants and Policy Needs in Turkey

Ahmet Uludağ[1,2]

[1]Faculty of Agriculture and Nature Sciences, Düzce University, Turkey
[2]Faculty of Agriculture, Canakkale Onsekiz Mart University, Turkey

Although benefits have been held from many alien plants as crops or ornamentals, few of them have become invasive in some introduced areas. However, this misleads many citizens and policy makers about impact of invasive alien plants (IAP) on biodiversity and ecosystem services. CBD being aware of impacts of IAP requires parties by 2020 that "IAS and pathways are identified and prioritized, priority species are controlled or eradicated and measures are in place to manage pathways to prevent their introduction and establishment". Many alien plants (AP) introduced to Turkey that have been known as invasive in other countries including Europe and Mediterranean Basin; but, no action has been taken to manage them including dedicated legislation. On the contrary, a group of scientists prepared a list of AP in Turkey and uploaded to GBIF website recently. This list includes 340 AP excluding crop and only-planted species, which is lower than many other countries. It is expected that the list can help to create awareness which may lead legislation or rules making; but, some further work is needed to convince administrates and policy makers. The first attempt should be assessing IAP in Turkey through risk analysis using the current list. It was found that the most AP in Turkey is native to Americas followed by Asian. The main pathway for AP is ornamental plants and only 28.1 % is introduced deliberately. It is speculated that increasing ornamental plant imports in the last decades could result in further IAP occurrence in Turkey. It is apparent that these new database can be used to develop management plans and create awareness but there is a need for further details including biology and ecology of AP as well as detailed distribution maps.

O-015

Medieval and modern volunteer vegetation shift in Jammu and Kashmir Himalayas

Anil Kumar[1], Jai Kumar[1], A.P.Singh[1], Lobzang Stanzen[2], Vikas Abrol[1] and Sapna Bhagat[3]

[1]Advanced Centre for Rainfed Agriculture, SKUAST-Jammu

[2] AICRP on Agrometeorology, SKUAST-Jammu

[3] Division of Agronomy, SKUAST-Jammu

The North-West Himalayan region of Jammu and Kashmir state lies between 32^{0}.17'' to 36^{0}.58'' North latitude and 73^{0}.26'' and 80^{0}.30'' East longitude. The high montane zone constituting the Kashmir Valley, Pir Panchal range and its off-shoots including Doda, Poonch and Rajouri districts and part of Kathua and Udhampur districts comprises of major area under scrutiny. The soils of Jammu & Kashmir are generally clayey illite type of clay mineral which are rich in K naturally. Invasive Alien Species (IAS) have been emerging as one of the major threats to native bio-diversity of the region. They are considered the second largest threat for global biodiversity loss after the habitat destruction. IAS are introduced from outside their natural range of distribution by either intentional or unintentional human activity, has established self-reproducing populations in the wild and have caused obvious changes in the local or natural ecosystems. The plant invasions started in J&K Himalayas dating back to 15^{th} century onwards from Central Asia which went on invading thereafter till the recent times. Total alien flora of the Kashmir Himalaya is represented by 571 plant species, belonging to 352 genera and 104 families. Families with largest number of alien representatives are *Poaceae* (60 species), *Asteraceae* (54 species) and *Brassicaceae* (30 species). Alien weeds in Himalayan region of Jammu and Kashmir are *Anthemis cotula, Centaurea calcitrapa, Conyza canadensis, Parthenium hysterophorus, Xanthium spinosum, Jacobaea vulgaris, Cirsium arvense, Adonis aestivalis, Malva neglecta, Plantago lanceolata, Oxalis stricta, Capsella bursa pastoris, Euphorbia helioscopia, Galium aparine, Medicago lupuilina, Rumex crispus, Chenopodium album.* Most of the alien plant species (38%) trace their origin to Europe, followed by Asia (27%) and Africa (15%) besides other continents of the world. A concerted effort is required to asses these invasions precisely in an endeavour to preserve our endemic biodiversity.

O-016

SCREENING MAIZE FOR COMPATIBILITY WITH F. OXYSPORUM TO ENHANCE *STRIGA ASIATICA* (L.) KUNTZE. RESISTANCE

Admire I.T. Shayanowako, Mark D. Laing, Hussein Shimelis

University of KwaZulu-Natal, African Centre for Crop Improvement, Pietermaritzburg, South Africa

Striga. asiatica is among the leading abiotic constraints to maize production under small-holder farming communities in southern Africa. Conventional breeding programmes have been progressing slowly due to the complex nature of the inheritance of *Striga* resistance, hence the need for more innovative approaches. This study aimed to achieve partial resistance as well as to breed for compatibility with *Fusarium oxysporum* fsp *strigae,* a soil fungus that is highly specific in its pathogenicity. Invitro assays and glasshouse pot trials were done to select genotypes based on their potential to stimulate germination of *Striga* and to test the efficacy of Fusarium oxysporum as a biocontrol agent. Results from agar gel assays showed a moderate to high potential in the release of Strigalactones among the 33 OPVs. Maximum *Striga* germination distances from the host root of 1.38 cm and up to 46% germination were observed in most of the populations. Considerable Resistance was observed in a landrace *'8lines'* which had the least *Striga* germination percentage (19%) with a maximum distance of 0.93 cm compared to the resistant check *Z-DPLO-DTC1* that had 23% germination at a distance of 1.4cm. The number of *fusarium* colony forming units significantly deferred ($P < 0.05$) amongst the genotypes growing between germination papers. Pot trials showed significant differences between the *fusarium* coated and the uncoated treatments in most agronomic and *Striga* traits. *Striga* emergence counts and *Striga* flowers were low in fusarium treated pots. Plants in *fusarium* treated pots had non-significant differences in height with the control treatment. This suggest that *foxy 2* absorbs the impact of *Striga* damage. Variability within fusarium treated genotypes with respect to traits under evaluation point out the varying degree of hospitality with the biocontrol. These differences were confirmed by 20 SSR DNA primers that showed an average polymorphic information content at 0.74.

Keywords: Maize, *Striga asiaitca*, resistance, compatibility, F. oxysporum

O-017

iTRAQ-based differential expression proteomics in roots of sunflowers differing in resistance to *Orobanche cumana*

Na Zhang[1] , Chong Yang[1], Ling Xu[1] , Xiaopeng Yun[2], Quanjiang Bai[2], Weijun Zhou[1]

1 Institute of Crop Science and Zhejiang Key Laboratory of Crop Germplasm, Zhejiang University, Hangzhou 310058, China

2 Institute of Plant Protection, Inner Mongolia Academy of Agricultural & Animal Husbandry Sciences, Hohhot 010000, China

Abstract: Sunflower is one of the most important cash crops worldwide. However, the emergence of*Orobanche cumana* in the field adversely affects the yield of sunflowers. In order to understand the resistance mechanisms underlying the interaction between sunflowers and *O. cumana*, we used iTRAQ-based proteomics to investigate the differentially expressed proteins in sunflowers exposed to *O. cumana*. Enrichment analysis showed that up-regulated pathway was associated with oxidative phosphorylation in resistant cultivar JY207 as compared to the susceptible cultivar TK0409, whereas down-regulated pathway was involved in biosynthesis of phenylpropanoids, valine, leucine and isoleucine degradation, citrate cycle, and pyruvate metabolism in susceptible cultivar as compared to the resistant cultivar. The resistance interaction was characterized by alteration of defense-related proteins mainly involved in recognition of parasites via PTI and/or ETI, accumulation of pathogenesis-related proteins, et al. In contrast, the susceptible interaction was characterized by down-regulation of proteins involved in biosynthesis and signaling of plant growth regulators including auxin, gibberellin, brassinosteroid and ethylene.

Key words: *Orobanche cumana*, parasitic weed, sunflower, iTRAQ, resistant, susceptible

O-018

INVENTARITATION OF WEEDS IN SWEET CORN (*Zea mays* L Saccarata Strurt) AT **DIFFERENT** FIELDS CONDITITION

Uum Umiyati[1)] , and Denny Kurniadie[1)]

Department of Agronomy, Agriculture faculty, Unpad, West Java, Indonesia

Umiyati.crb@gmail.com

[1] *Agriculture faculty,* University of Padjadjaran , *West Java, Indonesia.*

Keywords : Sweet corn, weeds dominance , inventaritation.

Sweet corn can be in cultivation on the highlands and lowlands. Now sweet corn planted on the rice fields after rice cultivation. Shallot crops affect the composition of the Weeds. The composition of the weeds on crops monocultures in a long time indicates the composition is lower than with the planting pattern rotation. The planting pattern changes also change the composition of the dominant type of weeds, from the types of weeds-leaf replaced by weeds the grass. This weed community differences were suspected because of the difference in the processing of land, distance planting, the age of the plants when observation and the condition of land used. Sweet corn cultivation land weed in dry land came from twenty-seven species weeds comprising seventeen species of broad-leaved weeds, seven species of weeds grasses and three species of sedgess. There are seven dominant weed i.e. *Amarantus d, Axonopus compressus, Cynodon dactylon, Digitaria c, Echinochloa colona, Euphorbia hirta, Lindernia*. On land the cultivation of sweet corn in the wetland there is twenty one of a species weed by which consist of thirteen species of broad-leaved weeds, grass weed species and six species of weeds sedges. There are six *Cynodon dactylon* as dominant weed, *Digitaria c, Eleusine indica, Fimbristylis m, Leptocloa sinensis, Portulaca. Digitaria* species sp is found in all regions of observation.

O-019

Weed diversity is comparable in Bt-transgenic and conventional cotton fields

Yongbo LIU[1]

[1]State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of Environmental Sciences, Beijing 100012, China

Do the cultivation of genetically modified (GM) crops affect weed biodiversity? Insect-resistant transgenic cotton expressing *Bacillus thuringiensis* (Bt cotton) has been cultivated for two decades in China. We conducted a field investigation at twenty-seven sites and a research base in northern China to detect the diversity of weeds and insects in cotton fields. Comparative study showed that weed diversity was not significantly different between Bt and non-Bt cotton fields. The long-term cultivation of Bt cotton decreased the species number and diversity of insects, and the leaf damages of broadleaf weeds as well as neighbor sweet potato and peanuts. Similarly, the diversity of neighbor crops and the abundance of weeds reduced the leaf damage of cotton. Our study highlights that the ecological interactions of insects and weeds might determine the fate of transgenic crops and the sustainable development of agriculture.

Key words: Biosafety assessment; weed biodiversity; Genetically modified crops; leaf damage.

O-020

Hyperaccumulator identification from weed species and its phytoremediation potential in Cd contaminated field

Shuhe Wei [1,*] Huiping Dai [2]

[1] Key Laboratory of Pollution Ecology and Environment Engineering, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110016, P.R. China

[2] Shaanxi Province Key Laboratory of Bio-resources, Shaanxi Sci-Tech University, Hanzhong 723001, P.R.China

Abstract

Phytoremediation is a promising technology for remedying contaminated soils by heavy metals. As two important mechanisms of phytoremediation, phytoextraction can permanently remove heavy metals from polluted site mainly using hyperaccumulators. Phytostabilization can reduce ecological risk of wind and water erosion of heavy metals, in particular, safely gain agricultural products (without heavy metal pollution) through planting excluder crops in polluted soil. However, seldom hyperaccumulators and excluder crops were found till now. In this study, pot culture, small scale experiment, sample analyzing experiment in polluted site and pilot experiment were used to identify hyperaccumulative plant and excluder crop and to explore remediative mechanisms and strengthening measurements. 66 weed species in 22 families were tested to identify Cd, Pb, Cu and Zn hyperaccumulator. After that, 50 cultivars of rice were determined the potential to Cd accumulation. We also tested the effection of some chelators and fertilizers on these remediative plants phytoremediating Cd contaminated soil.

The main results include:

1). 4 characteristics that critical concentration, translation, tolerance and accumulation coefficient are indispensable properties of hyperaccumulators and hyperaccumulator can also be found in unpolluted site;

2). *Solanum nigrum* L., *Rorippa globosa* (Turcz.) Thell. and *Bidens pilosa* L. (3 weed plants) were Cd hyperaccumulators with higher remediation potential;

3). Shendao 4 is Cd excluder rice which can be safely. Co-planting hyperaccumulator and low accumulation crop experiments in contaminated soils were completed and gained good results.

4). Though some chaletors can significantly improve phytoextraction efficiency, the adoption of modernization agriculture technology will be a short cut to the commercial apply of phytoremediation to heavy metals.

Key words: phytoextraction; hyperaccumulator; excluder crop; safe production

Acknowledgements

This work was supported by the Special Plan in the Major Research & Development of the 13rd Five-Year Plan of China (Grant No. 2016YFD0800802) and the National Natural Science Foundation of China (41571300, 31270540 and 31070455).

O-021

Management of southern blight of bell pepper by soil amendment with dry biomass of *Datura metel*

*Arshad Javaid, Nadia Jabeen and Amna Shoaib

Institute of Agricultural Sciences, University of the Punjab, Lahore, Pakistan.
*Email: arshad.iags@pu.edu.pk, arshadjpk@yahoo.com

Southern blight of bell pepper (*Capsicum annuum* L.) is caused by a notorious soil-borne fungal plant pathogen *Sclerotium rolfsii* Sacc. It is a serious disease that causes significant yield losses in bell pepper annually. A pot experiment was carried out for the management of this disease using dry biomass of *Datura metel,* a weed of family Solanaceae having medicinal properties. Soil was amended with 0.5, 1.0, … , 3.0% dry biomass of *D. metel* with and without inoculation of *S. rolfsii*. The highest disease incidence (100%) was recorded in positive control where soil was inoculated with *S. rolfsii* without any soil amendment. Disease was completely controlled by 2% soil amendment. This soil amendment treatment enhanced bell pepper yield by 30% over negative control (without any inoculation or amendment) and 136% over positive control. Activities of defence related enzymes namely polyphenol oxidase (PPO), peroxidase (PO) and phenylalanine ammonia lyase (PAL) were significantly increased in positive control which became lowered significantly due to soil amendment with *D. metel*. Bioassays guided fraction showed that chloroform sub-fraction of methanolic extract of *D. metel* was the best in controlling *in vitro* growth of the pathogen. GC-MS analysis of this sub-fraction revealed the presence of 18 compounds among which 1,2-benzenedicarboxylic acid, bis (2-methylpropyl) ester was the most abundant (26.60%) followed by 1-hexacosanol (10.31%), 1-octadecene (8.57%), 2-methyl- 3 phenyl- 2-propenal (6.99%) and 1-eicosanol (5.44%).

O-022

Competitiveness of two broad-leaf weeds: sesbania pea (*Sesbania cannabina*) and bladder ketmia (*Hibiscus trionum*) in mungbean (*Vigna radiata*).

Sudheesh Manalil[1,2] and Bhagirath Singh Chauhan[1]

[1]The Centre for Plant Science, Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, Gatton, Queensland 4343, Australia.
[2]Amrita University, Coimbatore, India.

Mungbean (*Vigna radiata*) is one of the major summer crops grown in Queensland and New South Wales in Australia. As a crop of 3-4 months duration, mungbean could fit very well in a wide planting window from late September to late February in Australia. At present, around 95% of the crop produce is exported to Asian countries. Weed management is one of the major production constraints, especially emerging broad-leaf weeds offer great difficulties compared to grass weeds. In a study, the competitiveness of *Sesbania cannabina* (sesbania pea) and *Hibiscus trionum* (bladder ketmia) was evaluated in a mungbean (*cv*. Jade-AU) crop at the University of Queensland research station at Gatton in October 2016. The experiment was conducted in a randomised block design with three replications. Four levels of weed densities were established: control, low, medium and high. The average grain yields were 1808 and 1818 kg ha^{-1} in the control plots of *S. cannabina* and *H. trionum*, respectively. Compared to the control plots (no weed), there was 29, 48 and 61% yield loss at low (8 plants m^{-2}), medium (15 plants m^{-2}) and high (26 plants m^{-2}) densities of *S. cannabina*, respectively. The yield loss was 22, 55 and 65% from *H. trionum* at low (12 plants m^{-2}), medium (30 plants m^{-2}), and high (48 plants m^{-2}) densities, respectively. The weed competition led to a reduction in the number of pods per unit area and the number of grains per pod. Based on the exponential regression model, a density of 21 and 33 plants m^{-2} of *S. cannabina* and *H. trionum*, respectively, was sufficient to cause a yield reduction of 50%. The study indicates the superior competitiveness of two rapidly emerging weeds in the mungbean cropping systems and demand for proactive management strategies to reduce the emergence of these weeds.

O-023

An Ecological Genetics Study on Seed Overwintering in Weedy Rice

Muhamad Shakirin Mispan[1], Jiuhuan Feng[2], Xing-You Gu[2]

[1] Institute of Biological Sciences, Faculty of Science, University Malaya, Kuala Lumpur, Malaysia.
[2] Agronomy, Horticulture, and Plant Science Department, South Dakota State University, Brookings, 57007, USA.

Weed seeds, usually dormant upon maturation, may survive in soil seedbanks for months to years, depending on genotypes and environmental conditions in agroecosystems. This research used conspecific weedy and cultivated rice (*Oryza sativa* L.) as a model to elucidate ecological genetics mechanisms underlying seed longevity in croplands. A population of 150 recombinant inbred lines (RILs) from a cultivated/weedy rice cross were evaluated for seed survivability both on soil surface and in burial (20 cm deep) in a rice field on Southeast Missouri Rice Research Farm for an period from October to the next April. A wide range of genotypic variation for seed survivability (evaluated by % germination) on soil surface and in burial was observed, with heritability estimates being 0.76 and 0.84, respectively. The burial enhanced seed survivability by 18.8% on average. Seed survivability under the surface and burial conditions was correlated with each other (r=0.37), and also correlated with primary dormancy (r=-0.23 for the burial) and the pericarp color (r=0.12 & 0.21), plant height (r=0.13 & 0.17) and flowering time (r=0.15 & 0.30) traits. A total of five quantitative trait loci were associated with seed overwintering under the soil surface (2) or the burial (3) conditions, including one collocated with the pleiotropic gene for both seed dormancy (*qSD7-1*) and red pericarp color (*Rc*). This research demonstrated that there are functionally differentiated genes controlling the natural variation in seedbank longevity, and some of these genes are also involved in the development of primary dormancy.

Keywords: weedy rice, seed overwintering, seed dormancy, quantitative trait locus, recombinant inbred lines.

O-024

Genetic diversity and population differentiation of weedy red rice in Japan

Toshiyuki Imaizumi[1], Kaworu Ebana[1], Maiko Akasaka[1], Ayumi Deguchi[2,3], Atsushi J. Nagano[2] and Hiroyuki Kobayashi[1]

[1]NARO, Japan; [2]Ryukoku University, Japan; [3]Chiba University, Japan

Until the 1970’s, weedy red rice was occasionally found in Japanese rice fields. The widespread use of mechanical transplanting and pre-emergent herbicides effectively managed weedy red rice, causing it to have negligible impact on rice fields. However, weedy rice has reappeared in recent years. As shifting from transplanted to direct-seeded rice has been considered the main cause of the emergence of weedy rice, but only few studies have been investigated the relationship between this shift and weedy rice emergence. Additionally, knowledge of the genetic relationships among weedy rice populations in Japan is still limited. In this study, we interviewed farmers to obtain the methods of planting rice (transplanting or direct seeding) in fields infested with weedy rice. We also investigated the population structure of weedy rice using whole genome sequencing and restriction-site associated DNA sequencing. We found no relationship between the rice planting method and weedy rice emergence. In fact, rice was produced using only the transplanting system in most of the fields infested with weedy rice. Further, we found that the weedy rice population structure in Japan was divided into three major groups. These three groups were not closely related to the cultivated rice variety widely grown in Japan.

O-025

Innovative solution for the management of weedy rice and other weeds in wet-direct seeded rice systems

Virender Kumar[1], Jhoana Opeña[1], Katherine Valencia[1], Ofelia Namuco[1], Teodoro Migo[1], Shalabh Dixit[1], and David E. Johnson[1]

[1] International Rice Research Institute, Los Baños, Philippines

The increased use of direct-seeded rice (DSR) has led to greater weed infestation. Further, weedy rice has emerged as a serious threat to rice production in countries such as Malaysia, Sri Lanka, Thailand, Vietnam, Philippines, and Indonesia in areas where DSR has been widely adopted. In this study, we examined the interaction of early flooding and pre-emergence (PRE) herbicide using rice cultivar tolerant to anaerobic germination (AG) conditions during germination and early emergence stage as a possible means to suppress weedy rice and other weeds in wet-DSR. Field and screenhouse experiments were conducted during 2016-17. The field experiment was consisted of flooding depths (0, 2, 4, and 6-cm flood depth) as main plot, and sub-plots were doses of PRE herbicide (pretilachlor with safener; 0, ¼ X, ½ X, and 1X rate of recommended). Pre-germinated seeds of IR-64+AG1 (IR-64 with AG) were sown. The PRE herbicide was applied 24-h after rice sowing and different flooding depths were established 24-h after herbicide application. In screenhouse experiment, a factorial study was conducted with factor 1 as flooding depth (no flooding, 2-cm and 4-cm), factor 2 as PRE herbicide (pretilachlor with safener) dose (0 and ½ X rate of recommended), and factor 3 as time of flood establishment (12, 24, 48, and 72-h after PRE herbicide application). Pre-germinated seeds of rice cultivars Ciherang + Sub1 and Ciherang + Sub1+ AG1 were sown in puddled soil in plastic trays along with two weedy rice biotype viz. BVR (Bicol weedy rice from the Philippines) and VWR (Vietnam weedy rice). PRE-herbicide was applied 24-hr after sowing and flooding was established 12, 24, 48, and 72-h after herbicide application. In both studies, establishment and biomass of crop and weeds were estimated at 21 DAS. Field results showed that rice establishment of IR64+AG1 under 2- and 4-cm flood depth was similar to non-flooded control. Herbicide application also had no significant effect on rice establishment. However, weed seedling emergence was reduced by 40, 60 and 80% due to flooding alone with 2, 4 and 6-cm flooding depth, respectively, compared to non-flooded control. Shallow flooding (2-cm) combined with lower dose of herbicide (1/4 X rate) reduced weed seedling density and biomass by 98-99% compared to the control of no flooding and without herbicide. In the screenhouse experiment, flooding alone was not effective in suppressing weedy rice either BWR or VWR. Emergence of BWR and VWR however was reduced by 80-90% when flooding (established within 48-h of PRE herbicide application) was combined with a low dose (1/2 X rate) of herbicide. When flooding was delayed by 72-h after herbicide application, suppression was reduced by 50-72%. These results suggest that AG tolerant rice could enables early flooding in wet-DSR and therefore early shallow flooding in combination with PRE herbicide can be utilized for weed control including weedy rice.

O-026

Weedy rice management strategies in transplanted aromatic rice in sub-tropical North-Western Himalayas of India

Anil Kumar[1], Jai Kumar[1], R. Puniya[2], B. R. Bazaya[2] and Susheel Rattan[3]

[1]Advanced Centre for Rainfed Agriculture, SKUAST-Jammu
[2] AICRP-Weed Management, SKUAST-Jammu
[3]Department of Agriculture, Jammu

Weedy rice has posed a tremendous threat to rice farming owing to its morphological similarity to rice plant and has a high competitive potential to threaten yield sustainability of rice-based production systems. Multipronged strategies need to be integrated to discourage weedy rice infestations. In the famous Basmati rice belt of R.S Pura area of Jammu district with typical sub-tropical Himalayan foot hill climate of Jammu and Kashmir State, weedy rice has been found to severely infest the transplanted aromatic rice leading to heavy losses in crop yield where five strains of weedy rice were reported from the domain area. An experiment entitled "Effect of different weedy rice management strategies on weedy rice dynamics and crop productivity" was conducted in weedy rice fraught fields during *Kharif* 2015 and 2016 to identify the appropriate management options. Other weed species which were found to infest the crop were *Echinocloa crusgalli, Cynodon dactylon, Cyperus rotundus, Cyperus defformis, Cyperus iria, Scirpus roylie, Caesulia axillaris* and *Alternanthera philoxeroides.* Weedy rice density as well as weedy rice biomass/m^2 was found to be lowest in the treatments involving stale seed-bed with herbicides (Glyphosate 1.5 kg/ha and Paraquat 0.8 kg/ha). Weedy rice density as well as weedy rice biomass/m^2 was statistically at par in recommended practice (Butachlor 1.5 kg/ha) and weedy check, however, density and biomass of other weeds was significantly lower in the recommended practice. All the weed management treatments recorded significantly higher grain yield of rice as compared to weedy check and recommended practice. The stale seed-bed technique along with subsequent use of Glyphosate 1.5 kg/ha and Paraquat 0.8 kg/ha prior to transplanting was found to be most effective in controlling weedy rice infestations in transplanted rice besides enhancing the crop productivity in the domain area.

O-027

Weedy rice: A threat to rice cultivation in Sri Lanka

A.S.K Abeysekara, H.M.S.D. Kulatunga, D.D Witharana and W.M.U.B Wickrama

Rice Research and Development Institute, Bathalagoda, Sri Lanka

Weedy rice (WR) is made up of the undesirable biotypes of rice which are morphologically similar to cultivated rice. It has been a significant phenomenon ever since broadcast sowing became popular a few decades back. Currently it is a major issue in rice cultivation. WR, reported Sri Lanka 1990s, Efforts were made over the last decade to understand morphological and physiological properties to develop control methods and disseminate such to the farmers for immediate action to prevent further spread. Some of the distinct features are; diverse grain color; shape, presence of awn; leaf color and angle and panicle characters. WR collected from different locations showed some features specific to the location. More than 3,000 WR types collected so far, agro-morphological features of 1,800 WR types were evaluated. WR has well developed roots system as compared to cultivated types indicating in support of their high competitive nature. The seed of WR has a high dormancy period and a lengthy viability under submerged conditions in rice soils as compared to cultivars. This feature facilitates WR to develop a seed bank in paddy soil. WR has various biological properties, for instance more than 30%WR types tested found to possess resistance to brown plant hopper. The package developed for control found satisfactory in controlling. It included; use of uncontaminated seed paddy, burning of straw soon after harvesting to encourage dormant weedy rice to germinate, proper land preparation, use of pre-plant herbicides, use of row seeding, water seeding or parachute method or transplanting instead of direct seeding, rouging of WR plants, application of glufosinate ammonium for wiping of WR panicles at heading and use of crop rotation. Currently >95% farmers were aware of WR threat and negative effects on the yield but still they reluctant to remove it from their field.

O-028

Spatial Distribution Pattern of Weedy Rice (*Oryza sativa* L.) in Two Rice Granaries in Peninsular Malaysia

Muhamad Shakirin Mispan, Fazrul Rahman Yatim, Intan Filzah Mahmod

Institute of Biological Sciences, University of Malaya, 50603 Kuala Lumpur, Malaysia

Weedy rice (*Oryza sativa* L.) is one of the notorious weeds in Malaysia rice agro-ecosystems. This study examines the spatial distribution patterns of weedy rice in two rice granaries in Peninsular Malaysia. A series of field surveys was conducted at two and five farm blocks in IADA Barat Laut Selangor (IBLS) and IADA Seberang Perai Selatan (ISPS) rice granaries, respectively to evaluate distribution pattern and quantitative indices. ISPS displayed significantly higher weedy rice infestation rate than IBLS based on dominance (ISPS= 61.8% ± 9.4; IBLS= 37.4% ± 14.5) and relative abundance (ISPS= 7.4 ± 1.6; IBLS= 4.1 ± 2.5). In ISPS, weedy rice dominance ranged from 44% to 71% with Sungai Tok Tuntung (ST) farm block recorded the highest (71% ± 14.83). Relative abundance of weedy rice in Tanjung Beremban (TB) farm block (5.54) and ST (4.62) were significantly higher than other farm blocks in ISPS. In IBLS, Sungai Besar (SB) farm block (47% ± 24.8) recorded more dominant weedy rice infestation as compared to Sawah Sempadan (SS) farm block (29% ± 20.3). However, relative abundance of weedy rice in SS and SB was not significantly different indicating the similar population density and infestation rate of weedy rice in both farm blocks. Majority of rice field plots in all farm blocks in both rice granaries registered clustered and under-dispersed spatial distribution patterns of weedy rice based on variance-to-mean-ratio (VMR) and Lloyd’s patchiness index. This clustered distribution indicates that weedy rice problems in IBLS and ISPS were probably caused by seed contaminant and/or weedy rice seedbank persistence.

O-029

Herbicide-Resistant Crops: A Quarter Century Journey from Dominance to Diminished Utility to Diversified Weed Management Practices

Krishna N. Reddy

United States Department of Agriculture, Agricultural Research Service, Crop Production Systems Research Unit, Stoneville, Mississippi, USA

A quarter century journey of herbicide-resistant (HR) crop technology has been characterized by a remarkable adoption (dominance), unsustainable over-reliance (diminished utility), and renewed conservation (diversified weed control tactics). HR crops, predominantly glyphosate-resistant (GR) crops (canola, corn, cotton, soybean) have been widely grown in several countries where adopted, since the mid-1990s. GR crops represent a revolutionary breakthrough in weed control technology and was a blessing for growers as it provided simple, flexible, effective, and economical weed management options. Although bromxynil-resistant canola and cotton (since discontinued) and glufosinate-resistant (canola, corn, cotton, soybean) crops were available, GR crops dominated the modern cropping systems. Glyphosate provides effective control of a broad-spectrum of weeds and was often only herbicide used for managing weeds in GR crops. Glyphosate has become a victim of its own success – used too often on same area with no diversity in weed management. Over-reliance on glyphosate and a lack of diversity in weed control tactics have increased selection pressure that led to the evolution of GR weeds and weed shifts toward difficult-to-control weeds. As of April 2017, 37 weed species have developed resistance to glyphosate globally. Evolution of weeds resistant to glyphosate has diminished its utility considerably. Efficacy of glyphosate continues to decline as more weeds develop resistance. The next generation of multiple HR crops that combine glyphosate resistance with resistance to other herbicides has been pursued vigorously by several agrochemical industries. These stacked-trait crops will provide new options with existing herbicides, but will not be the total weed management solution because several weeds have already evolved resistance to these herbicides. HR crop technology alone cannot provide total weed control and must be integrated with other control methods (cultural, mechanical, and chemical, and biological where available) to increase the diversity of weed control tactics. The future weed management tactics look a lot more like the ones used in the past i.e., the pre-HR crop era. GR weeds are not yet a problem in many parts of the world, especially where GR crops are not commercialized, lessons can be learnt to take proactive actions to conserve the sustainability of glyphosate.

O-030

SUSTAINABILITY OF THE CLEARFIELD® PRODUCTION SYSTEM FOR RICE IN MALAYSIA

Azmi, M[1]., George, T.V[1]., Alex, T[1]., Kevin, C[1], Dilipkumar., M.[2] and Weston, B.[4]

[1]BASF (Malaysia) Sdn Bhd. 2, Jalan Astaka U8/U7, Seksyen U8, Bukit Jelutong, 40706 Shah Alam, Malaysia
[2]Rice Research Centre, MARDI Seberang Perai, 13200 Kepala Batas, Penang, Malaysia.
BASF SE, Speyerer Strasse 2, 67117 Limburgerhof, Germany. *Email; azmibinman@gmail.com*

Two locally developed Imidazolinone tolerant rice varieties (MR 220CL1 and MR 220CL2) were officially launched in July 2010 in Malaysia as the Clearfield Production System. This is the outcome of collaborative work initiated in 2003 between the Malaysian Agricultural Research and Development Institute (MARDI) and BASF. Clearfield Production System combines high yielding MARDI rice varieties containing a non-GM Imidazolinone tolerance trait together with BASF Imidazolinone herbicides specifically formulated for Malaysian rice production practices. The use of the Clearfield Production System has greatly benefited farmers, implementers and the rice industry in Malaysia by providing an effective management tool for weedy rice, substantially reducing the cost of weed management in rice cultivation and controlling weedy rice with a single Imidazolinone (OnDuty WG) application. By utilizing proper agricultural procedures and practices, such as those stated in the Clearfield Production System stewardship guidelines, the occurrence of resistance weedy rice biotypes can be minimized.

O-031

Fifteen years of Clearfield ™ Rice in Brazil: What we have learned

Luis Avila[1], Aldo Merotto Jr.[2], Edinalvo Camargo[3]

[1] Universidade Federal de Pelotas, Pelotas, RS, Brazil
[2] Universidade Federal do Rio Grande do Sul, RS, Brazil

The Clearfield rice (CL) system was launched in 2003 in Brazil as a tool for weedy rice management. This system includes the use of a tolerant cultivar with the application of imidazolinone herbicides. The main problems associated with the CL technology were the evolution of weedy rice resistant to imidazolinone herbicides originated by gene flow from the herbicide resistant rice cultivars and the carryover effect of imidazolines to susceptible crops. In addition, the over use of these compounds contribute for the evolution of herbicide resistance in barnyardgrass and other weeds. The benefits of the CL technology are related with the weedy rice control and also by providing better opportunities for seeding in the most adequate period and better use of nitrogen by the cultivated rice. These benefits associated with other chances in crop management adopted in southern Brazil provided increasing of rice grain yield from the historical 5.000 $kg.ha^{-1}$ to 7.500 $kg.ha^{-1}$. Nowadays the sustainability CL technology is achieved by crop rotation with soybean, which requires a well-planned drainage of the fields and fallow in some areas. In addition, is important to follow a strict program based on minimum tillage, non-selective herbicides applied at pre-sowing or just prior to emergence (spiking stage) aim to eliminate the maximum amount of weedy rice and other weeds, use of certified seeds, full label rates of imidazolinone herbicides at PRE followed by POST application and complementary weedy rice management practices such as rouging of uncontrolled plants. In our talk we will discuss the basis for the sustainability of CL technology based on the experience we have had in Brazil.

O-032

Learning About the Provisia® Rice Technology

Nilda Roma-Burgos[1], Christopher E. Rouse[1], Vijay Singh[1,2]

[1]University of Arkansas, Fayetteville, AR 72704, USA

[2] Current address: Texas A&M University, College Station, TX 77843-2474, USA

Weedy rice was a problem with no in-crop chemical weed control solution until Clearfield® rice was developed. Clearfield® rice has resistance to acetolactate synthase (ALS) inhibitors attained via mutation breeding hence, is non-GMO. Fifteen years since its commercialization, it is still viable in the US although herbicide-resistant (HR) weedy rice outcrosses commonly occur in fields with a history of Clearfield® rice. Farmers following the stewardship recommendations manage the technology well and Clearfield® rice fields are still among the cleanest in the US mid-south. Provisia® rice, also non-GMO, with resistance to acetyl coenzyme-A carboxylase (ACCase) inhibitors will be commercialized in 2018 to complement Clearfield® rice in managing weedy rice as well as HR weedy outcrosses and volunteer plants from Clearfield® varieties. Weedy rice and *Echinochloa* spp. show differential tolerance to Provisia® herbicide (quizalofop-P-ethyl). At 120 g/ha, up to 25% weedy rice could survive from any one population, but a sequential application of 120 g ha^{-1} quizalofop overcomes this problem. Cyhalofop-tolerant *Echinochloa* could not be controlled with a single application. Saturated soil around application time increases herbicide activity. Studies across the US mid-south showed that some rice herbicides (i.e. bispyribac-sodium, penoxsulam, propanil, quinclorac, thiobencarb) could antagonize the activity of quizalofop. Antagonism would show on difficult-to-control grasses, within about 10-80% reduction in efficacy. Rotations with glyphosate-resistant soybean, Clearfield® rice, and (if possible) fallow could result in zero weedy rice infestation in four years. Provisia® rice technology allows farmers to plant more rice in the rotation, but must be used with other management tools.

O-033

Provisia™ Rice System: Efficacy, Stewardship and Potential

S. Luke Mankin [1], Sudakir Sudakir [2], S. Tan [1], Brigitte Weston [3]*, Zuhair Zainal Abidin [4]

[1] BASF Corporation, Research Triangle Park NC, United States
[2] BASF Indonesia, Jakarta, Indonesia
[3] BASF SE, Limburgerhof, Germany
[4] BASF Malaysia, Kuala Lumpur, Malaysia

The Provisia™ Rice System is a new, conventionally bred, non-GM herbicide-tolerance system under development by BASF. Provisia rice will complement the existing Clearfield® Rice System by providing growers another effective tool for weedy rice, grass control and resistance management in rice. The system combines Provisia traited rice with the quizalofop-P-ethyl based Provisia™ Herbicide. In field trials conducted from 2013 through 2016, Provisia rice exhibited excellent tolerance to single and sequential applications of Provisia Herbicide. Provisia Herbicide will provide post-emergence control of non-Provisia rice [red rice, volunteer conventional rice (Oryza sativa), hybrid rice and Clearfield rice types] and other common annual and perennial grasses, including barnyard grass (Echinochloa crus-galli). Research indicates that Provisia herbicide when tank mixed with other rice herbicides provided control of broadleaf and annual grass weeds. The Provisia Rice System used in conjunction with the Clearfield Rice System, as part of an integrated weed management plan, offers growers a sustainable management program for weedy and volunteer rice types.

O-034

Evaluation of herbicide tolerant transgenic corn hybrids in India

Satbir Singh Punia

Department of Agronomy,
CCS Haryana Agricultural University, Hisar 125 004, INDIA

Corn (*Zea mays* L.) is one of the most versatile crops having wider adaptability under varied agro-climatic conditions. Wide spacing and slow initial growth of corn favours the growth of weeds even before crop emergence. Magnitude of yield loss in corn, range from 30 to 50 per cent depending upon the growth and persistence of weed population in standing crop. The introduction of glyphosate-resistant crops has created new opportunities for the use of effective, non-selective herbicide like glyphosate for selective weed control. To study the weed control efficacy of transgenic herbicide tolerant corn hybrids viz. 900M Gold and Hishell (event NK 603) with application of Roundup® formulation (MON 76366), present study was carried out at Agronomy Farm, CCS Haryana Agricultural University, Hisar. Roundup® at 900 and 1800 g ae/ha provided effective control of sedges, grassy and broadleaf weeds as compared to university recommended practice and unsprayed control. Roundup® at 900 and 1800 g ae/ha was safe to both the transgenic hybrids *viz*. 900M Gold and Hishell. Transgenic hybrid Hishell + Roundup® at 1800 g ae/ ha yielded highest (10.23 t/ha) corn grain yield and it was at par with Hishell + Roundup® at 900 g ae/ha, 900M Gold at 900 and 1800 g ae/ha of Roundup® Both, transgenic corn hybrids yielded at par their conventional counterparts at university recommended practices. The national check (Pro Agro 4640) control recorded the lowest (7.07 t/ha) corn grain yield. It can be concluded that the cultivation of herbicide tolerant transgenic corn and spraying with Roundup® can act as an effective way to control weeds, thereby increasing the benefit to cost ratio in favour of corn growers in India.

O-035

Physical and genetic exploration for effective biocontrol agents of the climbing fern *Lygodium microphyllum*: progress, problems, potential

Jeff Makinson[1], Graham McCulloch[2], Ryan Zonneveld[1], Ellen Lake[3]
[1] ABCL, CSIRO Health & Biosecurity
[2] University of Queensland
[3] IPRL, USDA ARS

Lygodium microphyllum is a climbing fern native to the tropical and subtropical regions of the Old World: Australasia, Asia and Africa where it is common in forest understories and riparian zones. In Japan it is known only from the Ryukyu Islands (Nansei shotō).

The invasive *L. microphyllum* has spread rapidly since it was first recorded in Florida in 1958 and is considered to have become naturalised by 1965. It is one of the worst weeds in Florida and is listed on the US Federal Noxious Weed list. It inhabits wetland and mesic habitats in peninsular Florida and creates a dense mat of live and dead fern fronds. The prolific growth rapidly shades or smothers the underlying vegetation including tall trees, promoting fire in plant canopies, changing fire regimes, altering the habitat structure and reducing the native plant diversity. Biological control is considered to be the best solution for controlling this weed.

Many ferns are known to have few herbivores; ABCL has found only about 40 herbivore species in 10 countries over 20 years of research. The majority of these species are generalists, leaving only 18 candidates that have so far required any assessment as potential biocontrol agents. The history of biocontrol efforts on *L. microphyllum* is summarised, explaining some problems associated with finding specific and impactful agents. An integrated approach of genetics and field research can maximise the chances of successful, sustainable control. The need to examine possible cryptic species or population level differences through genetics and comparative testing is critical to our research.

O-036

Biological control of prickly acacia (*Vachellia nilotica* subsp. *indica*) in Australia: prospective agents from Ethiopia and Senegal

Kunjithapatham Dhileepan[1], Boyang Shi[1], Jason Callander[1], Mindaye Teshome[2], Stefan Neser[3], Nathalie Diagne[4] and Anthony King[5]

[1] Biosecurity Queensland, Department of Agriculture and Fisheries, Ecosciences Precinct, Boggo Road, Queensland, Australia

[2] Central Ethiopia Environment and Forest Research Center, Addis Ababa, Ethiopia

[3] Forestry and Agricultural Biotechnology Institute, University of Pretoria, Pretoria, South Africa

[4] Senegalese Institute of Agricultural Research, National Centre for Agronomic Research, Bambey, Senegal

[5] Agricultural Research Council, Plant Protection Research Institute, Pretoria, South Africa

Abstract: Prickly acacia (*Vachellia nilotica* subsp. *indica*) is a serious weed of grazing areas in western Queensland and has the potential to spread throughout northern Australia. Biological control is the most economically viable management option for prickly acacia. Biological control efforts so far have focused on agents from Pakistan, Kenya, South Africa and India, with limited success to date. Hence, search for new biological control agents was redirected to Ethiopia and Senegal with *V. nilotica* subspecies with moniliform fruits, similar to subsp. *indica*. Surveys conducted in Ethiopia (July 2014, December 2015 and November 2016) and in Senegal (March 2017) identified natural populations of *V. nilotica* in the Oromia, Amhara and Afar regions in Ethiopia (subsp. *indica*, subsp. *tomentosa* and subsp. *leiocarpa*), and in the Kaolack and in the Senegal River Valley regions in Senegal (subsp. *tomentosa* and subsp. *adstringens*). In Ethiopia, a gall thrips (*Acaciothrips ebneri*) inducing shoot-tip rosette galls, a gall midge (*Lopesia niloticae*) inducing leaf rachis galls, and three morphologically distinct eriophyid gall mites (*Aceria* sp.): type-1 forming red, spherical leaflet galls; type-2 forming creamy-white fluted leaflet galls; and type-3 deforming leaflets, rachides and shoot-tips were prioritised as prospective biological control agents. In Senegal, in addition to the gall thrips, a morphologically different eriophyid gall mite (*Aceria* sp.) (type-4 deforming emerging leaflets and rachides) and a yet to be identified tephritid inducing stem galls were identified as prospective biological control agents. Based on damage potential, field host range, geographic range and climate match, the gall thrips from Ethiopia was imported into high-security quarantine in Brisbane, Australia and host specificity tests are in progress. The type-3 eriophyid gall mite from Ethiopia has been imported into quarantine in Pretoria, South Africa for colony establishment and host specificity testing. Future native range surveys will focus on subsp. *nilotica* with moniliform fruits in climatically suitable areas in Egypt.

O-037

The development of biological control of C*hromolaena odorata,* a common invasive alien species in the Southeast Asian region

S. Tjitrosemito[1*], I. Mawardi[2], S. Bachri[2],Setiabudi[2], Sri S.Tjitrosoedirdjo[1], and I. Wahyuni[2]

[1]*Affiliate Scientist,* [2] *Research Assistance, Research Laboratory of Weeds and Invasive Plant Species, BIOTROP, Jln Raya Tajur, Km 6, Bogor, West Java, Indonesia*

An experiment on the classical biological control of *C.odorata* using its bioagent, *C. connexa* was carried out at BIOTROP, West Java, in a confined area under the shade of oil palm trees from March to November 2016. The experimental design was factorial, the first factor was *C. odorata* shoot tips density consisting of 3 levels, i.e., 5, 10 and 20, shoot/ cage, and the second factor was with release and without release of 5 pairs of *C.connexa* imago to the caged *C.odorata*. There were 6 treatment combinations, replicated 4x., and randomised completely. In March 2016, 24 plastic pots of 5 lt capacity were filled with local soil fertilized with composted goat manure at 1:1 ratio, and planted with 3 cut stem of *C.odorata* . In June, the potted *C.odorata* were selected and trimmed to have the required density and put in a cage measuring 50 x 50 cm with the height of 150 cm. The cages were made of wooden frame with plastic net of 1 x 1 mm mesh covering the whole sides to prevent parasites from entering the cage, and there were a total of 24 cages. In June 4, 5 pairs of *C.connexa* imago were released to the apropriate cages. The imago were generated strictly by screening the imago against hyperparasites. The release of *C.connexa* imago induced the production of higher vegetative shoot tips on higher initial shoot tip density. The release also induced the production of galls, however the release reduced the production of flower heads, especially after the second generation of *C.connexa*. The release of *C.connexa* require 2.5 months to generate the second generation. In that period a considerable new vegetative shoot tips were produced. It was suggested to release the imago every 3 weeks for the first 2,5 months. It is not really classical but more of inundative biological control.

O-038

An emerging success story of a seed-attacking weevil *Cissoanthonomus tuberculipennis* Hustache (Coleoptera: Curculionidae) released against balloon vine *Cardiospermum grandiflorum* Sw. (Sapindaceae) in South Africa

David O. Simelane and Khethani V. Mawela

Simelaned@arc.agric.za

Agricultural Research Council-Plant Protection Research Institute, Private Bag X134, Queenswood, 0121 South Africa

Evaluation of weed biocontrol success not only provides better justification for biocontrol funding but also informs the agent selection process for subsequent projects. Based on a series of field and laboratory studies, a seed-feeding weevil *Cissoanthonomus tuberculipennis* Hustache (Coleoptera: Curculionidae) was found to be suitable for release against balloon vine in South Africa, and approval for its release was granted in 2013. This study assessed the establishment, impact and dispersal of the weevil *C. tuberculipennis* on *C. grandiflorum* at 16 selected sites in KwaZulu-Natal (KZN), Limpopo, Gauteng, Mpumalanga, North West and Eastern Cape Provinces of South Africa. A three-year monitoring conducted since the release of *C. tuberculipennis* shows that establishment and dispersal of the beetle has been rapid, and that infestation levels have been increasing at almost all the study sites. To determine the percentage of *C. grandiflorum* seeds predated upon by *C. tuberculipennis* per site, a sample 50 fruits, each containing a maximum of three seeds, were inspected to quantify the proportion of seeds damaged by the weevil. By the year 2017, 50% of the seeds had been destroyed by *C. tuberculipennis* at KZN, Mpumalanga and Eastern Cape sites, and the weevil had dispersed at a rate of 33 to 37km/year along the same region. Furthermore, the effect of seed damage by *C. tuberculipennis* on soil seed bank, seed rain, inflorescence and pod densities at various sites are some of the measures of biocontrol success being assessed. Preliminary data show reductions in seed bank densities and seedling recruitment at some sites where *C. tuberculipennis* has established. The invasiveness of balloon vine *C. grandiflorum* can be attributed to its prolific seed production, and therefore any natural enemy which impacts directly on the plant's fecundity would be of great benefit for the long-term management and containment of this weed.

O-039

Biological control programs of the invasive weeds in the Mariana Islands

Gadi V. P. Reddy and R. Muniappan
[1]Western Triangle Ag Research Center, Montana State University, 9546 Old Shelby Rd., P. O. Box 656, Conrad, MT 59425, USA
Email: reddy@montana.edu

[2]IPM Innovation Lab, Office of International Research, Education & Development
The International Affairs Offices (IAO), Virginia Tech, 526 Prices Fork Road, Blacksburg, VA 24061, USA, Email: rmuni@vt.edu

Invasive plant species are one of the most serious threats to biodiversity and sustainable development in the Mariana Islands. Biological control has proven to be effective in managing some of the perennial weeds. *Lantana camara* (Verbenaceae) was one of the plants documented as an invasive weed by the Invertebrate Consultants Committee for the Pacific of the National Research Council and its natural enemies were introduced from Hawaii starting in 1948. The Siam weed, *Chromolaena odorata* (Asteraceae) was targeted for biological control in 1983, ivy gourd, *Coccinia grandis* (Cucurbitaceae) in 2002, *Mimosa diplotricha* (Mimosaceae) in 2008, and *Micania micrantha* (Asteraceae) in 2011.

.

The biological control programs have provided satisfactory (*C. coccinia* and *C. odorata*) to adequate (*L. camara*) control of a few invasive weeds in the Western Pacific. However, biological control agents introduced for *M. micrantha* and *M. diplotricha* have either not established or not effective and hence additional efforts for their establishment and spread are required.

O-040

The adventive pathogen *Cercosporella dolichandrae* and its impact on the biological control of cat's claw creeper, *Dolichandra unguis-cati*, in South Africa

Anthony M. King[1]

[1] Agricultural Research Council, Plant Protection Research, Private Bag X134, Queenswood, Pretoria, 0121, South Africa

Dolichandra unguis-cati (L.) L.G. Lohmann is an exotic, evergreen vine that has become a significant threat to biodiversity in a variety of sensitive ecosystems in South Africa. Owing to its growth habit, as well as the difficulties and prohibitive costs associated with mechanical and chemical controls, biological control is considered the only practical and sustainable means of managing the weed. A biological control programme was initiated against *D. unguis-cati* in 1996, which has seen the testing and release of five arthropod natural enemies into South Africa. The establishment and effectiveness of these insects has been variable but some successes have been achieved. In 2012, the leaf-spot pathogen, *Cercosporella dolichandrae* Crous & den Breeÿen, began to appear at an increasing number of infestations across the country. Infection results in the development of necrotic spots, and shortly thereafter, the premature abscission of infected leaves. To evaluate the pathogen's impact, as well as possible effects this defoliation might have on previously established biocontrol agents, infected *D. unguis-cati* was monitored at four field sites for three annual growth seasons. Image analysis software was used to quantify seasonal leaf coverage and insect feeding along a 30m permanent transect established at each locality. Extensive and repeated defoliation caused by *C. dolichandrae* infection was recorded at all study sites, in some instances approaching 100%. Although regrowth of *D. unguis-cati* was noted both at the start, and during each growth season, new leaves were quickly infected resulting in sustained leafless periods. Proliferation of secondary understory vegetation and declines of resident natural enemy populations were also observed in conjunction with these abnormally high rates of defoliation. *Cercosporella dolichandrae* appears to be extremely virulent and is capable of spreading rapidly through large infestations. Consequently, despite potential negative effects on already established biocontrol agents, it is expected to make a valuable contribution to the management of cat's claw creeper in South Africa. *Cercosporella dolichandrae* should be prioritised in biological control programmes against *D. unguis-cati* elsewhere in the world.

O-041

Prioritizing weeds as targets for biological control: a consultative and transparent framework for investing limited resources for weed management

S. Raghu[1] and Louise Morin[2]

1. CSIRO Health & Biosecurity, Brisbane, Australia
2. CSIRO Health & Biosecurity, Canberra, Australia

Invasive weeds represent significant threats and costs to production (rangelands, croplands) and natural landscapes. Classical biological control programs can yield substantial benefits in the management of invasive weeds and historical programs have high benefit-cost ratios. However, these programs are typically long-term investments with significant up-front costs to develop safe agents, the efficacy of which can be uncertain. Given that resources to manage weeds in any jurisdiction are often limited, there is a need to better prioritize weed targets for biological control to facilitate their management in the most cost-effective manner possible. To improve on previous prioritization processes developed and applied for weed classical biological control, we propose a two-stage, structured framework that achieves this in a consultative and transparent manner. The first stage elicits, captures and characterizes the relative importance of a weed, its impacts and desirable management goals. This stage captures the knowledge of weed scientists and land managers to ensure that those investigating and managing impacts on the ground arrive at a list of weeds for which biological control may be desirable. The second stage subsequently assesses the feasibility of biological control and the likelihood of achieving the desired management goals for these weeds. This stage takes advantage of the collective experience of biological control scientists and practitioners to classify the prospects of biological control contributing to successfully achieving the management goals. Using an example from our recent work undertaken on prioritizing weeds of both natural and agricultural systems in the USA, we illustrate the strengths and utility of this approach.

O-042

Biological control of invasive weeds – a potential weed management strategy for Japan

Daisuke Kurose, Marion K. Seier

CABI, Bakeham Lane, Egham, TW20 9TY, UK

The negative impact of invasive alien weeds on ecosystems, local economies and livelihoods as well as on human and animal health has been well documented around the globe. Mechanical and/or chemical control of these invasives is often not feasible due to cost, available labour and safety reasons. Classical biological control using damaging, highly specific natural enemies from the native range of a plant species for control in its introduced invasive range can offer an environmentally benign, cost effective and sustainable alternative with a proven track record for safety.

The National Institute for Environmental Studies lists alien plant species recognized as invasive in Japan. A number of these are regulated by the Invasive Alien Species Act which prohibits their import and distribution. Although successful classical biocontrol programmes have been implemented against some of these listed species in other countries, this control strategy has as yet not been applied in Japan. However, Japan developed the first bacterial biopesticide (Camperico™) based on a native strain of *Xanthomonas campestris* var. *poae* for use against *Poa annua* in turf grass and more research has been conducted to develop mycoherbicides against other native noxious weeds. Japan has also been the source of biocontrol agents such as the sap-sucking psyllid, *Aphalara itadori*, released as a classical biocontrol agent against the invasive Japanese knotweed (*Fallopia japonica*) in the UK and Canada, and the leaf-spot fungus *Mycosphaerella polygoni-cuspidati* currently under evaluation as a potential mycoherbicide for this weed in its introduced range. Another biocontrol programme running with Japanese involvement is targeting Japanese honeysuckle (*Lonicera japonica*) in New Zealand.

This paper discusses the potential for biological control of invasive weeds in Japan and highlights opportunities for research into classical biocontrol of Japanese native plant species which have become invasive in other parts of the world.

O-043

[Title]

Biological control of parthenium weed (*Parthenium hysterophorus* L.) in China: opportunities from Australia

[Authors]

Boyang Shi[1] and Kunjithapatham Dhileepan[1]

[Affiliation]

1. Biosecurity Queensland, Department of Agriculture and Fisheries, Ecosciences Precinct, Brisbane, Queensland 4001, Australia

[Abstract]

Parthenium weed (*Parthenium hysterophorus* L., Asteraceae) is an invasive weed of global significance and has come to dominate rangelands in a wide range of regions around the world, especially within Eastern and Southern Asia, Eastern and Southern Africa, Australia and the Pacific. Parthenium weed continues to invade new countries that have a suitable climate to support its growth, then spreads rapidly causing serious impacts on rangeland livestock production, crop production, human and animal health, and biodiversity. For example, in China, it causes a wide range of harmful effects, including traffic obstruction, reduced crop production and dermatitis and respiratory illness in people. However, government and farmers paid little attention to control this weed which allowed it to spread. Biological control is one of the most effective approaches for parthenium weed management in order to minimize their economic and environmental impacts. Since there are not many people investigating biological control agents among South and South East Asian countries, some collaborative projects could be developed between China and Australia. In China, *Epiblema strenuana* was introduced from Australia to China in 1990 for management of ragweed (*Ambrosia artemisiifolia* and *Ambrosia trifida*) and now *E. strenuana* is also found on parthenium weed. In Australia, nine insects and two rust pathogens have been released as biological control agents for parthenium weed, and the majority of them have become established and are proving effective in its control. Hence, there is an opportunity to introduce additional agents like the seed-feeding weevil (*Smicronyx lutulentus*), the stem-boring weevil (*Listronotus setosipennis*), the root-feeding moth (*Carmenta ithacae*), the winter rust (*Puccinia abrupta* var. *partheniicola*) and summer rust (*Puccinia xanthii* var. *parthenii-hysterophorae*) from Australia into China, to implement more effective biological control of parthenium weed in China.

O-044

Enhancing mycoherbicidal potential by combination treatment of fungi for biological control of waterhyacinth

Puja Ray[1], Sushilkumar[2] and Akhilesh Kumar Pandey[3]

[1]Multitrophic Interactions and Biocontrol Laboratory, Department of Life Sciences, Presidency University, 86/1 College Street, Kolkata-700073, India

[2] Directorate of Weed Research, Jabalpur, Maharajpur, Adhartal, Jabalpur (M.P.)- 482004, India

[3]Mycological Research Laboratory, Dept. of Biological Science, R.D. University, Jabalpur (M.P.) India

Waterhyacinth, *Eichhornia crassipes* (Martius) Solms., is ranked as one of the most troublesome aquatic weed in the tropical and subtropical regions of the world. The menace caused by waterhyacinth in various parts of the world is well documented. Various control measures employed have proved futile. In such a situation integrated management with biological control as key component has been considered as one of the most eco-friendly options to control waterhyacinth. During periodical survey of various water bodies in Jabalpur (M.P.), several phytopathogens were isolated and purified from diseased plant-parts of waterhyacinth. Among these, *Alternaria alternata* induced maximum disease. *Fusarium pallidoroseum*, *Curvularia lunata* and *Alternaria eichhorniae* also incited appreciable disease. Compatibility and damage potential of *A. alternata* in combination with other three phytopathogens were determined by growing in Richard's media plates. A separate set containing only single pathogen in each plate was taken as control. The plates were incubated at 25^{0}C for 21 days. Observations were made for radial mycelial growth, sporulation and formation of inhibition zone. All the experiments were done in triplicates. It was observed that all the pathogens were compatible to *A. alternata* except *A. eichhorniae.* Radial growth and sporulation was equally good and comparable to the control plates. The combined effect of various pathogens was more than tested alone. The triple combination of *A. alternata* + *C. lunata* + *F. pallidoroseum* resulted in maximum disease development followed by *A. alternata* + *C. lunata*. *A. alternata* + *F. pallidoroseum* combination and *C. lunata* + *F. pallidoroseum* combinations gave similar results. It was concluded that better control of the weed can be achieved by using combination of pathogens instead of alone use.

O-045

Genetic variation for tolerance to defoliation in *Cirsium arvense*

M.G. Cripps[1], C. A. Dowsett[2], S. D. Jackman[1], A. D. L. Noble[1], G. J. Houliston[3]

[1]AgResearch, Lincoln, Private Bag 4749, Christchurch 8140, New Zealand

[2]AgResearch, Ruakura Research Centre, Private Bag 3123, Hamilton 3240, New Zealand

[3]Landcare Research, Gerald St, Lincoln 7608, New Zealand

The pasture weed, *Cirsium arvense* (Californian thistle, Canada thistle, creeping thistle), is notorious for its ability to tolerate defoliation by herbivores, mowing, or herbicides, which is facilitated by the growth of adventitious shoots from its extensive clonal underground root system. In an outdoor potted plant experiment we examined the tolerance of 36 unique genotypes of *C. arvense* to defoliation by establishing pairs of clonal replicates that were assigned to a clipped, or unclipped treatment. Three clipping treatments were applied from spring to early summer (22 October, 19 November, and 15 December 2015). The final height, number of shoots, and biomass, were measured at the end of the growing season (from 18 February to 4 March) to compare the fitness between the clipped and unclipped clones of the genotypes. The majority of genotypes were negatively affected by the clipping treatment and showed a reduction in most final fitness measurements. However, some genotypes were equivalent or even greater than their unclipped counterparts indicating a large genetic range for tolerance to defoliation. The mean range in tolerance ratios (clipped/unclipped) was 0.17 to 1.3 for shoot height, 0.26 to 1.2 for shoot density, and 0.6 to 1.2 for biomass (where a ratio of 1 indicates equivalence to the unclipped state). Since repeated defoliation is recommended as a control technique for this weed, selection for more tolerant genotypes is possible, and should be taken into account for the management of this weed. This will be discussed in relation to the effectiveness of biocontrol insects against this weed.

O-046

Fungi species infesting weed species of lentil in Diyarbakır province, Turkey

Cumali Özaslan

Department of Plant Protection, Dicle University, Diyarbakır, 21280, Turkey

This study was performed to observe the fungi species infesting weed species of lentil crop in Diyarbakır province, Turkey. Periodic surveys were conducted during lentil growing season of 2016-17. A total of 76 fields were surveyed and 43 different fungi species were observed on 55 different weed species. Some of the fungi observed were; *Albugo candida* (Pers.) Roussel, *Alternaria alternata* (Fr.) Keissler, *Blumeria graminis* (DC.) Speer, *Botrytis cinerea* Fr., *Cercospora centaurea* Died, *Cercospora sorokinii* Sacc., *Cladosporium epiphyllum* (Pers.) Nees, *Coleroa circinans* (Fr.) G. Winter, *Erysiphe convolvuli* DC., *E. cruciferarum* Opiz Ex L. Junell, *Fusarium* sp., *Golovinomyces cichoracearum* (DC.) V.P. Heluta, *Leveillula taurica* (Lév.) G. Arnaud, *Melampsora gelmii* Bress., *Myrothecium* sp., *Peronospora aparines* (de Bary) Gäum., *Peronospora arborescens* (Berk.) D. Bary, *Peronospora cephalariae* Vincens, *Peronospora dianthi* de Bary, *Peronospora lallemantiae* Kolymb., *Peronospora lamii* A. Praum., *P. narbonensis* Gäum., *P. parasitica* (Pers.) Fr**.,** *Peronospora sisymbrii-officinalis* Gäum., *Peronospora trifolii-pratensis* A. Gust, *Podosphaera dipsacacearum* (Tul. & C. Tul.) U. Braun & S. Takam., *Podosphaera ferruginea* (Schltdl.) U. Braun & S. Takam., *Puccinia bromina* Eriks, *P. calcitrapae* DC., *P. cirsii* Lasch., *Puccinia crepidicola* Syd., *Puccinia dioicae* var. *opizii* (Bubák) U. Braun, *Puccinia falcaria* (Pers.) Fuckel, *P. isiacae* (Thüm) Winter in Kuntze, *P. malvacearum* Mont., *P. montana* Fuckel, *Puccinia* sp., *Pyrenophora chaetomioides* Speg., *Ramularia centaureae* Lindr., *Ulocladium* sp., *Uromyces gypsophilae* Cooke, *Uromyces haussknechtii* Tranz. and *Ustilago cynodontis* (Pass.) Henn. on the weed species. Three microfungi species viz., *P. chaetomioides*, *C. sorokinii* and *P. cephalariae* were detected on host species i.e., *A. sterilis*, *C. arvensis* and *C. syriaca*. These three fungi were most commonly observed in the lentil crop. The observed fungi species could be potential biological control agent of respective weed species, however thourough investigations are needed in this regard.

Key words: Fungi, biological control, lentil, weed, Diyarbakir, Turkey

The current study was supported by Dicle University, Coordinator of Scientific Research Projects (DUBAP) with a project number ZIRAAT.17.008

O-047

Non-chemical weed management technique for rice

[1]Eagan Somasundaram, [2]Bhavaji Gudi Shoba Rathod and [1]D. Udhaya Nandhini
[1]Department of Sustainable Organic Agriculture, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India
[2]Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India

Rice (*Oryza sativa* L.) is a major crop in the world and India has tremendous potential to export organic rice to the international market. Domestic demand for organically rice grown is also gaining momentum. Identifying an effective non-chemical weed management technique for rice is the demand driven need and hence the present study was conducted in rice at wetland farms of Tamil Nadu Agricultural University, Coimbatore during 2014-15. The field experiment was laid out in randomized block design and replicated thrice. The treatments comprised of ten different weed management practices *viz*., Application of paddy straw @ 3 t ha^{-1} on 3 DAT + Hand weeding on 35 DAT (T_1), Azolla as dual crop with rice and incorporation on 35 DAT using power weeder (T_2), Hand weeding twice on 15 DAT and 35 DAT (T_3), Cono weeder 3 times on 20, 30, 40 DAT (T_4), Mulching with biodegradable polyethelene sheet (T_5), Intercropping mesta (*Hibiscus cannabinus*) with rice as paired row and harvested as greens (T_6), Intercropping dhaincha (*Sesbania aculeata*) with rice as paired row cropping and incorporation on 35 DAT (T_7), Application of rice bran followed by 2 t ha^{-1} on 3 DAT + Hand weeding on 35 DAT (T_8), Hand weeding on 15 DAT followed by azolla inoculation on the same day (T_9), Unweeded check (T_{10}). Among the treatments, application of rice bran @ 2 t ha^{-1} on 3 DAT followed by hand weeding on 35 DAT reduced the weed density and weed dry weight. The higher grain (5557 kg ha^{-1}) and straw yield (7207 kg ha^{-1}) of rice were obtained by mulching using biodegradable polyethelene sheet. Rice bran application effectively suppressed major paddy weeds and also increased the grain yield of rice. Therefore, this practice would be incorporated as an integral part of organic rice farming.

O-048

Utilization of *Chromoleana odorata* integrated with water irrigation on weed control, rice growth and yield

Nawapon Pimtong[1], Udomporn Pangnakorn[1] and Thanatchasanha Poonpaiboonpipattana[1]

[1]Department of Agricultural Science, Faculty of Agriculture, Natural Resources and Environment, Naresuan University, Phitsanulok, Thailand, 65000

The utilization of allelopathic plant residues integrated with water irrigation was a new strategic for weed control in directed wet seed on rice cultivation. This idea was applied residues together with water irrigation on a paddy field at 7 – 10 days after rice seed emergence. *Chromolaena odorata* L. is a perennial weed which generally distributed in every area in Thailand. It was reported on allelopathic property. This research was aimed to examine *C. odorata* dried leaf integrated with water irrigation on weed control and rice growth in pot and field condition. Dried leaf of *C. odorata* at the rates of 400, 800 and 1,200 kg/hectare reduced barnyardgrass by 40%, 90% and 100% respectively in pot condition, while the growth of rice seedling did not affect. Another field experiment with the same treatments showed that *C. odorata* can reduced paddy weeds by 60%, 75% and 90% respectively. The rice yield increased by 15%, 20% and 30% respectively when compared with unweeded and non-significance when compared with chemical control. This result suggested that the application of allelopathic residues integrated with water irrigation was a new strategic for sustainable weed control in paddy field.

O-049

Effect of *Biden pilosa* L. Integrated with Water Logging on Changes of Water and Soil Properties, and Its Physiological Mechanisms to Control Barnyardgrass

Saiwaree Poolkum[1], Wipa Homhaul[1], Udomporn Pangnakorn[1] and Thanatchasanha Poonpaiboonpipattana[1]

[1]Department of Agricultural Science, Faculty of Agriculture, Natural Resources and Environment, Naresuan University, Phitsanulok, Thailand, 65000

The utilization of allelopathic plant residues integrated with water irrigation was a new strategic for weed control in directed wet seed on rice cultivation. This idea was applied residues together with water irrigation on a paddy field at 7 – 10 days after rice seed emergence. The waterlogging condition where the most of weed species were flooded under water caused reducing on weed growth, while rice seedlings was not affected. *Biden pilosa* L. var. *radiata* interestingly represented reducing on paddy weeds by this strategic. However, the mechanisms of this strategic was unclear. Thus, this research aimed to investigate effects of *B. pilosa* integrated with waterlogging on changes of water and soil properties and its physiological mechanisms on barnyardgrass. Fresh *B. pilosa* was applied to the waterlogging condition under pot scale. Dissolved oxygen and pH in the water rapidly reduced 12 h after application. They slowly increased since 4 days after application until normal condition. The electrical conductivity (EC) value, total phenolic and flavonoid contents significantly increased after application and decreased on 7 days after application. The leaves of barnyardgrass with waterlogging integrated with *B. pilosa* extract showed increasing on the EC value and malondialdehyde content which caused lipid peroxidation and cell membranes disrupt. The chlorophyll and carotenoid content in the leaves were reduced which suggested destroying on the photosynthetic.

O-050

Evaluating of bio efficacy of the aqueous solution of *Mechalia champaca* seeds in controlling common weeds in agricultural lands.

P. K. M. Deepani, K.G. Prematilake*, A G A W Alakolanga

Department of Export Agriculture, Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka, Badulla (90 000), Sri Lanka.

The use of herbicides has been restricted in Sri Lanka concerning the hazardous effects to the environment and health of people. Hence, tea growers have been compelled to move towards manual, cultural and biological means of weed management. Some plant parts such as roots, seeds, leaves, flowers are known to be released chemical compounds with allelopathic, potentials which cause to kill or suppress the growth of some weed species. Preliminary investigations showed that the seed extract of *Michelia champaca* L. [Local name: Ginisapu] has some ability to suppress weed growth. Hence, a study was conducted to evaluate the bio-efficacy of different concentrations of aqueous solution of *M. champaca* seeds and, the effect of three types of additives against centrifuging to minimize the adhesiveness of aqueous solution. Seeds were thoroughly ground with water and supernatant was filtered. Each aqueous solution incorporated with an additive or centrifuged solution was sprayed to more tender weeds in the field. Bio assays were also undertaken to ascertain the most promising concentration of aqueous solution and the rate of centrifuge. Finally, the bio-efficacy of 30% and 40% of centrifuged aqueous solutions were evaluated along with two herbicides under field conditions. Visual injury symptoms in weeds, partially and totally dead weed percentages were evaluated and weed dry was measured three weeks after application (WAA). The best performance in weed control occurring 50-60% death at three WAA was reported by 40% aqueous solution, which was subjected to centrifuge at 1000 rpm for 20 minutes. Aqueous solution of *Michelia champaca* L. seeds could thus be exploited as a source of natural herbicides.

Key word: *Michelia champaca* Seeds, Allelopathy, Adhesiveness, Natural herbicides.

O-051

Altering arbuscular mycorrhizal native density has effects on weed suppression in wheat fields

Muhammad Akbar[1]*, Muhammad Sajjad Iqbal[1], Tayyaba Khalil[1], Aqeel Ahmad[2]

[1]Department of Botany, University of Gujrat, Gujrat, 50700, Pakistan.
[2]Institute of Agricultural Sciences, University of the Punjab, Lahore, 54000, Pakistan.

Use of mycorrhizae in weed management programs is relatively new and has not been widely studied. The idea behind this phenomenon is that different plants respond differently to different mycorrhizal fungi. Also invasive weed species are less adapted to response indigenous mycorrhizal fungi as compared to local crop plants. So by disturbing the native mycorrhizal fungal species density may profit crop plant as compared to invasive weed species. So inclusion of mycorrhizae in weed management under field conditions will be a first attempt under field conditions. Suppressive effects of different mycorrhizal species were initially assessed under pot conditions involving one dicot. (*Rumex dentatus* L.) and one monocot. (*Avena sativa* L.) weed and wheat crop. Pot experiments indicated positive weed suppressive effect involving different combination of mycorrhizal species on the growth of *R. dentatus* weed while no negative effects were observed in case of *A. sativa* and wheat. There was significant decrease in infection process of mycorrhizae in *R. dentatus* that resulted in poor growth of *R. dentatus*. So this weed was selected to investigate the effects in the presence of wheat crop under field conditions. In field experiments, combination involving increased density of *Glomus intraradices* resulted in better weed control as compared to *Acaulospora laevis* and *Ambispora fennica* while there was no negative effect on wheat in all treatments. There was 78% reduction in weed biomass where density of *Glomus intraradices* was increased and 59% 57% reduction in weed biomass where *Acaulospora laevis* and *Ambispora fennica* were utilized.

O-052

Natural Herbicides from Essential Oils: Prospects and Constraints

Daizy R. Batish[1], Shalinder Kaur[1]

[1]Department of Botany, Panjab University, Chandigarh-160014, India

Unlike synthetic herbicides, use of natural plant products provides an environment-friendly and safer method of weed control. Besides, these are generally non-toxic and exhibit chemical and structural diversity and possess novel target sites. These also help in finding novel and useful scaffoldings for the development of new herbicides using cheminformatics and synthetic techniques. The studies have shown that essential oils of plants like *Eucalyptus* species, *Callistemon viminalis, Tagetes minuta*, *Artemisia scoparia,* and *Anisomeles indica* are promising source of bioherbicides. These help in effectively controlling noxious weeds of paddy crop like *Echinochloa crus-galli* and *Cyperus rotundus* and that of wheat crop like *Phalaris minor*. Application of these essential oils at ecologically relevant concentrations provides a practical solution for the weed control without affecting the growth and yield of crops. These not only reduced weed emergence but also had a detrimental effect on their growth with signs of visible injury. At higher concentrations, these even caused weed mortality. Their effect can be comparable to synthetic herbicides. Moreover, their effect on weeds can further be improved by adding adjuvant or surfactants and their solutions/formulations with other natural products. However, there are certain constraints such as their economic viability and commercialization, which can be overcome by conducting suitable focused studies. The present paper discusses various issues related to the use of essential oils as herbicides.

O-053

Competition and Allelopathic potential of *Cyperus rotundus* L. on Sweet corn

Panwaree Uchaiya[1], Surasak Thongmuang[1] and Thanatchasanha Poonpaiboonpipattana[1]

[1]Department of Agricultural Science, Faculty of Agriculture, Natural Resources and Environment, Naresuan University, Phitsanulok, Thailand, 65000

Purple nutsedge (*Cyperus rotundus* L.) is a noxious weed and distribute throughout the tropic and sub-tropic of the world. It is difficult to control and eradication. Purple nutsedge interferes other plants by its competition ability and allelopathy. Thus, this research aimed to investigate the influence of purple nutsedge density and allelopathic effect of extract and residue on germination and growth of sweet corn. Four densities of purple nutsedge including 125, 250, 500, and 1,000 tubers/m^2 were investigated on germination and growth of sweet corn. The reduction of growth and yield varied on the increasing of densities. For allelopathic effect, the aqueous extracts of tuber and upper part was tested on sweet corn at the concentrations of 12.5, 25, 50 and 100 g/L. The upper part extract showed more inhibitory effects on the germination and seedling growth of sweet corn than tuber extract. Another study on allelopathic effect of purple nutsedge was studied on soil incorporation with dry upper part residue at the concentrations of 1:40, 1:30, 1:20 and 1:10 w/w on emergence and growth of sweet corn. All concentrations significantly reduced growth and biomass of sweet corn. The inhibitory level increased with increasing on the concentrations. These results supported the hypothesis which purple nutsedge interfered yield crop of corn by both competition and allelopathy.

O-054

Allelopathic potential of *Ludwigia sedioides*

Dinusha Debarawatta[1], Kapila Yakandawala[1], Thilak Attanayaka[2]

[1]Department of Horticulture and Landscape Gardening, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila, (NWP), Sri Lanka ,60170.
[2]Department of Biotechnology, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila, (NWP), Sri Lanka ,60170.

Ludwigia sedioides (Humb. & Bonpl.) H. Hara is a recently naturalized alien ornamental aquatic plant in Sri Lanka. Though this plant has not been identified as an invasive plant elsewhere in the world, due to its rapid spread, efficient mode of reproduction and aggressive nature, it could have a negative impact on agriculture, environment and recreational activities in water bodies of the country in the future. Hence, it has been identified as a potential invasive plant in Sri Lanka. Exotic species have to surpass different biological filters to invade a new habitat. Allelopathy is one such mechanism which is common in aquatic macrophytes in response to competition. Hence the present study was conducted to investigate the potential allelopathic effect of the *Ludwigia sedioides* under laboratory conditions.
Twenty five top cuttings 6 cm in length with roots were randomly collected from natural populations and grown in plastic containers with 3 kg of media (Top soil: sand 2 : 1). Containers were filled with 20 L of water and placed inside a polytunnel and water level was maintained to be constant throughout the experiment. Water directly obtained from these containers were used for the bioassay. Two treatments were tested *viz.* water directly obtained from *L. sedioides* grown containers and tap water (control) and the experiment was repeated at 30, 60 and 90 days after planting *L. sedioides* cuttings. Each treatment was replicated 7 times with 20 seeds of Radish (*Raphanus sativus*) per petri dish which was arranged in Complete Randomized Design (CRD). Fifteen days after sowing seeds, growth performance of radish seedlings was measured which included seed germination percentage, radicle and hypocotyl length. Data were analyzed by analysis of variance (ANOVA) and mean comparison was done by Turkey’s method using Minitab 16 software.
Significantly high seed germination rates were recorded in the control in 30, 60 and 90 DAT compared to treatment. However radicle length was significantly reduced only in 30 DAT in treatment while hypocotyl lengths were significantly reduced (P ^0.5) in 30 and 90 DAT. Therefore, seed germination of Radish seeds has a negative effect from *L. sedioides* grown water. Compared to control 30 DAT both shoot and root growth also has a negative impact. Hence, the bioassay confirms that *L. sedioides* has a negative effect on Radish growth and further studies should be conducted to investigate the effect further. This negative impact could be a fact that led to the invasive success of *L. sedioides* in aquatic ecosystems of the country.

This project was funded by a grant (SRHDC/RP/04/13-02) received from Wayamba University of Sri Lanka.

Keywords: *Ludwigia sedioides*, Allelopathy, Potential invasive aquatic plant, *Raphanus sativus*

O-055

Two growth inhibitory substances in the leaves of the tree fern, *Cyathea lepifera*

Noriyuki Ida[1], Toshiaki Teruya[2], Arihiro Iwasaki[3], Kiyotake Suenaga[3], and Hisashi Kato-Noguchi[1]

[1]Kagawa University, 2393 Ikenobe, Miki 761-0795, Japan
[2]University of the Ryukyus, 1 Senbaru, Nishihara 903-0213, Japan
[3]Keio University, 3-14-1 Hiyoshi, Yokohama 223-8522, Japan

Cyathea lepifera Copel. is a tree fern belonging to the family of *Cyatheaceae* and dominates in the subtropical and tropical forests of East and Southeast Asia. There had been no available information about allelopathy of *C. lepifera*. However, our previous study demonstrated that aqueous methanol extracts of *C. lepifera* leaves had the concentration dependent inhibitory activities on the growth of several test plants, suggesting that *C. lepifera* leaves may have allelopathic activities and may possess growth inhibitory substances. Therefore, the present study was undertaken in order to isolate and identify the growth inhibitory substances with allelopathic activity in *C. lepifera* leaf extracts. Two growth inhibitory substances were finally isolated from the leaf extracts. One substance was identified by the spectroscopic analysis as (-)-3-hydroxy- β-ionone, and the other one substance has not been identified yet. (-)-3-hydroxy- β-ionone significantly inhibited the hypocotyl and root growth of cress at concentrations greater than 10 μM. (-)-3-hydroxy- β-ionone at 30 μM inhibited the hypocotyl and root growth of cress by 12.0% and 8.8% of control, respectively. The concentrations required for 50% growth inhibition of (-)-3-hydroxy- β-ionone on the hypocotyl and root growth of cress were 10.7 μM and 11.2 μM, respectively. The present results suggest that *C. lepifera* leaves may contain at least two growth inhibitory substances, and those substances may play an important role in allelopathic activity of *C. lepifera*. The release of allelopathic substances into the surrounding environment could contribute to the domination of *C. lepifera* in the forests.

O-056

Bioefficacy and phytotoxicity of Eucalptus leaf oil on wheat and associated weeds under field condition

Ankita Arya[1], Vipin C Dhyani[1], Sumit Chaturvedi[1]

[1]Department of Agronomy, GBPUAT, Pantnagar, India

The use of botanicals and allelopathic chemicals are fast becoming an important means to control noxious weeds. Volatile oil from leaves of *Eucalyptus citriodora* significantly reduced germination, seedling length and chlorophyll content in *Triticum aestivum* (Sasikumar *et al*., 2001), *P. hysterophorus* (Chaturvedi *et al.*, 2012), *Zea mays* and *Raphanus sativus* (Kohli *et al*., 1998 and Daizy *et al*., 2004) thus has the potential to be used as natural herbicide. Therefore, the present investigation was undertaken to assess the phytotoxicity of eucalypt oil against some weeds and wheat with a view to explore it as a natural herbicide for weed management in wheat crop under field condition. Twelve treatments consisting of different Eucalyptus oil concentrations (1.0, 2.5, and 5.0 per cent) applied at different stages (pre emergence, i.e. PE, 20 days after sowing, i.e. 20 DAS and 30 days after sowing i.e. 30 DAS) of application, alongwith best bet herbicide (Pendimethalin as PE + Sulfosulfuron at 30 DAS), weed free and weedy check were replicated thrice in a field experiment. Concentrations were not combined but were applied once at 20 DAS and 30 days and also twice as PE and 30 DAS. 5.0 % Eucalyptus oil spray at 30 DAS has lowest total dry matter accumulation which was at par with best bet herbicide. In field condition, 5 % Eucalyptus oil spray applied at preemergennce+ 30 days stage caused effective control of weeds comparable to best bet herbicide (Pendimethalin+Sulfosulfuron) and significant increase in wheat grain and straw yield over weedy check. Visual toxicity was seen at oil spray above 2.5 % concentration but crop recovered later on and produced comparable dry matter to best bet herbicide.

O-057

Allelopathic potentiality of Bangladesh indigenous rice variety ‘Boterswar’

Sheikh Muhammad MASUM[1&2], Md. Amzad HOSSAIN[3], Hikaru AKAMINE[3], Jun-Ichi SAKAGAMI[4], Takahiro ISHII[3], Shinichi GIMA[5], Takara KENSAKU[3], Prasanta Chitta BHOWMIK[6]

[1]United Graduate School of Agriculture Sciences, Kagoshima University, Japan
[2]Department of Agronomy, Sher-e-Bangla Agricultural University, Bangladesh
[3]Faculty of Agriculture, University of the Ryukyus, Japan
[4]Faculty of Agriculture, Kagoshima University, Japan
[5]IRC, University of the Ryukyus, Japan
[6]Department of Plant, Soil and Insect Sciences, University of Massachusetts, Amherst, MA

The potential use of allelopathy in weed management has been explored by several researchers, and this weed management technology has been considered as ecologically sound, resource conserving and economically viable method. In this study, allelopathic activities of Bangladesh indigenous rice var. ‘Boterswar’ (*Oryza sativa* var. *indica* L.) were determined by using donor-receiver bioassay, equal compartment agar method (ECAM), aqueous methanol extracts, aqueous extracts, chromatography and spectroscopic analyses. Lettuce (*Lactuca sativa* L.), cress (*Lepidium sativum* L.), radish (*Raphanus sativus* L.), barnyardgrass (*Echinochloa crus-galli* L. Beauv.) and jungle rice (*Echinochloa colona* L.) were used as test plants. Among 50 Bangladesh indigenous rice varieties the highest inhibition effect was given by ‘Boterswar’ in donor-receiver bioassay and ECAM tests. ‘Boterswar’ also gave strong inhibitory effect on barnyardgrass and jungle rice in aqueous methanol extracts test. Growth parameters and total dry matter of barnyardgrass in the greenhouse pot-experiment were significantly reduced due to the application of aqueous extract of the ‘Boterswar’ rice variety. Four biologically active compounds viz., syringaldehyde (4-hydroxy-3,5-dimethoxy-benzaldehyde), (-) loliolide**,** 3β-hydroxy-5α, 6α-epoxy-7-megastimen-9-one, and 3-hydroxy-β –ionone were isolated from the aqueous methanol extracts of ‘Boterswar’ rice using chromatography and spectroscopic analyses**.** The biological activity on barnyardgrass results showed that 10μM was the minimum inhibition concentration of the isolated alllelochemical compounds. The concentration required for 50% growth inhibition (I_{50}) ranges from 16.03 to 75.49 μM. The inhibitory activity of a mixture of the four compounds was much higher than that of individual inhibition activity of the compounds. Thus, Bangladesh indigenous rice ‘Boterswar’ may be potentially useful for weed management in a field setting and further to develop new variety tolerant to weeds.

O-058

Mechanism action analysis of horseweed (*Conyza canadensis*) subject to botanic caryplic acid stress

Zuren Li[1,2,3],Qiong Peng[1,2,3],Lifeng Wang[1,2,3], Lamei Wu[1,2,3],Haona Yang[1,2,3], Xiaomao Zhou[1,2,3], Qin Yu[2]*, Lianyang Bai[1,2,3]*

[1]Hunan Agricultural Biotechnology Research Center, Hunan Academy of Agricultural Sciences, Changsha 410125, China.
[2]Huan Provincial Key Laboratory for Biology and Control of Weeds, Hunan Academy of Agricultural Sciences, Changsha 410125, China.
[3]Collaborative Innovation Center for Field Weeds Control, Loudi 417000, China.

Caryplic acid (eight-carbon saturated fatty acids) has been used as an antimicrobial pesticide, a disinfectant, and algaecide etc. In our preliminary study, we found caryplic acid might be a natural substance with potential herbicidal activity.

The possible mode action of caryplic acid as a potential herbicide for control of horseweed (*Conyza canadensis*) was investigated. Transmission electron microscope (TEM) revealed fractured leaf chloroplast structure, disordered thylakoid and irregular matrix lamellar following caryplic acid treatment. In addition, defense enzyme (e.g. PAL, PPO, POD) activities, chlorophyll content and photosynthetic indicators (Pn and Tr) of horseweed leaves were significantly induced after the treatment. And induction of defense enzyme activity and chlorophyll content were affected by light intensities. These results indicate the herbicidal effect of caryplic acid may be related to plant photosynthesis.

Furthermore, the label-free quantitative method based on LC-MS /MS was used to analyze differential protein expression in caryplic acid treated (12 hours later) and untreated horseweed leaves. Total 698 proteins in treated, and 805 in untreated sampleswerequantified.Significant differences in protein abundance were considered with a ratio B05.10/T4(R) in the range 0.6>R>1.67, and without unique peptides=1. Among differentially expressed 112 protein species, 46 proteins were up regulated and 66 down regulated in treated samples. The differentially regulated proteins were annotated and classified using the UniprotKB database according to the biological process of each gene product. At last, we transcriptionally (using qRT-PCR) validated six differently regulated photosynthesis proteins (A0A103XLU4, A0A103XJN2, Q946G1, etc). Further studies are under way.

O-059

Administration effect of L-DOPA・ allelopathic substance of Mucuna prurens on dogs

Hiromi Shimasaki[1], Taiki Iida[1], Yoshiharu Fuji[1]

[1] International Environmental and Agricultural Sciences, Tokyo University of Agriculture and Technology, 3-5-8, Saiwai-cho, Fuchu-shi, Tokyo, 183-0057, Japan

It has been found that Mucuna prurens-delivered L-dopa to be a causative agent of allelopathic activity which promotes or inhibits growth of other plants. Mucuna prurens has been used for Parkinson's disease patients and tonic agents in human, although reports on the results of administration to dogs are commonly unseen. This time, as a result of administration of Mucuna prurens to three dogs, behavioral abnormalities at night and excretion behavior were suppressed, so we will present a summary. These three dogs were patients of animal hospital, not experimental dogs.

Case 1, Shetland Sheep-dog , 14 years 10 months ,was having sleep disorder at night due to aging. Wandering behavior, and enuresis were also observed. We administered Mucuna prurens 0.16 g/kg/day, these symptoms improved on the next day.

Case 2, Dachshund, 13 years 5 months, was having sleep disorder at night and enuresis. We administered Mucuna prurens 0.19 g/kg/day, these symptoms turned around after two days.

Case 3, Shiba, 10 months, was having frequent pruritus and scratching floor at night. We administered Mucuna prurens 0.18 g/kg/day, these behavior calmed down after 2 days.

An internal neurotransmitter, The L-dopa preparation, has been known that it will increase the renal blood flow and cardiac output of dogs. Mucuna prurens contains 5% of the weight of beans as L-dopa. Calculating L-dopa from Mucuna prurens given to cases 1 to 3, the dose of L-dopa was 8 mg to 9.5 mg/kg/Day. This suggested that there are differences of sensitivity of each animal species. And It was suggested that Mucuna prurens has possibility for treatment of abnormal behavior and anxiety symptoms at night of dogs.

O-060

Impact of climate change on weed growth and control

Khawar Jabran[1,2], M.N. Doğan[2]

[1]Faculty of Agriculture and Natural Sciences, Department of Plant Protection, Duzce University, Duzce, Turkey

[2]Department of Plant Protection, Adnan Menderes University Aydin, Turkey

khawarjabran@gmail.com

Climate change [rising carbon dioxide (CO_2) levels and atmospheric temperature] is expected to impact the growth of weeds and their control. In these studies, we evaluated the effects of normal and elevated levels of CO_2 and temperature, and their interaction on the growth and control of an important winter weed *Hordeum murinum* L. The CO_2 levels investigated were: CO_2 = 400-450 ppm (normal conditions) and 900-950 ppm (elevated levels), while the temperatures were: normal (20/10 °C day/night) and high levels (25/15 °C day/night). The results indicated that CO_2 had improved the growth of this weed, however, high temperature mostly had a negative effect. A combination of high CO_2 and temperature also improved the growth that was probably the result of high CO_2 rather than temperature. Dose-response curve indicated that glyphosate had a similar effect on this weed under different climatic conditions. This implies that *H. murinum* can be controlled effectively under changing climatic conditions using the same doses of herbicides as under the normal climatic conditions.

Keywords: Global warming, elevated carbon dioxide, weeds, growth, glyphosate, control

O-061

Nitrogen scheduling and impact on Weed management in Aerobic rice

B. Sreedevi *, B. Dhanunjaya Reddy, A. Sandhyarani, R. Mahender Kumar,
P. Senguttuvel and V. Ravindrababu
ICAR- Indian Institute of Rice Research, Rajendranagar, Hyderabad-500030,
Telangana State, India
sreedevi.palakolanu@gmail.com

Aerobic rice is a new development in water saving technologies where rice is grown like any other upland cereal crop with supplementary irrigation. Nutrition is especially nitrogen nutrition. Increasing NH_4 form of nitrogen improves the nitrogen source to plants of aerobic rice by adopting alternate wetting and drying system of irrigation. Weeds are one of the serenest constraints to aerobic rice production system. The aerobic soil, dry tillage, alternate wetting and drying are conducive to the germination and growth of weeds causing yield losses of 50 – 91%. With this back ground the study was initiated in kharif 2009 and continued in 2010, at six different locations (soil type varied from clay, clay loam to silty loam and sandy loam) with the objective of optimum nitrogen requirement for effective weed management. The treatments were three nitrogen levels (75%, 100% and 125% RDF) and five management practices (W1- Pendimethalin @ 0.75 kg a.i./ha (PE) + Rice : Dhaincha (1:1) + one hand weeding at 60 DAS; W2 – PE + 2 mechanical weedings at 20 and 40 DAS; W3 – PE + Rice : Cowpea (1:1) + one hand weeding at 60 DAS; W4 – Two mechanical weedings at 20 and 40 DAS; W5 – Unweeded control). The results revealed that in clay and clay loam soils, the nitrogen schedule of 100-125 kg/ha along with pre-emergence herbicide application of Pendimethalin + Rice : Daincha (1:1) / Rice : Cowpea + 1 hand weeding at 60 DAS ; in silty loam and sandy loam soils 125 kg/ha nitrogen along with pre emergence herhicide application of Pendimethanin + sole rice crop + 2 mechanical weedings at 20 and 40 DAS was found to be the better package for efficient nitrogen and weed management in aerobic rice. Economics and Energy analyses also revealed the efficiency of the above mentioned package.

O-062

Sustainable Weed Management Options for Conservation Agriculture in Eastern Indo-Gangetic Plains of India

U. P. Singh*,Yashwant Singh, A.V. Dahiphale, Sanjeev Kumar Kashyap and Sandeep Kumar

Department of Agronomy, Institute of Agricultural sciences, Banaras Hindu University, Varanasi-221005 , India

**E-mail:udaipratap.singh1@gmail.com*

ABSTRACT

Indo-Gangetic Plains (IGP) occupies 56.07 million hectares of the total geographical area of India; holds nearly 40 percent of the total population, half of the total irrigation water supplies and nearly 65% of the people located in these plains depend on agriculture. Major problem of weeds associated with the CA based production system is due to less expertise / management skill in implementation of CA practices. Excessive tillage, use of poor quality seed, weed contaminated seeds, weed shift, monoculture, unavailability of labour for weeding, inappropriate selection and application of herbicides are key concerns for weed management in prevalent agricultural production systems in Eastern IGP. Research results has shown that zero tillage (ZT) combined with retention of crop residue is a potential tool for effective weed management in rice –wheat (RW) cropping system in IGP. CA based practices i.e. permanent no-till residue managed beds and double no-till (ZT direct seeded rice- ZT wheat) reduced weed infestation in rice-based cropping systems due to less weed seed bank disturbance in soil and proper cover of soil by the residue. ZT DSR with anchored residue was found to be most effective in minimizing weed density, dry weight and nutrient depletion by weeds. Residue retention with *Trichoderma* application was more effective over the residue removal in minimizing the weed density and total dry weight in ZT wheat. Although, ZT alone without residue provided advantages in terms of weed suppression and yield increase in wheat but when ZT is combined with residue retention, advantage of weed suppression and yield increase are much higher. Sulfusulfuron + metsulfuron was very effective in controlling weeds in wheat. ZT rice–ZT wheat recorded higher growth, yield attributes and yield of rice-wheat system due to higher weed control efficiency and better crop establishment over conventional tilled (CT) rice–CT wheat. Application of bispyribac 25g ha^{-1} + azimsulfuron 35g ha^{-1} at 15-20 DAS/DAT in rice and clodinofop 60g ha^{-1}+ carfentrazone 20g ha^{-1} at 30-35 DAS in wheat under ZT Rice - ZT Wheat system provided efficient weed management, higher yield, system productivity and system profitability in RW cropping system. Diversification of the RW system by growing a short-duration vegetable crop (pea or potato) followed by late sown wheat or mungbean /cowpea after wheat was helpful in reducing weeds without any increase in herbicide use. Options such as stale seedbed technique, appropriate crop establishment with CA based practices, use of cover crops and crop residues, crop rotations and crop diversification with sensible use of pre and post-emergence herbicides should be integrated for sustainable weed management for CA systems in Eastern IGP of India.

***

O-063

Long term mechanical soil intervention and weed management on yield of irrigated Maize – Sunflower cropping system under semi arid tropics

Murali Arthanari Palanisamy[1],Chinnusamy Chinnagounder[2] N.K.Prabhakaran[3]and P.Janaki[4]

[1,2,3,4]*AICRP-Weed Management, Department of Agronomy,*
Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India
e-mail: agronmurali@gmail.com *and* agronmurali@tnau.ac.in

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore during *Kharif 2004* to *Rabi 2014* to study the weed seed and weed population dynamics and crop productivity in maize – sunflower cropping system as influenced by tillage and weed management methods. The experiments were laid out in split plot design with four replications. Main plot treatments consisted of four-tillage methods viz., zero tillage – zero tillage, zero tillage-conventional tillage, conventional tillage – zero tillage and conventional tillage – conventional tillage. Three weed management methods viz., hand weeding on 20 and 40 DAS, PE herbicides (Atrazine 0.5 kg/ha for maize and pendimethalin 1.0 kg/ha for sunflower) followed by hand weeding on 40 DAS and unweeded check for both the crops consisted the sub plot treatments. Eleven years result revealed that continuous zero tillage resulted in shift in weed flora from broad-leaved weeds to more difficult to control grasses. There was no shift in weed flora due to conventional tillage and weed management practices. Conventional tillage reduced the weed density, weed dry weight, grass and broad-leaved weed seeds to a greater extent. Further, it recorded higher weed control efficiency, higher nutrient uptake by crop plants and higher soil available N,P and K, reduced bulk density, higher total porosity, infiltration rate, higher micro organism and higher maize and sunflower yield than zero tillage in all the year of experimentations. Among the weed management methods, hand weeding twice and PE herbicide followed by hand weeding on 40 DAS performed better by control wide spectrum of weed flora, increased weed control efficiency, nutrient uptake, growth and yield attributes of both the crops.

O-064

Impact of tillage, crop residue, and weed management on crop productivity in a rice-wheat cropping system under conservation agriculture

Makhan S. Bhullar, Simerjeet Kaur, Navjyot kaur, Pervinder Kaur, Tarundeep Kaur and Gurjeet Gill[1]

Department of Agronomy, Punjab Agricultural University, Ludhiana, India; [1]The University of Adelaide, South Australia, Australia

Indian agriculture has been going through many changes including rapid adoption of mechanization of crop management practices. The availability of suitable farm machinery has now made it possible for the local farmers to consider adoption of conservation agriculture. This has been reflected in widespread adoption of zero-till (ZT) wheat and more recently adoption of dry-seeded rice (DSR) in Punjab and Haryana in northern India. In this study, the impact of different tillage and residue management practices in rice-wheat cropping system on crops productivity, and influence of weed management practices on weed seedbank, weed infestation and crop yield were investigated over two cropping cycles in 2014 and 2015 at Ludhiana, India. Conventional tillage puddle transplanted rice (CT-PTR) recorded higher seed bank of *Echinochloa colona* and lower seed bank of *Dactyloctenum aegyptiacum* than CT/ZT-DSR. ZT-wheat, with or without residue retention, recorded lower seed bank of *Phalaris minor* compared to CT-wheat. The weed seed bank under integrated weed management (IWM) treatment was lower compared to when herbicides used alone. The weed biomass was higher under CT/ZT-DSR than CT-PTR, and under CT-wheat than ZT-wheat. Under IWM treatment, CT/ZT-DSR recorded similar rice grain yield to CT-PTR; rice grain yields for CT-PTR were similar under herbicides, IWM and unsprayed check. CT-wheat, following CT-DSR, recorded the highest grain yield which was similar to CT/ZT-wheat following CT-PTR. DSR-wheat system, under continuous CT, recorded the highest system productivity. Harvest time residues of herbicides applied to both rice and wheat, under different tillage and residue management systems, in soil and crop produce were below detectable limits. At long-term farmers field sites also, across three years, CT-DSR recorded similar grain yield to CT-PTR, and grain yields of ZT-wheat were 100 to 300 kg/ha higher than CT-wheat.

O-065

Direct seeded rice in sequence with zero tillage wheat in north-western Indo-Gangetic plains: dealing with increased complexity in weed management

Dharam Bir Yadav[1], Ashok Yadav[2], Dalip Kumar Bishnoi[1] and Gurjeet Gill[3]

[1]CCS Haryana Agricultural University, Hisar, Haryana, India 125004
[2]IRRI-CSISA Hub, OUAT Campus, Bhubaneswar, Odisha, India 751 003
[3]School of Agriculture, Food and Wine, University of Adelaide, Adelaide, South Australia 5064

Rice-wheat has been the main cropping system in the north-western Indo-Gangetic plains for a long time. Rice has traditionally been grown as manual transplanting in puddled fields. In recent years, local farmers have shown interest in direct seeded rice (DSR) as an alternate method for rice production due to savings in labor, water and energy use as compared to the conventional method of puddled transplanted rice (PTR). However, weed infestation in DSR tends to be greater and more diverse due to absence of water stagnation during the early growth stages as compared to PTR.

A series of field experiments and farmer-participatory trials were undertaken in Haryana during the last decade (2006-2016) to understand and address some of the complex issues related to DSR. Weed dynamics studies showed that weed flora changed rapidly after the adoption of DSR. Grass weeds such as *Leptochloa chinensis, Dactyloctenium aegyptium* and *Eragrostis spp.* and sedges like *Cyperus rotundus* became major weeds in DSR, which were previously minor weeds in PTR. However, *Echinochloa crus-galli* was found to have broad adaptation and was the most dominant weed under PTR and DSR. A diagnostic survey of farmers (2012-13) also revealed higher infestation of grass weeds and sedges (98%) along with volunteer rice (10%) in DSR than PTR, which was consistent with the results of field experiments.

Based on a long-term field experiment during 2010 to 2015 at Karnal, productivity of *basmati/*scented rice under direct drill seeding (2.4-3.9 t/ha) was found to be similar to PTR (2.6-4.1 t/ha) but the cost of production in DSR (US\$ 359-508 ha^{-1}) was significantly lower than PTR (US\$ 460-625 ha^{-1}). The DSR based rice-wheat system gave higher system productivity and net economic returns mainly due to higher productivity of wheat (0.4-0.6 t/ha). However, there was higher infestation of a more diverse weed flora in rice, along with greater infestation of *Phalaris minor* in wheat under DSR based systems. The integration of pre-emergence (pendimethalin 1000 g ha^{-1}) and post-emergence (bispyribac-sodium 25 g ha^{-1}, pyrazosulfuron 25 g ha^{-1}) herbicides with need based manual weeding proved highly effective in DSR, which has now been widely adopted by the local farmers. Use of cover crops and stale seedbed technique proved effective in reducing weed infestation and managing volunteer rice in DSR. Management skills of farmers practicing DSR have improved markedly with experience and they are now consistently achieving savings in irrigation water, labor, fuel and overall cost of cultivation in DSR.

O-066

Row spacing, herbicides and nitrogen effect on crop-weed competition in cereal-broadleaf crop rotation

A. Hashem[1], W. Vance[2], R. Brennan[3] and R. Bell[2]

[1]Department of Primary Industry and Regional Development, Government of Western Australia, 75 York Road, Northam 6401, Australia
[2] School of Veterinary and Life Sciences, Murdoch University, South Street, Murdoch WA 6150, Australia
[3]Department of Primary Industry and Regional Development, Government of Western Australia, 4 Albany Highway, Albany WA 6330.

Compared to wide rows, crop plants in narrow rows are more competitive than weeds. In dry land conservation agriculture (CA), strategic N application technique may maximise the access of crop plants to N compared to weed plants. A three-year (2012-2014) rotation study was undertaken to examine the interaction of N rate (and N application technique) and weed control options under 22 and 44 cm row spacing in a wheat –lupin (*Lupinus angustofolius*)–canola (*Brassica napus*) rotation in a high infestation of ACCase-resistant rigid ryegrass (*Lolium rigidum*). Roundup Ready® (RR) canola crop was grown in 2014 season in all wheat and lupin plots of 2013. Trifluralin and pyroxasulfone were applied to wheat crop while simazine and dimethenamid-P to lupin crop. Glyphosate was applied in 2014 RR canola at 2- and 5-leaf stages. Wheat and canola crops received three nitrogen treatments viz., Urea N 25 kg/ha, Urea N 50 kg /ha (Urea drilled in front of tynes), and Flexi 50 kg N/ha as Flexi N placed at 7 cm depth for wheat and 4.5 cm for canola. Increase in row spacing from 22 to 44 cm reduced weed control and wheat yield in 2013 season but did not influence lupin grain yield. Pyroxasulfone was more effective on weeds in wheat than trifluralin while dimethenamid was more effective than simazine in lupin, leading to increases in grain yield of wheat and lupin. Flexi N had higher initial weed plants than urea N25 or N50, indicating a possible stimulation of rigid ryegrass emergence by Flexi N. Use of effective herbicides, close row spacing, flexi N and RR canola in rotation reduced ACCase-resistant rigid ryegrass by almost 100% compared to no weed control in canola.

O-067

Quantitative Sustainable Weed Management Strategy in Intensive Rice-Wheat Double Cropping Fields

Sheng Qiang

Weed Research Laboratory, Nanjing Agricultural University, Nanjing, 210095, China,
Email: wrl@njau.edu.cn

Abstract

Weed control has overdepended on herbicides which cause evolution of herbicide-resistant weed and pollution of arable land and water system environment posing a great threat to agricultural production safety, ecological system, food security and human health. In the middle and lower Changjiang River, four to six times of herbicide applications may ordinarily need to control weeds in rice and wheat fields in the double-cropping system. We developed an integrated sustainable weed management technique to ecologically deplete weed seed bank, consequently reduce weed occurrence density and finally decrease conventional herbicide application frequency. The key ecological methods adopted here were to clean irrigation water through interception of floating seeds at water entrance and exit and net-fish out floating seeds to prevent weed seed feedback to seed bank during necessary irrigation before rice planting. A long term experiment showed that three years' continuous application of the technique could reduce 50% weed density with 60% weedseed declined. Consequently, two to four times of herbicide applications may be cut down quantitatively-based on weed seed bank and occurrence scale so that it could reach the target to reduce 50% of herbicide application and 30% costs and labor work compared to conventional weed control. Furthermore, the quantitative model analysis on seedbank and population dynamics showed that consecutive adoption of this integrated strategy may finally get weed-free without addition of any other measurements just when weed seedbank may be depleted to over 95%.

Key words: Weed seedbank, interception of floating seeds; reduction of herbicide applications; ecological weed control

The project supported by the National Key Research and Development Program (2016YFD0200805), Natural Science Foundation of China(31500350), Agrotechnical Innovation Projects of Jiangsu Province (SXGC(2016)S321600-17)

O-068

Effect of integrated weed management practices on growth, yield and economics of transgenic cotton

Y. R. Aladakatti and Ramesh H. Jatti
University of Agricultural Sciences, Dharwad, Karnataka, India
E-mail:yraladakatti@rediffmail.com

Cotton is an important commercial and fiber crop of India. After release of transgenic cotton (Bt cotton) in India during 2002-03, the area under cotton cultivation consequently increased constantly. However, low production with 390 lakh bales and declining productivity (565 kg ha^{-1} lint as against global productivity of 759 kg ha^{-1} lint) is an alarming concern. Cost effective weed management practices in transgenic cotton plays an important role in enhancing the productivity. Hence, field studies were undertaken during 2012 to 2014 at the University of Agricultural Sciences, Dharwad, India, during the monsoon season in vertisols to assess the effect of pre and post emergent weedicides on growth and yield of Bt cotton. The trial consisted ten different treatment combinations of different pre and post emergent weedicides with three replications laid out in randomized compact block design (RCBD). Crop production practices remained common for all the treatments.

Results indicated that pre emergent application of Pendimethalin 30 EC @ 1.5 kg a.i/ha followed by (fb) post emergent application of Pyrithiobac Sodium 10 EC @ 62.5 g ai/ha + Quizolofop ethyl 5 EC @ 0.05 kg ai/ha at 30 DAS (Tank mix) with once intercultivation and manual weeding at 45 days after sowing resulted in higher seed cotton yield (2853 kg/ha) which was on par with the seed cotton yield obtained with weed free check (2943 kg/ha). Higher net returns were obtained with this treatment (Rs.69,693/ha) with lower weed dry weight (26.7 g/m^2) and higher weed control efficiency (71.9 %). It was concluded that pre emergent application of Pendimethalin 30 EC 30 EC @ 1.5 kg a.i/ha fb post emergent application of Pyrithiobac Sodium 10 EC @ 62.5 g ai/ha + Quizolofop ethyl 5 EC @ 0.05 kg ai/ha at 30 DAS (Tank mix) with once intercultivation and manual weeding at 45 days after sowing found to be efficient and optimum for Bt cotton.

O-069

Evaluation of eight rice varieties for their weed-suppressive ability under different water regimes

Abdul Shukor Juraimi and Masitah Ab Jalil

Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia (UPM), 43400 Serdang, Selangor, Malaysia

It is predicted that rice global demand will be doubled by 2050 (Van Nguyen, 2009). Weed infestations are recognized as a serious biological constraint to rice production in both lowland and upland ecosystems at all seasons (Ni et al., 2000). Most weeds are found abundantly in saturated and field capacity condition. Conversely, water limited conditions allow low water usage and decrease greenhouse gases missions and ammonia volatilization (Bouman et al., 2007). The constant use of chemical herbicides leads to an increased risk of herbicide-resistant, environmental pollution, unsafe agricultural products and negative effects on human health (Vyvyan, 2002). The identification and development of competitive rice varieties may be more effective in weed management (caton et al., 2003). Therefore, a study was carried out to assess different rice varieties with characteristics that can adapt to the water deficit environment besides having high weed suppressive ability. The glasshouse experiment was conducted to evaluate the weed-suppressive ability of eight rice varieties under three water regimes (flooded, saturated and field capacity) and three weed treatments (weedy, once weeded at six weeks after sowing and weeded throughout the growth period). The results showed AERON 1 and MRQ 74 attained the highest and lowest plant height, respectively. Conversely, MRQ 74 rendered the highest number of tiller while AERON 1 had the lowest tiller number. Tiller number had a negative correlation with weed dry weight while a positive correlation with grain yield and above-ground biomass. The potential traits of weed suppressiveness are tiller number and relative yield loss as they had a significant influence on rice growth and yield. Thus, these findings can aid in identifying the potential traits of weed-suppressive ability under limited water condition.

O-070

A new weed control measure of synchronous seeding and spraying herbicides with the precision rice hill-drop drilling machine

Jianping Zhang, Yongliang Lu, Wei Tang, Xiaoyue Yu

State Key Laboratory of Rice Biology, China National Rice Research Institute, 359 Tiyuchang Road, Hangzhou 310006, China.

It is important to establish the mechanized production pattern for modern agriculture scale-management way. The precision rice hill-drop drilling technique is one kind of mechanized production which efficiently integrated agricultural machinery and agronomy and gradually become popular in rural area because it is simplified cultivation pattern with high-yield and high-efficiency. The key of widespread popularization and application of this technique depends on the matching measures of weed control. A new measure of weed control was developed to resolve this problem. It could synchronously spray the soil treatment herbicide, for example, the mixture of Syngenta pretilachlor and bensulfuron methyl, with a high-pressure spray device while the precision rice hill-drop drilling machinery sowed seeds. It could efficiently control above 95% of the broadleaf weeds and almost 90% of the grasses (barnyardgrass and *Leptochloa chinensis* (L.) Nees) before rice were 3 leaf stage, but no significant influences on the rate of rice emergence. After the 2-3 leaf stage of rice, stem leaf herbicide were chosen and sprayed according to weed variety and density to control weeds and improve the competitiveness of rice. It will result in the high yield of rice. This measure could not only efficiently control weeds in the direction rice filed, but also is simple, save time and labor cost. It also decreased 10% pesticide dosage, protected agroecological environment and meet the long-term goal of sustainable development of agriculture.

Key words: Synchronous seeding and spraying; Weed control; Rice mechanical production.

O-071

Evolving appropriate tillage, weed and nutrient management practices for improving resource use efficiency in Green Manure - Maize - Pulse cropping system for the Semi Arid Tropics

***R.Thirumalaikumar[1], N.S.Venkataraman[2], K.Balakrishnan [3], R.Babu[4] and A.Rathinasamy[5]**

[1]Research Scholar, Department of Agronomy, [2] Professor and Head, Department of Agronomy

[3]Professor (Crop Physiology), Department of Seed Science and Technology

[4]Professor and Head, Department of Farm Management, [5]Professor, Department Soils and Environment

Agricultural College and Research Institute

Tamil Nadu Agricultural University

Madurai- 625 104, Tamil Nadu, INDIA.

***Corresponding author's E-mail**: *thiruhid@gmail.com*

ABSTRACT

Resource Conservation Technology (crop diversification, conservation tillage, residue management and mechanization) is a resource-saving agricultural production system that aims to achieve production intensification and high yields while enhancing the natural resource base through compliance with good production practices of integrated plant nutrient, water and pest (insect, disease, weeds etc.) (Makhan *et.al* 2016). Indiscriminate use of natural resources and mono cropping creates serious agro-ecological and sustainability problems. Hence, it warrants shifting the current practices of conventional tillage to scientific based conservation tillage, integrated weed and nutrient management practices.

A green manure crop used primarily as a soil amendment and a nutrient source for subsequent crops may provide such an alternative. Maize is an important crop for food, feed and nutritional security. One of the important resource conservation practices that influence maize productivity is tillage management. Tillage operations affect the soil physical properties like soil structure and organic carbon by hastening the process of decomposition. However, different tillage practices significantly influence weed population. Irrespective of the weed species, conventional tillage significantly reduced the population of weeds compared to reduced tillage and minimum tillage. Use of herbicides in no-tillage systems, and in other tillage systems as well, may cause a shift in weed species that predominant in a given situation. Maintaining soil fertility with sufficient soil biota is one of the main perquisites for sustainable agriculture. Reducing the use of inorganic nitrogen in crop production by cultivating green manure and pulse crop not only reduces the cost of input but also limit the emission of NO_2 (greenhouse gas), Carbon sequestration, besides restoring soil health and capacity to with stand adverse climatic condition.

Key words: *Conservation Tillage, weed and nutrient management, Maize, Pulse, Resource use efficiency and Semi Arid Tropics*

O-143

Response of some summer season crops on weed suppression

Javaid Iqbal[1], Javeria Muneer[1],Safdar Hussain[1], Muhammad Ishaq Asif Rehmani[1], Shahzadi Mahpara[1]

[1]Ghazi University, Pakistan

In all cropping systems weeds are a key biotic constraint. In weeds herbicide resistance is rapidly increasing phenomenon in the world causing higher cost of production and more weed impact. To reduce herbicide usage with cost-effective weed control in current pressures, the ability of crops or cultivars to suppress weed growth has become increasingly important. Crop itself has the ability to suppress the seasonal weeds. Keeping in view the possible suppressive potential of different crops the present study was conducted. During this experimentation different crops i.e. maize, sorghum, mungbean, pearl millet and mashbean were sown under the natural weeds pressure at farmer's field, Dera Ghazi Khan, Punjab Pakistan. Non crop plot was also maintained for comparison. Weeds flora of experimental site comprised of *Echinochloa colonum*, *Euphorbia granulata*, *Corchorus tridens*, *Physalis minima*, *Trianthema portulacastrum*, *Convolvulus arvensis*, *Dactyloctenium aegyptium*, *Mukia maderaspatana*, *Echinochloa crusgalli* and *Cyperus rotundus*. *Echinochloa colonum* was dominant weed. These weeds were suppressed by the test crops i.e. maize, sorghum, mungbean, pearl millet and mashbean as compared to control. Sorghum and pearl millet suppressed all weeds effectively (73% *E. colonum* control a dominant weed) however, other crops have also a significant suppressive potential against these weeds (9-59% *E. colonum* control). Highest inhibition in density, shoot length, fresh and dry weights was observed in sorghum and millet. Maize had least suppressive effect on these above weeds parameters (9% *E. colonum* control). Millet and mashbean reasonably inhibited various weeds. *E. colonum* has competitive ability with crops. Maize and mashbean were found least affective against these weeds.

O-072

Title:

ISSUES AND OPPORTUNITIES FOR SUSTAINABLE WEED MANAGEMENT IN PAKISTAN: A REVIEW

Authors:

Saima Hashim[1], Hafiz Haider Ali[2], Zarka Hanif[3], Arslan Masood Peerzada[4], and Bhagirath Singh Chauhan[4]

Affiliations:
[1] Department of Weed Science, University of Agriculture, Peshawar 25000, Pakistan
[2] Department of Agronomy, University College of Agriculture, University of Sargodha, Sargodha 40100, Punjab, Pakistan
[3] Department of Agronomy, University College of Agriculture and Environmental Sciences, The Islamia University of Bahawalpur, Bahawalpur 63100, Punjab, Pakistan.
[4] The Centre for Plant Science, Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, Gatton 4343, Queensland, Australia.

Body:

Despite decades of modern agriculture, lack of sustainable weed management is a major problem in Pakistan. Most research is focused on finding alternative weed control solutions, instead of identifying the root causes of weed problems, particularly herbicide-resistant weeds. Additionally, shortage of labour, increased wages, and high input costs make it difficult for farmers to control weeds over large areas. Nowadays, chemical control has facilitated efficient and timely weed control in agronomic and horticultural crops. However, poor spraying technology, adulterated herbicides, unavailability of safe new chemicals, and lack of technical knowledge about herbicides has resulted in several ecological and human health-related issues in recent years. Non-judicious herbicide application has increased the probability of weed population shifts and evolution of herbicide resistance in a number of weed species. In addition, farmers are generally unaware of alternative weed management strategies, which are capable of decreasing weed competitiveness with the crop for available growth resources, without reducing crop yield. Information on improved crop management practices, advances in chemical weed control, inexpensive biological approaches, and the integration of all these approaches would help farmers in designing more efficient weed management programs. Such strategies will be significant in securing maximum crop yields with minimal production cost, without affecting product quality.

Keywords: crop productivity, weed control, non-chemical control, herbicide, Asia

O-073

Weed research issues, challenges, and opportunities in Cambodia

Robert J Martin

The University of Sydney, Faculty of Agriculture and Environment, Suite 401, Biomedical Building, 1 Central Avenue, Australian Technology Park, Eveleigh NSW 2015

The area of cultivated agricultural land in Cambodia is 3.7 million hectares with 76% of this planted to lowland rice and 24% planted to upland crops such as cassava, maize, soybean, sugar cane and vegetables. Cambodia’s average rice paddy yield at around 3 t ha-1 is around 50% of the yield potential and losses caused by weed competition have been shown to be a significant constraint. The most important issues currently affecting weed management in Cambodia's cropping systems are (a) increased climate variability and climate change, and (b) migration of labour from the rural workforce and consequent rapid mechanisation of agriculture. As a result of climate change, the wet season in Cambodia now begins and ends approximately one month later, and the bimodal rainfall distribution has strengthened, resulting in more extreme events of drought and flood during the wet season. A decline in the availability of agricultural labour has resulted in rapid mechanisation of land preparation, broadcast seeding, herbicide use and machine harvesting of rice and these changes have had significant repercussions for weed management. The resultant challenges and opportunities for weed management are presented and discussed. The main weed management challenges are associated with rice crop intensification, transition from transplanting to direct-seeded rice, changed planting dates and tillage practices in response to climate change, over-reliance on post-emergence herbicides, excessive inversion tillage, and lack of knowledge about the safe and efficacious use of herbicides. Opportunities for improved weed management in Cambodia's cropping systems include the development of integrated weed management for double crop intensive rice systems, transition from hand broadcasting to drill-seeded rice, new seeding windows and minimum tillage, non-transgenic herbicide resistant crops and education and training of input sellers and farmers to improve safety and efficacy of herbicide use.

O-074

[Title]

Weed research issues and opportunities in China

[Authors]

Jinwen Zhu [a,*], Jian Wang [b], Chaoxian Zhang [c], Guiping Zheng [a], Wen Liang [a], Faisal Islam [b], Chong Yang [b], Xuexin Chen [a], Weijun Zhou [b,*]

[Affiliation]

[a] *Department of Plant Protection and Ministry of Agriculture Key Lab of Molecular Biology of Crop Pathogens and Insects, Zhejiang University, Hangzhou 310058, China*

[b] *Institute of Crop Science and Zhejiang Key Laboratory of Crop Germplasm, Zhejiang University, Hangzhou 310058, China*

[c] *Key Laboratory of Weed and Rodent Biology and Management, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing 100193, China*

[*] Corresponding author email: zhjw@zju.edu.cn; wjzhou@zju.edu.cn

[Abstract]

Weeds are vital constraints to crop production, which is of crucial importance for food security under great population pressure of 1.37 billions in China. Numerous herbicide resistant weeds are becoming a big challenge and invasive alien weeds further increasing the difficulties of weed management since the last decade. In this review, we describe the succession of weed communities, the status of invasive weeds and herbicide resistant weeds and weed management, identify the challenges and prospects in weed research. Invasive weeds together with changes in crop systems have significantly altered the weed spectrums in rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), maize (*Zea mays* L.), soybean (*Glycine max* (L.) Merr.), cotton (*Gossypium hirsutum* L.) and oilseed rape (*Brassica napus* L.) fields. In the meantime, 30 weed species have evolved resistance to 11 herbicide sites of action including 47 herbicides. Although tactics such as crop rotation and biological control have particular significance for tackling weeds, weed management is still mainly relying on herbicides in China. Research priorities for weed management include invasion mechanism and risk assessment of dangerous alien weeds in advance; the development of effective tactics such as allelopathic cultivars, straw mulching, and proper water management and precise fertilizer and herbicide application; and the integrated combination of diverse tactics based on an in-depth understanding of weed biological and ecological principles governing weed population dynamics. Further approaches such as herbicide resistant weed management (HRWM) program customization for integrated weed control with conservation agriculture (CA) can be employed to develop sustainable weed management strategies in China.

（This work was supported by the Special Fund for Agro-Scientific Research in the Public Interest (201303022), National Natural Science Foundation of China (31171863, 31570434, 31650110476), the Science and Technology Department of Zhejiang Province (2015C32062, 2016C02050-8, 2016C32089), and Jiangsu Collaborative Innovation Center for Modern Crop Production.）

Keywords: Weed community; Invasive weed; Herbicide; Herbicide resistance; Integrated weed management.

O-075

Weed research issues, challenges, and opportunities in India

A.N. Rao[1*], Ravi G. Singh[2], G. Mahajan[3], S.P. Wani[4], J.K. Ladha[5], Arvind Kumar[5] and B.S. Chauhan[6]

[1] ICRISAT Development center (IDC) & International Rice Research Institute (IRRI); International Crops Research Institute for Semi Arid Tropics; Building # 303, ICRISAT; Patancheru, Hyderabad, India – 502324; *Presenter, email: anraojaya1@gmail.com
[2] International Maize and Wheat Improvement Center (CIMMYT), Texcoco de Mora, Mexico
[3] The University of Queensland, Queensland Alliance for Agriculture and Food Innovation, Room # 130, Building 8103, Post Box 1218, Gatton 4343, Queensland, Australia
[4] ICRISAT Development center (IDC), International Crops Research Institute for Semi Arid Tropics (ICRISAT); Patancheru, Hyderabad, India – 502324
[5] International Rice Research Institute (IRRI), Los Baños, Philippines
[6] The University of Queensland, Queensland Alliance for Agriculture and Food Innovation, Room 125, Building 8103, Post Box 1218, Gatton 4343, Queensland, Australia

Agriculture is the major source of livelihood for nearly half of the Indian population. However, the productivity of crops is much lower than many countries and needs enhancement to produce ~400 million tons of food grains for meeting food demands of a population of 1.7 billion by 2050. Diverse climatic conditions in India favor the most adopted weeds to prevail and cause severe crop yield losses. Weeds also degrade quality of the produce, raise cost of production; harbor and serve as alternate hosts to several insect pests and diseases. *Parthenium hysterophorus* L.; *Phalaris minor* Retz.; *Leptochloa chinensis* (L.) Nees., *Echinochloa* spp.; weedy rice; *Lantana camara* L., *Chromolaena odorata* (L.) R.M. King & H. Rob.; *Mikania micrantha* Kunth., are a few of many major weeds of concern currently in India. Weed management in India is critical to improve crops productivity by minimizing weeds caused crop yield losses and to alleviate other adverse effects of weeds in different ecosystems. In spite of the progress made in evolving weed management technologies for different crops and other ecosystems, weeds continue to be a concern in varying ecosystems. The real challenges of Indian weed research are: managing weeds in small farms; non availability of labor and mechanical tools; inadequate information on weed biology and shifts in weed flora; popularizing integrated weed management with herbicides use by ensuring safe use to avoid adverse effect on human health, environment and avoid weeds developing herbicide resistance and prevention of entry and management of alien invasive weeds. The greatest opportunity of Indian weed science is the potentiality of appropriate weed management technologies to substantially improve the crops productivity. Thus, weed scientists have a greater role to play in the development, popularization and adoption of location specific effective, economical and eco-friendly weed management technologies for different ecosystems of India.

O-076

Weed Problems in Japan

Tohru Tominaga[1] and Shunji Kurokawa[2]

[1] Kyoto University, Kitashirakawa Oiwake-cho, Sakyo, Kyoto 606-8502, Japan
[2] National Agriculture and Food Research Organization, Kannondai, Tsukuba 305-8666, Japan

Weed problems of field crop production in Japan to be solved will be presented. Field crop production of Japan is characterized by rice cultivation and small size farming. Most major field crops other than rice are imported and various kinds and a very large amount of living weed seeds contaminate the imported grains. These alien weeds sometimes invade agricultural fields and cause losses of crop yields and reductions in the quality of agricultural products. Emergence of herbicide resistant biotypes of weeds, especially paddy weeds, is also issues to be solved. The first herbicide-resistant paddy weed biotype was reported in 1996, and was a *Monochoria korsakowii* resistant biotype to sulfonylurea (SU), an acetolactate synthase (ALS) inhibitor. Since then, SU herbicide-resistant biotypes of 21 species have been reported. Among them, target-site resistance is common. Non-target site resistance has been reported in *Sagittaria trifolia* and *Echinochloa crus-galli* var. *formosensis*. These resistance mechanisms are not fully understood. Weedy rice is recently emerging again due to the change of rice production system and the origin of recently emerging weedy rice is not clarified yet.

Weed flora is changing with the changes in cultivation practices. Due to the changing environment, weed flora is also changing; therefore, monitoring weed flora is important for avoiding the spread of the problematic weeds and the unintentional introduction of alien weed seeds.

O-077

Confirmation of imidazolinone-resistant weedy rice (*Oryza sativa*) in Malaysia

Dilipkumar Masilamany[1], Zuhair Zainal Abidin[2], George Varghese[2], Nilda Roma Burgos[3], Chuah Tse-Seng[4]

[1] Malaysian Agricultural Research and Development Institute (MARDI), 13200 Kepala Batas, Pulau Pinang, Malaysia
[2] BASF (Malaysia), 40706 Shah Alam, Selangor, Malaysia
[3] University of Arkansas, 1366 W. Altheimer Drive, Fayetteville, AR 72704, USA
[4] University of Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia

Clearfield® rice production system is an effective management tool for weedy rice and other weeds in direct-seeded rice. However, if farmers cultivating Clearfield® rice disregard stewardship recommendations, the industry could face a problem with herbicide-resistant weedy rice through selection of outcrosses. This study aimed to confirm imidazolinone-resistant weedy rice in Malaysia. The resistant weedy rice (R-WR) was 67-fold more resistant to OnDuty® (premix of imazapic and imazapyr) than the susceptible weedy rice based on the GR50 values (rate that causes 50% inhibition of shoot growth). The Clearfield® rice cultivar was 32-fold more tolerant to OnDuty® than the standard susceptible weedy rice. In addition, the R-WR was 54- and 89-fold more resistant to imazapic and imazapyr than the susceptible weedy rice, respectively, whereas Clearfield® rice cultivar tolerant to imazapic and imazapyr up to 140- and 40-fold more than that of standard susceptible weedy rice, respectively. This study documents the first case of weedy rice that is cross-resistant to imazapic and imazapyr in Malaysian Clearfield® rice field.

O-078

Current issues related to weeds and weed management in Sri Lanka

Buddhi Marambe
Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka
Email: bmarambe@pdn.ac.lk

Weeds have been reported to reduce crop yields by as much as 50%, in addition to quality of the final crop produce, thereby reducing the overall productivity of land and income of farmers and adversely affecting the quality of the island's native biodiversity. Sri Lanka has identified 25 Weeds of National Significance (WONS), which includes major weeds of rice, other field crops, waterways and plantation crops, and 20 priority invasive alien plants. Weedy rice (*Oryza sativa* L. *f* spontanea) has threatened the lowland paddy fields. A shift in weed flora has been observed in rice paddies over the years due to shift in herbicide use [e.g. dominance of *Leptochloa chinensis* (L) Nees due to continuous use of bispyribac sodium and *Ischaemum rugosum* Salisb due to use of quinclorac]. Paraquat-resistant *Erigeron sumatrensis* Retz. and *Crassocephalum crepidioides* (Benth). S. Moore, and propanil-resistant *Echinochloa crusgalli* (L) Beauv, are the consequences of the misuse of herbicides. Invasive alien plant species have become a menace to the country's agro-biodiversity. The government of Sri Lanka recently banned the importation and use of paraquat in 2014 due to its high mammalian toxicity. Glyphosate was banned while prapanil was restricted in use due to their suspected contribution to Chronic Kidney Disease of uncertain Etiology (CKDu). These decisions have seriously affected the pre-plant weed control in paddy and upland food crops and plantation crops such as tea. Adoption of new technologies of weed control to realize high yield potentials and economic returns from the crop production systems is of high priority at present in the country. National Priorities for Plant Protection Research, which includes research priorities in weed science, have been adopted, updated periodically to address these key issues related to weed control in Sri Lanka.

Keywords: Weeds of National Significance (WONS), National Priorities in Plant Protection, Weedy rice, herbicide-resistant weeds

O-079

Survey of Weed Floral Composition Under Aerobic Rice (*Oryza sativa* L.) Soil Condition In Malaysia

Siti Nur Anisah Aani,[1,3] Abdul Shukor Juraimi,[1,2] Muhammad Saiful Ahmad Hamdani [2] and Mohd Ridzwan A.Halim[2]

[1]Institute of Tropical Agriculture, Universiti Putra Malaysia, Serdang 43400, Selangor, Malaysia
[2]Department of Crop Science, Universiti Putra Malaysia, Serdang 43400, Selangor, Malaysia
[3]Department of Crop Protection, Universiti Teknologi Mara, Jasin 77300 Melaka, Malaysia

Aerobic rice systems that grown in nonpuddled and nonsaturated soil can become a significant alternative to the flooding rice cultivation system in the wake of water shortage and climate change crisis. This technology will be the best option of producing rice in water limited environment by reducing 50% of water application compared to full flooding system. However, aerobic rice cultivation is impeded by high weed pressure since it germinates simultaneously with weeds due to lack of standing water. Weed invasion will increase yield loss and inevitably increases cost of rice production. Survey on weed population growth in aerobic rice is very important because of the quick changing of weed flora in response to changing agronomic management. Due to heavy weed infestation and resultant grain yield reduction, aerobic rice system has led to an over reliance on herbicides for controlling weeds, which is less sustainable for a long term weed control. Since very limited studies pertaining weed population growth in aerobic rice, proper documentation of this topic will contribute to better understanding for weed management particularly in Malaysia.

These studies were performed with the aim to identify and characterize weed population growth in aerobic rice condition under different types of soil medium in the glasshouse and aerobic rice field around Malaysia. For glasshouse experiment, a Randomized Complete Block Design composed of two factors namely rice cultivar (AERON1 and MRIA1) and soil texture (Tg.Karang, Hilir.Perak and Bachok) was used with 4 replications. Weed composition survey was conducted in three fields around Malaysia namely FELCRA Hilir Perak, Seberang Prai and Pulai, Melaka according to the quantitative survey method by using standardized quadrat. The most dominant weed species growing in the glass house and field experiment regardless of rice cultivar and soil texture were *Leptochloa chinensis, Cyperus iria, Fimbristylis miliaceae* and *Digitaria ciliaris.* Weed population was mostly dominated by sedges and grasses with very little contribution of broadleaved. Family of Poaceae (grass) and Cyperaceae (sedge) comprise roughly 79% of the total number of C4 species which performed better in dry and drought condition. Clay soil (Tg.Karang, FELCRA & Pulai) has more fine particles that can hold water and nutrients needed by weed plant better than sandy soil (Bachok & Seberang Prai) which provides easier passage through its aggregation. These findings will be the key tool for sustainable weed management since weed invasion is the most fundamental problem in aerobic rice cultivation.

O-080

Opportunities for capacity building in weed management - Laos PDR

Deirdre Lemerle, Graham Centre for Agricultural Innovation, Charles Sturt University, Wagga Wagga NSW 2650, Australia
dlemerle@csu.edu.au

Weeds reduce crop and pasture yield and quality, harbor harmful pests and diseases, and impact on native ecosystems. In Laos PDR, traditional hand-weeding mainly by women and children is unsustainable and limits adoption of productive systems. The aim is to improve the capacity of small-holder farmers for cost-effective weed management, help achieve higher yields, generate greater income stability, and improve livelihoods at village level. Previous international research and development (R&D) support in capacity building for weed management has been short-term and fragmented.

A scoping study was undertaken: to identify the key weed species and their impacts in dry-season crops; to understand the farmers' constraints to weed management; and to develop recommendations for training and R&D programs to increase farmers' capacity to manage weeds.

Preliminary observations confirmed that the weed flora in fields are generally very diverse, and many species are common around lowland and highland areas. Farmers' and extension staff's knowledge of weed ID and management is very limited. Many plant species are considered both weeds and useful (wild-harvest food, medicinal, grazing). Symptoms of diseases, viruses and pests were observed on some weed species, an indication of the importance of weeds as foci of infection. There appears to be considerable opportunity for cattle grazing and forage cropping to assist integrated weed management.

Three key areas are needed in Laos for sustainable weed management: accurate weed ID and herbarium facilities; training material for smallholder farmers; and R&D to develop a range of integrated chemical and non-chemical options to enable farmers to grow weed-free cash crops.

The opportunities to undertake long-term support programs relatively cheaply using international volunteers (e.g. retirees, students, people on vacations) for capacity building is discussed. Coordinated volunteers with different skills, and clustered together at specific locations, could achieve synergies and provide on-going continuity of support.

O-081

The Wild Oat Problem in Wheat Fields in Turkey

Ahmet Uludağ[1,2], Süleyman Türkseven[3], İsmail Can Paylan[3], Mehmet Demirci[4], Deniz Çapkan[3]

[1]Faculty of Agriculture and Nature Sciences, Düzce University, Düzce, Turkey
[2]Faculty of Agriculture, Çanakkale Onsekiz Mart University, Çanakkale, Turkey
[3]Faculty of Agriculture, Ege University, İzmir, Turkey
[4] Agrobest Grup, Ulucak, Kemalpaşa, Izmir, Turkey

Wheat is the foremost crop, which cover over one third of total agricultural land of Turkey. Wild oats (*Avena* spp.) are among the most important weed species in wheat and some other crops. A study has conducted to identify wild oat species and to find oat distribution of herbicide resistant wild oats in wheat fields in Turkey. Identification of species was made by classical morphological approach and molecular studies using 377 seed samples. The similarity of identification between two methods was 96 %. *A. ludoviciana* (*A. sterilis* subsp. *ludoviciana*) was the most common species with 212 samples followed by *A. fatua* with 92 and *A. sterilis* (*A. sterilis* subsp. *sterilis*) with 73. The most common herbicides were tested in screen house to find out resistant populations and characterize them. Out of 377 populations 246 was resistant to Fenexoprop-p-ethyl, 79 to Pinoxaden, 40 to Tralkoxydim, 181 to Mesosulfuron methyl+iodosulfuron methyl sodium, 184 to Proxycarbazone sodium+mesosulfuron methyl. It is showed that multiple and cross resistance has occurred in some populations, which makes solution difficult.

This study was supported by TÜBİTAK 113 0 419 project.

O-082

The succession of weed community demanding glyphosate-resistant corn production in China

Xiang-ju LI*, Hai-lan CUI, Hui-lin YU
(Institute of Plant Protection, CAAS, Beijing 100193, China)

Corn is one of the major crops in China with 38.11 million hectares in 2015. Weed control is the farmer's biggest challenges in corn production because the succession of weed community in corn field. The densities of weed species such as *Commelina communis, Cirsium setosum* and *Sonchus brachyotus*, etc increased in recent years, which are difficult to be controlled by common herbicides. It is estimated that crop yield losses due to weeds are approximately 900 Mt in China. Excellent weed control was impossible until the development of glyphosate-resistant crops. Glyphosate traditional use has been limited to non-crops and orchards for post-emergence application but now glyphosate-resistant crop system provides corn growers a new way to use it. By fast rate of adoption, GR corn occupied 30% of the global area of corn production in 2015 and was grown in 17 countries. Although no GR corn was commercialized in China, Chinese farmers showed a strong enthusiasm in growing GR corn. In this paper, the demand of glyphosate-resistant corn production in China was discussed based on China's actual conditions of corn production and herbicide use. Firstly, GR corn overcomes succession of weed species such as *Commelina communis*, *Cirsium setosum* and *Sonchus brachyotus*,etc and provides excellent control. Secondly, Glyphosate could replace pre-herbicides such as acetochlor and atrazine, the widely used soil applied herbicide in corn field in China which usually provide poor control in dry soil conditions. Glyphosate could replace herbicides such as atrazine, which bring frequent injuries to the following broadleaf crops in northeast China due to residues. Third, GR corn does well with less tillage which needs a burn-down treatment before corn planting in wheat-corn double cropping systems. Lastly, GR corn can help the labour shortage situation in China.

O-083

[Title]

How to manage weed resistance and protect yields – a company perspective

[Authors]

Bodo Peters

[Affiliation]

Bayer AG

[Abstract]

Bayer is committed to sustainable agriculture as the best approach to overcome the global challenges in agriculture like climate change, limitation of farmland and competition for key resources. This includes measures to increase farmer's profitability, to improve people's quality of life and to preserve the environment. One key element of this approach is Bayer's integrated weed management program (IWM) which utilizes the complete toolbox of weed control techniques supported by products, stewardship and services. The concept is supported by in-house scientific competence and partnerships all around the globe within the Weed Resistance Competence Center (WRCC). In addition to IWM approaches, this talk will focus on the activities of the WRCC and the reasons behind it. This will include a short excursion into the definition of weed resistance, the many mechanisms behind it and the key weeds affected in the Asia-Pacific region. Furthermore it will give examples of how the WRCC is supporting the launch of the new herbicide Triafamone, how the WRCC is collaborating with scientists in Australia to better understand metabolic resistance in *Lolium rigidum* and how surveying for weed resistance is being done in Southeast Asia.

O-084

Overcoming the resistance to the uptake of Integrated weed management tactics in farming systems

Murray Scholz

Scholz Farming Company, Culcairn, NSW, Australia

When herbicides were introduced, farmers largely stopped using integrated weed management (IWM) tactics because herbicides were simple to use, cost effective and gave excellent results. Over time, herbicide resistance (HR) has developed, with implications for conservation agriculture and the long term financial sustainability of farmers. As HR has developed weed seed banks have built up, making management more difficult and expensive.

While farmers are aware that herbicide resistance can develop, they tend to avoid adopting IWM tactics before resistance develops. Even when they have an issue with HR, many farmers believe IWM to be too difficult, to have too much short-term cost or to be ineffective in controlling weeds despite research to the contrary. Farmers' lack of experience, combined with the mindset that they can buy a solution, discourages them from taking up IWM until they have a serious issue with HR.

On our own farm, we have overcome a major issue with HR ryegrass by adopting multiple IWM strategies. While this has increased management complexity many of these strategies have been low cost, had benefits beyond weed management and increased profitability. We have reintroduced livestock and a pasture phase, adopted narrow windrow burning, targeted soil fertility issues and narrowed our seeder row spacings to improve crop competition.

In conclusion, depending on herbicides alone for weed management is unsustainable and will eventually fail. Introducing IWM tactics to a farming system prolongs the life of herbicides and can reduce costs while improving farm profitability. Researchers need to work with forward-thinking agronomists and farmers to foster champions who can demonstrate that IWM can be successful.

O-085

Seventeen years of continuous application of glyphosate leads to evolution of resistance and shift in weed species

Abul Hashem, Catherine Borger and Mohammad Amjad

Department of Primary Industry and Regional Development, Government of Western Australia, Northam, WA, Australia 6401

A long-term trial was conducted at Merredin (118°16'41"E, 31°28'58"S), Western Australia (WA) to examine the effect of long-term continuous application of glyphosate on the evolution of resistance and shift in weed species. Four non-replicated treatments (low and high rates of glyphosate at 3-leaf stage and, low and high rates of glyphosate at spray-topping stage) were applied annually from 1999 to 2016 each on one hectare plot of clay loam soil initially infested with 400 plants/m^2 of rigid ryegrass (*Lolium rigidum*). In 1999, other weed species including barley grass (*Hordeum leporinum*), red brome (*Bromus rubens*) and wild oats (*Avena fatua*) were also present at very low densities (less than 1 plant/m^2). Densities of rigid ryegrass, red brome, barley grass, wild oats and other emerging weeds were recorded annually and the glyphosate resistance status in rigid ryegrass and other weed species was tested periodically. Continuous application of glyphosate not only evolved glyphosate-resistant weed biotypes but also resulted in the incursion of new weed species unforeseen on the site. Spray-topping with low rates of glyphosate increased density of barley grass, wild oats and windmill grass (*Chloris truncata*) while spray-topping with high rate of glyphosate reduced density of ryegrass but increased *Cleretum papulosum* and medic (*Medicago* spp). In contrast, high rate of glyphosate applied at 3-leaf stage greatly reduced density of ryegrass but drastically increased windmill grass. Shifts in the weed species' composition from highly susceptible toward more tolerant species occurred faster than selection of resistance. Growers need to use the correct label rate of glyphosate and rotate glyphosate with other effective herbicides from alternative mode of action along fence lines, firebreaks and in glyphosate-tolerant crops to minimise the risk of glyphosate resistance and the incursion of new weed species.

O-086

Herbicide Resistant Weeds and their Emerging Trends in China

Chaoxian ZHANG, Hongjuan HUANG, Shouhui WEI, Jingchao CHEN, Zhaofeng HUANG, Cuilan JIANG

Key Laboratory of Weed and Rodent Biology and Management, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing 100193, China

China is a big agricultural country, and many crops, including staple crops (rice, wheat, maize, sweet potato, potato, soybeans, etc) and cash crops (cotton, oil seed rape, sugar beet, tobacco, herbs, etc) have been grown with various cropping systems (multiple cropping, intercropping, rotation) and higher cropping index across the country. Not surprisingly, all crops are accompanied by WEEDS, and which are severely threatening food security, seriously reducing crop yields and quality of agricultural products. To curb down those weeds, mechanical, cultural, physical and biological means are encouraged to be implemented, however, chemical weed management has been playing a dominant role in weed management in China, thus, herbicide demand and herbicide treated areas are increasing steadily. As a result, unfortunately, there are 64 biotypes of 39 weed species (22 dicots, 17 monocots) have evolved resistance to 31 herbicides of 10 groups, and widely distributed in China, especially, some of those herbicide resistant weeds are highly resistant to herbicides. For example, *Descurainia sophia* had evolved high resistance to tribenuron with resistant indices up to 1175, 1472 and 1594 in Hebei and Shaanxi Provinces, respectively, besides of its high resistance, 124 *D. sophia* populations out of 154 populations collected from Hebei Province showed resistance to the herbicide. And more, tribenuron-methyl resistant *Galium aparine*, *Malachium aquaticum* and *Capsella bursa-pastoris* populations with resistant indices of 1834, 2187, 2950 in Henan Province and 1215, 2472, 3079, 3549 in other Provinces were also reported. Fenoxaprop-P-ethyl resistant *Alopecurus japonicus* with resistant indices up to 1574 was reported in Anhui Province. Even worse situation is that herbicide resistant weeds with either target (single, or multiple, or cross) or non target resistant mechanisms simultaneously exist in China. With the development of rural economy and reformation of agriculture, a more rational, sound and divers weed management is desired for Chinese agriculture.

O-087

Current status and management of herbicide resistance weeds in Sri Lanka

A.S.K. Abeysekara[1], D.D. Witharana[2], T.M.G.H Tennakoon[1] and W.M.U.B. Wikrama[1]

[1]Rice Research and Development Institute, Batalagoda, Sri Lanka
[2]Postgraduate Institute of Agriculture, Peradeniya, Sri Lanka

Weed control has become a major problem in wet seeded rice in Sri Lanka. Farmers mainly depend on chemical weed control practices due to weed control efficacy and low cost. However, herbicides becoming the prominent option, continuous application with the same mode of action, low spray volumes, farmer formulated tank mixtures, and unsuitable herbicides selection leads to the emergence of herbicide-resistant weeds. In different isolated regions of major rice growing areas in Sri Lanka weed species of *Cyperus iria, Cyperus difformis, Lindernia specioes, Echinochloa crusgalli and Ischaemum rugosum* resistant to MCPA and sulfonylurea group herbicides are found. Field studies were conducted to evaluate the efficacy of different herbicide with varying modes of action to eliminate the herbicide resistant weeds in herbicide resistance weed fields. Randomized complete block design used with three replicates in three different rice ecosystems, during major and minor seasons in 2015/16. Six treatments of different mode of actions were tested. Metamifop 10% EC @ 1500ml/ha (Acetyl Co-A Carboxylase Inhibitor), MCPA @ 1800ml/ha (Growth regulator), Metamifop 10% EC @ 1500ml/ha, Carfentrazone-ethyl 240g/l EC @ 75g/ha (Protoporphyrinogen oxidase inhibitor), Bispyribac sodium 100g/l SC @ 300ml/ha (Acetolactate synthase inhibitor) and Florpyrauxifen-benzyl 2.5% EC @ 1500ml/ha (Growth regulator) with weeded and un-weeded treatments. Results indicated that herbicide treated plots in all the locations showed significantly reduced weed density and weed dry biomass over the un-weeded plots. Further investigation showed that Florpyrauxifen-benzyl is an effective herbicide for control grass (96%), broadleaf (84%) and sedges (88%), Metamifop for grasses (90%) and Carfentrazone-ethyl is effective for broad leaf (85%) and sedges (87%). Bispyribac sodium and MCPA showed to have the lowest weed control efficacies of 32% and 25% respectively. The studied confirmed that integrated weed management strategies involving new mode of action of Florpyrauxifen-benzyl, Metamifop and Carfentrazone-ethyl are better alternatives for controlling resistant weeds.

O-088

Current and Future Herbicide Resistance Challenges in Asia

Vinod Shivrain[1], Florinda Vasquez[2], Xiaolong Jiang[3], Susan Knight[1], Ajit Kumar[4], Gaylene Marsden[1], Sugiyama Minoru[5]

[1] Syngenta Asia Pacific Pte. Ltd., Singapore
[2] Syngenta Philippines Inc., Manila, Philippines
[3] Syngenta (China) Investment Co., Ltd, Beijing, China
[4] Syngenta India Ltd., Karnal, India
[5] Syngenta Japan, Tokyo, Japan

Asia is one of the biggestand most diverse regions in terms of crops grown, (~ 400 million hectare) farm size, weed species, and rate of farming technology adoption. Among broad-acre crops, rice has the highest cultivation area, followed by cereals, corn, cotton, sugarcane, oil-palm and rubber plantations. Over last two decades, due to intensive farming, reduced availability of labour, and aging demographic of growers, herbicide usage has increased significantly across crops in the majority of the Asian countries, which has resulted in high selection pressure for resistant weed biotypes.

Within Asia, Japan, S-Korea & Taiwan are facing the tough challenge of weeds in rice that have resistance to multiple herbicides. For example, in Japan >90% of rice production area is infested with resistant weeds. The most serious problem is posed by the increasing frequency of non-target-site mutations to ALS inhibitors and the occurrence of Echinochloa spp. that are resistant to “new generation” ALS inhibitors. In India and Pakistan, Phalaris minor in wheat has evolved multiple resistance across two different modes of action. Some of these populations have low levels of resistance to ALS inhibitors but high levels of resistance to ACCase inhibitors. No herbicide resistant weed has been documented in rice production in India or Pakistan. The common practice of herbicide application followed by hand-weeding of surviving weeds may have helped in delaying resistance in this case. On the other hand, in China, region-specific multiple herbicide resistance has been documented in Echinochloa crus-galli and Beckmannia syzigachne, Alopecurus aequalis, Galium aparine in rice and wheat production systems, respectively. Additionally, 33% of the corn production area in China is affected by herbicide resistant weeds, mainly driven by ALS chemistry. In Southeast Asia (Thailand, Vietnam, Indonesia, Malaysia), resistance has been documented in key rice weed species across different modes of action.

Use of crop protection chemicals including herbicides is still increasing in the majority of Asian countries, thus increasing selection pressure for resistance evolution in weeds. If not managed properly, this will lead to more herbicide resistant weed populations and lower farm productivity. There is a huge opportunity in Asia for the public and private institutions to work together on this challenge, to delay the evolution of herbicide resistance Ultimately this will help to keep food production costs low and will ensure higher profitability for the farmers.

O-089

OUTCROSSING OF HERBICIDE RESISTANCE RICE WITH LOCAL WEEDY RICE VARIANTS IN MALAYSIA

Norida Mazlan[1,3], Nur Hidayatul Shuhada Anuar[1] , Engku Ahmad Khairi Engku Ariff[1],
Siti Nor Akmar Abdullah[1,] Abdul Shukor Juraimi[2] and Mohd Rafii Yusop[2,3]

[1]Department of Agriculture Technology, [2]Department of Crop science,
Faculty of Agriculture, Universiti Putra Malaysia.
[3]Institute Tropical Agriculture and Food Security, Universiti Putra Malaysia

Clearfield® varieties has successfully control weedy rice infestations. However, the possibility of gene to outcrossed to weedy variants producing super weeds is a major concern. The objective of this study was to examine whether the gene introgression from Clearfield® varieties to local weedy variants can occur. The study was conducted in three parts. In the first study, Clearfield® varieties and weedy variants were observe the morphological characteristics. The second study was conducted in rice field. Four variants of weedy rice were planted at a distance of 1m, 2m, 3m 4m and 5m from the Clearfield® rice. Germinated seeds (F1) from weedy rice were sprayed with OnDuty™ at day fourteen with a rate of 214 g/ha. In the third study, manual pollination between two Clearfield® varieties and weedy variants were performed. Crossed seeds were collected and germinated in trays before the progenies were sprayed with OnDuty™ at day fourteen with a rate of 214 g/ha. Molecular analysis was conducted for second and third studies to confirm whether the gene introgression has occurred in the F1 progenies using ten different Simple Sequence Repeats (SSR) primer. The first study showed that weedy rice was morphologically superior to Clearfield® rice whereby it had double the number of tillers and taller. In the second study, weedy rice V1 showed the highest survival percentage, at 22.45%. F1 of CL2 crossed with V2 were the best combination of parent with 28.91% seedlings survived. About 80% seedlings survived from CL2V1 at the distance of 1m. In the third study, WR4 crossed with CL1 produced the highest number of fertile seeds, while the lowest number is from the crossing of WR4 with CL2. The results also showed that between CL1 and CL2 variants, CL2 has higher compatibility to cross with all WR biotypes, with 100% were successfully survived. Molecular study showed that SSR primer RM251 is the suitable primer to confirm the hybridization between Malaysian Clearfield® rice and variants. In a nutshell, gene introgression from Clearfield® varieties to weedy variants can occur under field condition and the percentages could increase with days of overlapping and wind speed. Flowering synchronization and genetic compatibility between Clearfield® varieties and weedy biotypes also can influence the rate of gene introgression.

O-090

Weed Control Efficacy and Herbicide Resistance Management of Rinskor ™ Active in rice fields in Asian countries

Lê Duy[1], Trần Trọng Vinh[1], Mongkol Sripeangchan[2], Bobba Venkata Niranjan Kumar[3], Robert A. Master [4], Richard K. Mann[4] and Mauricio Morell [4]

[1] Dow AgroSciences Vietnam B.V, 106 Nguyen Van Troi, Ho Chi Minh city, Vietnam
[2] Dow AgroSciences Thailand, Whitegroup 2, Sukhumvit, Bangkok, Thailand
[3] Dow AgroSciences Malaysia, CP Tower, Jalan Damansara, Kualar Lumpur, Malaysia
[4] Dow AgroSciences LLC, Zionville, Indianapolis, Indiana, U.S

Four different rice herbicide products were tested for efficacy on multiple *Echinochloa crus-galli* weed populations collected from 10 locations in the Mekong delta of Vietnam and 3 locations from Suphanburi region in Thailand during the summer season of 2016. The screening test for penoxsulam, bispyribac-sodium, quinclorac and Rinskor™ active which belongs to arylpicolinate herbicide group) was conducted to calculate the LD_{90} and herbicide resistance level of the collected weed populations. Average LD_{90} of penoxsulam for the 10 *E. crus-galli* populations in Vietnam was 16.1 g ai/ha compared to 30.5 g ai/ha for populations in Thailand. Average LD_{90} for bispyribac-sodium in Vietnam and Thailand was 40.4 g ai/ha and 57.4 g ai/ha, respectively. *E. crus-galli* populations in Vietnam were more sensitive to quinclorac compared to populations in Thailand; the average quinclorac LD_{90} value was 319 g ai/ha for Vietnam as compared to 412 g ai/ha for Thailand. The LD_{90} for Rinskor for *E. crus-galli* populations in Vietnam was lower than for the weeds collected in Thailand (10.9 g ai/ha and 14.3 g ai/ha respectively). Weed control efficacy at recommended doses of the four tested products demonstrated resistance to penoxsulam, bispyribac-sodium, and quinclorac in several weed populations in the two countries. In Vietnam, based on Resistance rating scale of Moss *et al.* (2007) four out of ten populations were identified as resistant to penoxsulam, six populations were resistant to bispyribac, and seven populations were resistant to quinclorac. All ten populations were susceptible to Rinskor. In Thailand, all 3 weed populations were identified as being resistant to penoxsulam, bispyribac, and quinclorac, while Rinskor at its recommended dose provided >90% control of the 3 tested populations.

Keywords: herbicide resistance management, arylpicolinate herbicide, ALS inhibitor, rice, weeds

O-091

Strategies to manage multiple resistant wheat weeds in India to herbicides of several sites of action

Samunder Singh, Aman Dhillon, Pawan Gowda, Mohammad Irfan and Pradeep Kumar

Department of Agronomy, CCSHAU Hisar 125004, India; sam4884@gmail.com

Chemical weed control adoption not only simplified weed flora, but also caused weed shift and evolution of resistant species. Herbicides are the choice of weed management tools in north India covering 80-90% fields in wheat and paddy, respectively; however, resistant weeds so far evolved only in wheat. *Phalaris minor* has become the most troublesome wheat weed, significantly denting its productivity. Continuous use of a single herbicide over the years has not only evolved resistance to isoproturon (PSII) in the nineties, but also cross- and multiple-resistance followed to diclofop, fenoxaprop, clodinafop, pinoxaden (ACCase), sulfosulfuron and premix of mesosulfuron + iodosulfuron (ALS inhibitors) mediated by enhanced metabolism and target site mutation. Recently resistance too evolved in *Avena ludoviciana*, *Rumex dentatus*, *Chenopodium album* and *Polypogon monspeliensis* to several herbicides. Studies conducted in the University and farmers' fields using pendimethalin PRE alone or tank mixed with other PRE or sequential POE herbicides provided some control of *P. minor*, but not against all populations. Metsulfuron + carfentrazone or 2,4-D amine/ester were effective against resistant *R. dentatus* and *C. album* compared to metsulfuron, fenoxaprop/sulfosulfuron+metsulfuron and meso+iodosulfuron. Pinoxaden controlled clodinafop, fenoxaprop and sulfosulfuron resistant *A. ludoviciana* and *P. monspeliensis*. Mechanical weeding, is less effective due to narrow row spacing of wheat and no control of weeds in-between the rows, but can take care of 60-70% emerged weeds with manual hoe. Seed treatment with *Bacillus subtilis and Providentia rettgeri* not only increased wheat growth compared to untreated seed, but also significantly lowered herbicide toxicity; the results on *P. minor* suppression; however, were inconsistent over the years and need further investigation. Flumioxazin PRE has been found effective against resistant *P. minor*, but caused crop injury due to moisture variation in soil types. An integrated approach using agronomic practices, chemical, mechanical and biological approach is required to manage resistant weeds.

O-092

Efficacy of MSMA Based Premix Herbicides on Control of Goosegrass that Evolved Multiple Resistance Across Glyphosate, Glufosinate and Fluazifop in Malaysia

Sim Khay Chuan[1], Anthony Tan Swee Hock[1], Wong Kian Joo[1] and Chuah Tse Seng[2]

[1]Ancom Crop Care Sdn. Bhd., Malaysia
[2]University Malaysia Terengganu, Malaysia

Eleusine indica, commonly known as goosegrass, is an annual noxious grassy weed which has a wide tolerance to environmental stresses. In Malaysia, infestation of goosegrass at young oil palm and rubber plantations, orchards and vegetable fields has caused a significant loss in crop yields. Currently, this weed species has developed resistance to four groups of herbicides including glyphosate, glufosinate, paraquat or/and fluazifop. This study aimed to determine efficacy of MSMA based premix herbicides on control of the resistant biotypes of mature goosegrass (RG). Under greenhouse conditions, Monex HC (MSMA + Diuron at 2945 + 600 gai/ha) and Mistura 18 (MSMA + Diuron + Glufosinate at 1350 + 255 + 330 g ai/ha) provided 80-95% growth inhibition on the RG plants whereas glufosinate, glyphosate, fluazifop at their respective recommended rates gave less than 40% inhibition of growth or exhibited 125-135% growth stimulation on the RG plants 4 weeks after treatment. Under field conditions, both Monex HC and Mistura 18 gave complete control of the RG plants after 2 weeks of treatment at vegetable farms. In contrast, partial scorching was observed on the RG plants at one week after treatment with glufosinate, glyphosate and fluazifop, respectively, and the RG plants started to regrow at 2 weeks after treatment. These results suggest that MSMA plus diuron with or without glufosinate could provide excellent control of gooosegrass that evolved multiple resistance across glyphosate, glufosinate and fluazifop.

O-093

Strategic cultivation for control of glyphosate-resistant weeds in Australian conservation agriculture – considering weed ecology and cultivation type

Michael Widderick[1] and Andrew McLean[1]

[1]Queensland Department of Agriculture and Fisheries, Toowoomba Qld 4350, Australia

Conservation agriculture is commonly practiced in Australian farming systems, primarily to preserve soil moisture and reduce soil erosion. Great gains in crop production have been made as a result of this farming approach that relies heavily on herbicides for weed control. However, as a result of heavy reliance on herbicides, herbicide resistance is now widespread. In Australia's subtropical cropping region of Queensland and New South Wales, there are now eight weed species confirmed as having resistance to glyphosate, including *Echinochloa colona*, *Chloris virgata*, *Chloris truncata* and *Sonchus oleraceus*. This paper reports on the alternative control tactic of a strategic, one-off cultivation and the impact on seed burial, emergence and potential persistence of these four weeds.

A series of four field trials over four years compared five cultivation types; zero cultivation, harrows, gyral, offset discs and one-way discs. Prior to application of the single-pass treatments, seed of each target weed were sown on the soil surface. In addition, small glass beads, to mimic weed seeds, were placed on the soil surface. After tillage, soil cores were taken to recover buried glass beads as an indicator of seed burial, and seedling emergence was monitored over a period of 18 months.

The effect of cultivation differed between trials. In wetter years, all cultivation treatments resulted in a reduction in emergence of all species when compared with the zero cultivation treatment. However, in drier years, emergence of weeds was greater in cultivated treatments, due to persistence of buried weed seeds.

While the reintroduction of cultivation shows potential in reducing emergence of key weed species, the impact of seed burial on prolonging the persistence of the weed seed bank needs to be considered. In addition, if cultivation is to be reintroduced, it needs to be done so strategically to reduce risk associated soil and moisture loss.

O-094

Identification of paraquat-resistant *Eleusine indica* populations in corn fields across district of Tiga Binanga, Karo, Indonesia

Edison Purba[1], Kristian Adinata Ginting[1]

[1]Department of Agrotechnology, Universitas Sumatera Utara

Paraquat is commonly used for weed control when the corn plants growing older in Karo Regency, North Sumatera, Indonesia. Recently farmers in the area reported that paraquat was no longer effective to control goosegrass in the corn fields. However, no information related to the failure of to control goosegrass (*Eleusine indica*) either due to resistance or not in the populations. The study aimed to identify goosegrass populations that have developed resistance to paraquat. Seeds of goosegrass were collected from 50 to 60 clumps per population of 28 populations. Screening test for paraquat resistance was performed by spraying goosegrass plants at 4- to 6-leaf stage with 150 g a.i paraquat per hectare. Confirmed paraquat-resistant populations were further tested for dose response to paraquat. Survival plants were compared to a population which had never been exposed previously to herbicide collected from Universitas Sumatera Utara campus. Dose response test was performed onto the populations confirmed resistance on screening test by applying eight rates of paraquat (0, 25, 50, 100, 200, 400, 800, 1600 g a.i./ha). The results showed that two populations of *E. indica* have developed resistant, four populations developed moderate resistant, and 21 populations remained susceptible to paraquat. Resistant index of the two resistant populations were >5 and >9 times of susceptible population consecutively. These data highlight the importance of an appropriate weed resistance monitoring program to track the evolution and dispersion of resistance to mitigate these issues and raising awareness among stakeholders in the region.

O-095

a novel EPSPS Thr-102-Ser mutation endows glyphosate resistance in *Tridax procumbens*

Jingbo Li[1,2], Qiong Peng[2,3], Heping Han[2], Qin Yu[2], Stephen B. Powles[2]

[1]Hunan Provincial Collaborative Innovation Center for Field weeds control, Hunan University of Humanities, Science and Technology; [2]Australian Herbicide Resistance Initiative, University of Western Australia, Perth, WA, Australia; [3]Hunan Academy of Agricultural Sciences, Changsha, China

The tropical *Tridax procumbens* is a global weed of 31 crops in 60 countries. In Australia, it is mostly found in Northern Australia, infesting vegetables, pasture, irrigated and rainfed crops. Recently, a *T. procumbens* population from Kununurra, Western Australia was suspected to have evolved glyphosate resistance. This population had been managed with repeated glyphosate treatments over several years with poor control only recently evident. Glyphosate dose response experiments confirmed this population with low-level (3-4 fold) glyphosate resistance. Our mechanism studies found that resistance was not due to non-target-site reduced glyphosate uptake or translocation, nor due to target-site EPSPS overexpression. Instead, sequencing and cloning of a 998 bp EPSPS cDNA fragment covering potential mutation sites from resistant vs susceptible plants revealed a new point mutation at amino acid position 102 (ACC to TCC), resulting in Thr-102-Ser substitution. This novel mutation is very likely responsible for the low-level glyphosate resistance in this population. The Thr-102 is within the strictly conserved region in EPSPS, close to glyphosate binding site and crucial for EPSPS catalytic efficiency. Certain mutations at this Thr-102 site can endow high-level glyphosate resistance but reduce EPSPS catalytic efficiency unless compensated by other concurrent mutation(s), such as the recently discovered double Thr-102-Ile/Pro-106-Ser (TIPS) mutation in *Eleusine indica*. Nevertheless, the substitution of Thr-102 by the Ser residue (similar polarity to Thr and smaller than Ile) would likely be sufficient for endowing glyphosate resistance with minimum reduction of catalytic efficiency. In addition, the ploidy was determined to be tetraploid and two EPSPS genes confirmed for the resistant and susceptible *T. procumbens* plants used in this study. Further work underway involves cloning full EPSPS sequences and understanding the structural basis (3D) of glyphosate resistance endowed by this single Thr-102-Ser mutation.

O-096

The dose responses of various sulfonylurea-resistant *Monochoria vaginalis* to ALS inhibitors

Kensuke Ohta[1], Yoshimi Fujino[2], Yoshinao Sada[1]

[1]Health & Crop Sciences Research Laboratory, Sumitomo Chemical, 636-2, Kishiro-cho, Kasai 675-2333, Japan
[2]Crop Protection Division International, Sumitomo Chemical, 27-1, Shinkawa 2-Chome, Chuo-ku, Tokyo 104-8206, Japan.

Monochoria vaginalis is one of the most noxious weeds for paddy rice in Japan. *M. vaginalis* is known to become resistant to sulfonylurea (SU) herbicides by a target-site mutation in its acetolactate synthase (ALS) genes. Among five ALS genes (*ALS1~5*), an amino acid substitution in ALS1 or ALS3 is found from each of SU-resistant *M. vaginalis* plants. In this study, dose responses of SU-resistant accessions with different Pro_{197} mutations to imazosulfuron, bensulfuron-methyl, metsulfuron-methyl, imazaquin-ammonium and bispyribac-sodium at *in vivo* whole-plant level and those of the same accessions to imazosulfuron at *in vitro* enzymatic level were investigated.

In whole-plant tests, all the SU-resistant accessions with Pro_{197} mutations were highly resistant to two commonly used SU herbicides (imazosulfuron and bensulfuron-methyl), but were much less resistant to another SU herbicide, metsulfuron-methyl, and were substantially not resistant to imazaquin-ammonium and bispyribac-sodium. Furthermore, different Pro_{197} mutations conferred different dose responses to these herbicides on *M. vaginalis* plants.

In enzymatic tests, the ALS enzymes extracted from all the SU-resistant accessions were resistant to imazosulfuron *in vitro*, compared to that of the susceptible accession. In addition, the resistant levels of the ALS enzymes correlated with the whole-plant resistance levels. These results confirmed that the resistance of *M. vaginalis* is caused by the altered ALS enzymes. Furthermore, the dose–responses of the SU-resistant accessions with Pro_{197} mutations in ALS1 or ALS3 showed double-sigmoid curves with the plateaus located between 40% and 60% activity. This suggests that two of five ALS genes (ALS1 and ALS3) are working primarily in *M. vaginalis*.

O-097

Stacking effects of the mutated ALS genes in SU-resistant *Schoenoplectiella juncoides*

Yoshinao Sada

Health & Crop Sciences Research Laboratory, Sumitomo Chemical, 636-2, Kishiro-cho, Kasai 675-2333, Japan

Schoenoplectiella juncoides (Roxb.) Lye is a noxious sedge weed in Japanese rice paddy fields that has evolved resistance to sulfonylurea (SU) herbicides. The molecular basis of resistance is a target-site mutation in acetolactate synthase (ALS) genes. From each of SU-resistant *S. juncoides* plants, a nucleotide substitution in either of *ALS1* or *ALS2* causing an amino acid substitution is found. The loci *ALS1* and *ALS2* are considered independent. A new *S. juncoides* accession that has a Trp_{574}Leu mutation in both of ALS1 and ALS2 was established by cross-breeding between an ALS1-mutated plant and an ALS2-mutated plant. In this study, the resistance profiles of the double-mutated SU-resistant *S. juncoides* accession were investigated from the view of *in vitro* enzymatic resistance and whole-plant resistance in comparison with the parental half-mutated two accessions as well as a wild-type accession. In the enzymatic dose-response test using an SU herbicide imazosulfuron, the two half-mutated accessions drew double-sigmoid curves, suggesting a co-existence of sensitive and resistant ALSs. In the curves, the ALS1-mutated accession showed a higher plateau than the ALS2-mutated accession in the ALS activities, suggesting that ALS1 is more abundant than ALS2 in the extracts. On the other hand, the wild-type and the double-mutated accesions drew single-sigmoid curves. The double-mutated accession showed the highest resistance *in vitro*, followed by the ALS1-mutated accession, followed by the ALS2-mutated accession, and followed by the wild-type accession. In the whole-plant dose-response test, the double-mutated accession showed the highest resistance to imazosulfuron, followed by the two half-mutated accessions (similar to each other), and followed by the wild-type accession. Thus, the enzymatic profiles and whole-plant profiles were generally correlated. As a conclusion, stacking of the mutated ALS genes conferred higher resistance on both enzymes and whole plants.

O-098

Single nucleotide substitution at Asp-376-Glu conferred various resistance patterns to AHAS inhibitors in a problematic rice field weed *Limnocharis flava*

Norazua Zakaria[1], Muhammad Saiful Ahmad-Hamdani[1], Mahbod Sahebi[1], Abdul Shukor Juraimi[1], Norhayu Asib[2]

[1] Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia, 43400, UPM Serdang, Selangor, Malaysia

[2] Department of Plant Protection, Faculty of Agriculture, Universiti Putra Malaysia, 43400, UPM Serdang, Selangor, Malaysia

Limnocharis flava (*L. flava*) belonging to the Limnocharitaceae/Alismataceae family is a common problematic weed in rice fields many countries, including Malaysia. *L. flava* is also a threat to the environmental integrity of marshland. It is an emergent aquatic herb that has invaded the rice fields, irrigation systems, competes with inhabitant plants for space, nutrient and light, resulting in the changes of ecological balance and causes adverse impact to the native aquatic fauna as well. The sole dependence on herbicides for *L. flava* control by rice growers however has caused this weed to develop resistance to the herbicides used. In Malaysia, *L. flava* plants have been reported to develop multiple resistance to 2,4 D (synthetic auxin), and bensulfuron- methyl (AHAS inhibitor) in Seberang Perai and Seberang Perak rice fields, however their resistance profile has not been quantitatively investigated. The present study was conducted to elucidate the mechanisms endowing resistance to AHAS inhibitors in the resistant *L. flava*. The study revealed for the first time, a single nucleotide polymorphism (SNP) (GAC to GAG), resulting in Asp substitution by Glu at amino acid position 376, establishing point mutation in AHAS as a molecular basis of resistance in this resistant *L. flava* population. *In vitro* assay proved that the contributing resistance factors to AHAS inhibitors manifested stronger cross resistance to sulfonylurea (SU) than to pyrimidinyl (thio) benzoate (PTB) with I_{50} values were >83333-, 398-, 172- and, 48- fold greater than S population for bensulfuron- methyl, metsulfuron- methyl, pyrazosulfuron- ethyl, and pyribenzoxim, respectively. The basis of AHAS inhibitors resistance in *L. flava* was identified to be due to an Asp-376-Glu mutation in AHAS gene that reduced sensitivity of the target site to AHAS inhibitors. This is the first report of mechanism endowing resistance to AHAS inhibitors in *L. flava* species.

O-099

CRISPR/Cas9-mediated base-editing system efficiently creates point mutations conferring herbicide resistance in *Arabidopsis*

Linjian Jiang[1], Yiyu Chen[1], Zhiping Wang[2], Hanwen Ni[1],Yong Xu[3], Qijun Chen[2]

[1] Department of Plant Pathology, College of Plant Protection, China Agricultural University, Beijing, 100193, China
[2] State Key Laboratory of Plant Physiology and Biochemistry, College of Biological Sciences, China Agricultural University, Beijing 100193, China
[3] National Engineering Research Center for Vegetables, Beijing Academy of Agriculture and Forestry Sciences, Key Laboratory of Biology and Genetic Improvement of Horticultural Crops (North China), Beijing Key Laboratory of Vegetable Germplasm Improvement, Beijing, 100097, China

Introducing known herbicide resistant (HR) point mutations remains a great challenge in plant genome engineering, let alone generating new HR mutations. Recently, a modified CRISPR/Cas9 system performed base-editing in mammal cells and T0 rice plants, offering an immediate promise to address this issue. Here we show that this base-editing system can efficiently generate non-GM plants with known and novel inheritable HR point mutations. We constructed a base-editing vector referring to those worked in mammal cells, and tested whether it could introduce point mutations on *acetolactate synthase* (*ALS*) gene in *Arabidopsis*. After a simple transformation, 1.7% (4/240) transgenic T1 plants harbored point mutations at desired positions, containing the Pro197 codon, on *ALS* gene. These point mutations are inheritable to T2 generation and conferred T2 plants resistance to tribenuron. Moreover, we recovered six non-GM (T-DNA free) HR plants out of 64 examined T2 plants, three harboring known HR mutations (P197S) and the other three bearing novel HR mutations (P197F). Surprisingly, we discovered that the PAM region could be a new base-editing target for this new system, and revealed a second novel HR mutation G202D on *ALS* gene. Collectively, this new base editing system provides a powerful tool to create non-GM HR germplasm in virtually all crops.

O-100

A rapid assay method for detecting ACCase activities of grasses using malachite green

Yoshinobu Jin

Health & Crop Sciences Research Laboratory, Sumitomo Chemical, 636-2, Kishiro-cho, Kasai 675-2333, Japan

Acetyl CoA Carboxylase inhibiting herbicides (ACCase inhibitors) are widely used to control grass weeds in various crops. After the intensive uses, the spread of ACCase inhibitor-resistant weeds is becoming a serious problem especially in cereal cultivation. An efficient *in vitro* assay method to detect ACCase activities is desired for many purposes such as a resistance diagnosis, resistance profiling, and discovery of new herbicides effective on these weeds. In this study, a novel method to detect ACCase activities of grasses using a 96-well micro titer plate and malachite green that is more efficient than the existing methods (RI method & HPLC method) was developed. The detection of ACCase activities of grass plants was attempted using commercially available Malachite Green Phosphate Assay Kit (BioAssay Systems).

Enzymatic reactions using crude enzymes extracted from wildtype blackgrass (*Alopecurus myosuroides*) were performed. In the reactions, the generation of Pi depending on an addition of substrate Acetyl CoA was confirmed. Linearity between the Pi formation and the enzyme concentration or the reaction time was also confirmed. It was also confirmed that the Pi formation is inhibited by a herbicide clodinafop-acid (IC_{50}: 0.5uM). Furthermore, the inhibition was less likely to occur when a resistant biotype (Ile1781Leu at ACCase CT domain) of blackgrass was alternatively used as an enzyme donor (IC_{50}: 38.5uM). These results suggest that the Pi formation was caused by an ACCase activity of the extract instead of its non-specific phosphatase activity. Z'-Factor of the method was around 0.7. By using this method, inhibition profiles of various ACCase inhibitors on 5 resistant biotypes of blackgrass were obtained.

These results show that the present method is very effective to detect ACCase activities of grasses. The method could be useful for characterization of resistant grass weeds or for high throughput screening (HTS) of ACCase inhibiting compounds.

O-101

Investigating the glyphosate resistance mechanism in *Conyza canadensis* from Korea

WeiQiang Jia[1], Aung BoBo[1], Ok Jae Won[1], Young Tae Kim[1], Inkon Park[2], Kee Woong Park[1]

[1] Department of Crop Science, Chungnam National University, Daejeon 34134, Korea
[2] Syngenta Korea Limited, JinCheon 27855, Korea

Conyza canadensis is the weed species which most frequently develops glyphosate resistance in many agricultural crops. The extensive use of glyphosate has resulted in the selection of weeds resistant to glyphosate. This study was carried out to investigate the occurrence and distribution of glyphosate resistant *C. canadensis* populations in the Jeju province of Korea. Seeds of *C. canadensis* were collected from 18 sites in tangerine orchards in the Jeju province. In the preliminary screening, 5 resistant and 13 susceptible biotypes were found at the recommended application rate (3.28 kg/ha) of glyphosate in glasshouse experiments. In a dose response test, the confirmed resistant and susceptible biotypes were treated with stepwise half dilutions from 328 kg/ha of glyphosate to 10 rates. Resistant biotypes displayed a GR_{50} at 10.14 kg/ha as compared to a GR_{50} at 0.07 kg/ha in susceptible biotype. The GR_{50} of the resistant biotype was 144 times higher than that of the susceptible biotype. After glyphosate application (3.28 kg a.i./ha), the susceptible biotype tends to accumulate more shikimic acid compared to the resistant biotype. As the glyphosate rates increases, more shikimic acid accumulated in the both biotypes. However, the accumulations in the resistant biotype were much less than in the susceptible biotype. The nucleotide sequence analysis of the *EPSPS* gene demonstrated no point mutation in the resistant biotype. Known point mutation at P106 (proline to serine) in other glyphosate resistant weed species was not found in this study. Probably different EPSPS gene expressions, metabolism or sequestrations of glyphosate in the resistant plants are responsible for the mechanisms of glyphosate resistance in this case. Extended monitoring should be conducted to understand how widely the glyphosate resistant *C. canadensis* is spread out and to estimate the severity of this weed problem in the tangerine orchards of the Jeju province of Korea.

O-102

Enhanced activity of β-cyanoalanine synthase does not confer quinclorac resistance in multiple-herbicide resistant *Echinochloa phyllopogon*

Pattarasuda Chayapakdee[1], Satoshi Iwakami[2], Yoshitaka Kamidate[1], Akira Uchino[3], Longjiang Fan[4], Yukari Sunohara[1], Hiroshi Matsumoto[1]

[1] University of Tsukuba, 1-1-1, Tennodai, Tsukuba 305-8572, Japan
[2] Kyoto University, Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan
[3] Central Region Agricultural Research Center, NARO, 360 Kusawa, Anou, Tsu 514-2392, Japan
[4] Zhejiang University, 866 Yuhangtang, Hangzhou, Zhejiang 310058, China

Echinochloa phyllopogon populations in California have evolved resistance to multiple herbicides with different modes of action including quinclorac. Quinclorac is an auxinic herbicide which induces production of the senescence hormone ethylene, resulting in the accumulation of toxic HCN. Yasuor *et al*. (2012) revealed enhanced activity of the HCN-detoxifying enzyme β-cyanoalanine synthase (β-CAS) in resistant *E. phyllopogon*. Therefore, enhanced activity of the enzyme has been considered as one of the mechanisms of quinclorac resistance in this biotype. In this study, we examined the involvement of β-CAS in quinclorac resistance at the molecular level. We isolated two copies of β-CAS gene from resistant (R) and susceptible (S) plants: β-CAS1 and β-CAS2. Accumulation of β-CAS1 mRNA in R plants was five-fold higher than in S plants, while no significant difference was observed in that of β-CAS2. Alternative splicing leading to aberrant transcripts (exon inclusion) was observed in β-CAS1 of the S line whereas only normal transcripts of β-CAS1 existed in the R line. We infer that a single nucleotide polymorphism (SNP) on the border of an exon-intron junction explains the loss of alternative splicing in the R line. We investigated the association of the SNP, existence of aberrant transcripts, transcript level, and enzyme activity of β-CAS1 in 32 lines of F6 crossed progenies of S and R plants. Complete correlation among four characteristics was observed. The results suggest that enhanced β-CAS activity in the R line is caused by the loss of aberrant alternative splicing. However, no correlation was observed between the enhanced β-CAS activity and quinclorac resistance in F6 lines, indicating the enhanced β-CAS activity is not involved in quinclorac resistance in this biotype. Further research is required to elucidate the molecular mechanisms of the quinclorac resistance.

O-103

Effect of metabolic enzyme inhibitors on herbicides

Tao Bo[1] Sun Hao[1] Li Jingjing[1]

[1]Northeast Agriculture University Harbin 150036

Resistant weeds affects growth of crop seriously and cause herbicide effective to be reduced, while excess herbicides are used in crop field, leading to frequent occurrence of herbicide damage in China. How to ensure its stable herbicidal activity to weed, effective control of resistant weeds, has become a serious problem of agricultural production in China .

In this paper, the synergistic effect of metabolic enzyme inhibitors and herbicides were researched by bio-assay and field methods in maize and soybean fields. There was a significant difference in the synergistic effect of metabolic enzyme inhibitors at different doses of 15-75 ga.i.hm^{-2}, with the increase of the dose of metabolic enzyme inhibitor, the more obvious the synergistic effect. The metabolic enzyme inhibitors have significant synergistic effects on maize herbicides, with metabolic enzyme inhibitors increasing the effect of nicosulfuron on weed control by 32%, atrazine increasing by 26.25%, and mesotrione increasing of 24%. The effect of metabolic enzyme inhibitor on soybean weed was significant, and the metabolic enzyme inhibitor increased quizalofop-p-ethyl the control effect on the weed control by 36%, the effective of the fomesafen on weed was increased by 34.47%, the effective of the sethoxydim was increased by 36.05% The Metabolizing enzyme inhibitors can significantly reduce the GSTs activity of the resistance to barnyardgrass (*Echinochloa crus-galli.L*) and the cytochrome P450 content, thereby reducing resistance of barnyardgrass to atrazine, nicosulfuron and sulphcomycin in maize; reducing the resistance of barnyardgrass to quizalofop-p-ethyl and sethoxydim in soybean. Metabolic enzyme inhibitors have no effect on the growth and development of maize and soybean plants, and are safe for maize and soybean.

Key words: metabolic enzyme inhibitors, herbicides, GSTs, cytochrome P450

O-104

Multiple-resistance to ACCase- and ALS-inhibiting herbicides in *Polypogon fugax*

Xiaoyue Yu[1]; Wei Tang[1]; Jianping Zhang[1]; Yongliang Lu[1]

[1]China National Rice Research Institute, Hangzhou, 311400

Asia Minor bluegrass (*Polypogon fugax*) is a common weed in wheat-rapeseed rotation and wheat-rice rotation in China. With the frequently and large amount use of chemical herbicide, the resistant *P.fugax* population become a serious problem. We found a *P.fugax* population resistant to acetyl-CoA carboxylase (ACCase)-inhibiting herbicide, such as clodinafop-propargyl (1991-folds), fluazifop-p-butyl (364-folds), haloxyfop-R-methyl (269-folds), quizalofop-p-ethyl (157-folds) and fenoxaprop-p-ethyl (8-folds). Further study found that the resistance population had a substitution of 2041 Ile to Ala at ACCase gene. We also found that this resistant population was 3-5 folds resistant to acetolactate synthase (ALS)-inhibiting herbicide, such as metsulfuron-methyl (3.4-folds), ethametsulfuron-methyl (4.0-folds) and pyroxsulam (4.0-folds). To determine if resistance to ALS-inhibiting herbicide is target-site based, ALS genes in resistant and susceptible population are sequencing and analysis. We used TAIL-PCR to amplify the full-length of ALS gene in *P.fugax*. The deduced amino acid sequences of *P.fugax* ALS gene showed approximately 95% identity of *Poa annua*, 89% identity of *Echinochloa crus-galli*, 91% identity of *Oryza sativa* and 96% identity of *Triticum aestivum*. However, none of the amino acid substitutions were found which are associated with resistance to ALS inhibitor in previous reported. To detect if resistance mechanism is involved in metabolism-based resistance, we test the expression level of cytochrome P450 genes, which enhanced rates of metabolism of several herbicides. The results showed that *CYP72A32* gene expression is increased approximately 9-folds in resistant population compared with susceptible population after 24h treated with metsulfuron-methyl. These results suggested that the mechanism of *P.fugax* resistant to ACCase-inhibiting herbicide is caused by mutation of target gene, but the mechanism of resistance to ALS-inhibiting herbicide maybe caused by metabolism-based resistance.

O-105

Tribenuron-methyl resistance in *Myosoton aquaticum* : ALS resistance mutation and P450-mediated enhanced herbicide metabolism

Weitang Liu[1], Shuang Bai[1], Lele Zhang[1],Wei Li[1], Jinxin Wang[1],

[1] Shandong Agricultural University, Tai'an, Shandong, China

Water chickweed (*Myosoton aquaticum* L.) is a widespread and competitive winter annual or biennial weed of wheat in China. One water chickweed population (AH03), collected from Anhui Province, was suspected to be resistant to tribenuron and several other ALS inhibitors. This study aims to characterize the cross-resistance pattern of resistant population AH03 (R) and investigate the potential resistance mechanisms involved in herbicide resistance. Compared with sensitive population HN03(S), R population was highly resistant to tribenuron（270.9-fold）. Cross resistance patterns established that the R population was high resistant to flucarbazone-Na and pyroxsulam, moderate resistant to pyrithiobac-sodium and florasulam, while sensitive to imazethapyr, imazethapyr, 2,4-d butylate, fluroxypyr-meptyl, isoproturon, and diflufenican. ALS gene sequencing revealed Pro197Ala substitution in resistant plants. Based on the ALS gene sequences analysis, molecular markers were also developed to identify the spesific Pro197Ala mutation. An *in vitro* ALS assay confirmed that the ALS from R plants showed high resistance (58-fold) to tribenuron. The pretreatment of malathion reduced the GR_{50} value of tribenuron by 43% in R population, while 24% reduction in S population. These fidings suggested that target-site and non-target-site resistance mechanisms involved in tribenuronmethyl -resistance in water chickweed. This study firstly doucumented the ALS Pro197Ala mutation in water chickweed.

O-106

Investigation of clomazone resistance mechanism in multiple-herbicide resistant *Echinochloa phyllopogon*

Feng Guo[1], Satoshi Iwakami[2], Takuya Yamaguchi[1], Kiichi Nagai[1], Akira Uchino[3], Yukari Sunohara[1] and Hiroshi Matsumoto[1]

[1] University of Tsukuba, 1-1-1, Tennodai, Tsukuba 305-8572, Japan
[2] Kyoto University, Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan
[3] Central Region Agricultural Research Center, NARO, 360 Kusawa, Anou, Tsu 514-2392, Japan

Herbicide resistant *Echinochloa phyllopogon* (Stapf.) Koss. has been found in the Sacramento Valley in California, USA. The resistant plants exhibit resistance to multiple herbicides with different modes of action including acetolactate synthase (ALS) inhibitors and clomazone. Previously, we identified cytochrome P450 genes whose overexpressions are associated with resistance to ALS inhibitors (Iwakami *et al*. 2014 Plant Physiol). Meanwhile, genes involved in the resistances to clomazone remains to be identified although similar mechanism, enhanced metabolism, is suggested as the basis of the resistance (Yasuor *et al*. 2010 Plant Physiol). In this study, we characterized P450 genes that are overexpressed in multiple-herbicide resistant plants. Two P450 genes that are highly expressed in the resistant plants were cloned into a binary vector, pB2GW7, under the promoter of CaMV35S. The genes were transformed into *Arabidopsis* using *Agrobacterium* via floral dip method. T3 homozygous lines were selected and investigated for clomazone sensitivity. The true leaves of wild type *Arabidopsis* were bleached at 0.1 μM of clomazone. On the other hand, transformed *Arabidopsis* with either of the P450 genes of *E. phyllopogon* were not affected at the concentration, indicating that the genes confer clomazone resistance in *Arabidopsis*. Next, we examined whether the higher expression of the P450s genes were cosegregated in the progeny of susceptible and resistant *E. phyllopogon*. Higher transcript levels of the P450 genes cosegregated with decrease of clomazone sensitivity in at least 16 F_6 lines. Further research is required to elucidate the molecular mechanism of clomazone resistance in the multiple-herbicide resistant *E. phyllopogon*.

O-146

[Title]

Studies on germination ecology and interference of *Cleome viscosa* in mungbean (*Vigna radiata* (L.) Wilczek)

[Authors]

Hafiz Haider Ali[a], Muhammad Mansoor Javaid[a], Zaighum Abbas[a], Muhammad Ehsan Safdar[a], Asif Tanveer[b].

[Affiliation]

[a]Department of Agronomy, University College of Agriculture, University of Sargodha, Sargodha, Pakistan

[b]Department of Agronomy, University of Agriculture, Faisalabad, Pakistan

[Abstract]

Germination ecology of *Cleome viscosa* and its interference in mungbean was studied at the Agronomic Research Area and laboratory, Department of Agronomy, University College of Agriculture, University of Sargodha, Sargodha, Pakistan. The effects of several environmental factors such as temperature, light, pH, salt and drought stress and burial depth on the weed seed germination and emergence were studied under laboratory and field conditions. Germination response of weed was low at a cooler temperature and maximum germination was recorded at 30°C. More than 70% of *C. viscosa* seeds germinated at pH between 5 and 7; whereas, *C. viscosa* seeds germination was considerably decreased at pH 9. Weed was tolerant to salinity and germination of weed plant occurred at 200 mM NaCl. Maximum germination under osmotic stress observed for control, while the minimum for the treatment of -1.0 MPa. Maximum germination percentage observed for seed depth 1 cm and minimum germination percent observed for seed depth 5, 6 and 7cm. Results indicated that *C. viscosa* seeds can germinate over a wide range of environmental factors except for water stress; however, the environmental factors adversely affect germination or emergence. A field trial was carried out to measure the competitive effect of weed plants with density levels of 0, 10, 20, 40, 80 and 160 plants (m^{-2}) with mungbean crop. Mungbean yield losses ranging between 50 to 70% with weed densities from 80 to 160 weed plants (m^{-2}). Mungbean yield factors like plant height, the number of pods, and the number of grains per pod also 1000-grains weight significantly reduced with increasing densities of *C. viscosa* plants. Based on the tolerance of this species against a range of environmental stresses, we conclude that this weed is likely to become a serious threat in near future. Integrated management strategies should be aimed to keep this weed below a threshold level in the field conditions.

O-107

Discovery and development of novel pesticides by combining biological and chemical rationales with computational technologies

Boaz Inbal

Evogene Ltd., 13 Gad Feinstein St., Park Rehovot, P.O.B. 2100, Rehovot 76120, Israel

Evogene Ltd. is a biotechnology company aiming to improve crop productivity for the food, feed and fuel industries. For this purpose, Evogene developed a proprietary technology platform, leveraging scientific understanding and computational technologies for introducing improved seed traits, innovative ag-chemicals and novel ag-biological products.

In Ag-chemistry, Evogene is focused on the discovery and development of novel pesticide solutions for pest control. For this purpose, we have developed innovative and robust computational platforms for the discovery and assessment of novel essential protein targets (PoinTar™), and potential specific small molecule modulators for these targets (PointHit™). These platforms have already been utilized for novel plant protein target discovery and design of small molecules libraries that resulted in bio-validated novel herbicide hits and new herbicide modes-of-actions. Such discovery capability provides the foundation for both our collaboration with BASF and the generation of our internal novel herbicide pipeline. In Evogene's internal herbicide program, a subset of 10 previously validated Evogene chemical groups have now demonstrated initial positive results in greenhouse evaluation. These compounds were computationally predicted to impact six essential targets for their herbicidal activity. In addition, we continue our work aimed at establishing biological proof of the novel mode-of-action for those 10 chemical subsets.

Another key activity, includes the establishment of a computational infrastructure addressing key parameters for molecule optimization such as efficacy, toxicity, and resistance emergence in weeds. In this respect, we are perusing three different optimization candidates: (i) Improve Efficacy/Tox. issues of a non-selective major herbicide, (ii) Broaden spectrum of a limited fungicide (iii) Confer selectivity against a beneficial organism for a group of major insecticides with severe toxicity issues.

Today Evogene is collaborating with leading partners in the agrochemical industry leveraging its unique approach and tools to bring innovation pesticides to the market.

O-108

Weed control efficacy and crop safety of Rinskor ™ Active against common weeds in rice fields in Asian countries

Lê Duy[1], Trần Trọng Vinh[1], Mongkol Sripeangchan[2], Marman Maulana[3], Jasmi Aiman Hanis[4], Bobba Venkata Niranjan Kumar[4], Richard K. Mann[5] and Mauricio Morell [5]

[1] Dow AgroSciences Vietnam B.V, 106 Nguyen Van Troi, Ho Chi Minh city, Vietnam
[2] Dow AgroSciences Thailand, Whitegroup 2, Sukhumvit, Bangkok, Thailand
[3] Dow AgroSciences Indonesia, Wisma GKBI, Sudirman 28, Jakarta, Indonesia
[4] Dow AgroSciences Malaysia, CP Tower, Jalan Damansara, Kualar Lumpur, Malaysia
[5] Dow AgroSciences LLC, Zionville, Indianapolis, Indiana, U.S

Rinskor™ active is a novel rice herbicide discovered by Dow AgroSciences. The herbicide is a synthetic auxin (HRAC Group O) mode of action and belongs to the arylpicolinate group. Rinskor offers broad spectrum post-emergence weed control in rice. At 14, 28 and 42 days after application, weed control was assessed on common rice weed species, including *Echinochloa* spp., *Cyperus iria, Cyperus difformis, Fimbristylis miliacea* and several broadleaf weed species. In 56 direct-seeded rice field trials conducted in Thailand, Vietnam, Malaysia and Indonesia during 2016 summer season, Rinskor at 20 to 25 g ai/ha applied at 10-16 days after rice seeding (DAS) provided 90 to 95% control of *Echinochloa* spp., *Cyperus iria* and *Cyperus difformis*. Rinskor at 25 to 30 g ai/ha provided 85 to 90% control of *Fimbristylis miliacea*. Common broadleaf weed species, including *Monochoria vaginalis, Sphenoclea zeylanica* and *Ludwigia octovalvis* were highly sensitive to Rinskor at 5 to 10 g ai/ha with 95 to 98% control observed in all trials. Rinskor at 25 and 30 g ai/ha provided 70 to 75% suppression of *Leptochloa chinensis* when herbicide applied at 10 to 12 DAS. Rice response to herbicide treatments was evaluated 1, 3, 5, 7, 14 and 28 days after application. In some trials Rinskor applied at 10-16 DAS at 20 and 25 g ai/ha caused slight (up to 10%) rice plant biomass reduction, with symptoms including transient leaf malformation and plant stunting up to 3 days after application, with rice recovery by 7 to 14 days after application. Rice yields in Rinskor treated plots were 7 to 16% and 20 to 60% higher than hand-weeded and untreated plots, respectively.

Keywords: Post-emergence herbicide, arylpicolinate herbicide, rice, weeds.

™Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow.
™Rinskor is not registered at the time of this presentation. The information presented is intended to provide technical information only and is not an offer for sale

O-109

Rinskor™ Active: Biological Studies with Granule and EC Formulations in Japan

Masanori Kobayashi, Shun Nomoto and Ikuo Shiraishi

Dow AgroSciences Division, Dow Chemical Japan Ltd.

Rinskor™ active is the newest arylpicolinate herbicide being developed globally, including Japan, by Dow AgroSciences for primary use in rice. Even though Rinskor belongs to HRAC group O / WSSA group 4, it is clearly differentiated from other auxin herbicides by binding with a unique auxin receptor. It has favorable toxicological and ecological profile such as low use rate, low volatility and rapid degradation in soil, water and plants. The 0.5% granule (GR) formulation is being developed only in Japan to be applied by water-injection directly into paddy water for weed control at mid-post application timing. The GR formulation applied with oil provided excellent efficacy on *Echinochloa spp*, *Monochoria vaginalis* and *Lindernia procumbens* with good crop safety. The 2.7% (w/w) NeoEC formulation of Rinskor is being developed for use around the world in water-seeded, dry direct-seeded and transplanted rice as a foliar applied herbicide. Official trials with emulsifiable concentrate (NeoEC) formulation across Japan in 2015 and 2016 demonstrated higher efficacy on 5Lf stage of *Echinochloa spp* at 50 g active ingredient (ai)/ha than standard products without negative impact on rice yield. The 2.7% NeoEC Rinskor formulation provided better foliar post-emergence efficacy than current leading herbicide products against difficult-to-control weeds such as SU-resistant *Monochoria korsakowii* at 5 to 6-leaf stage in Hokkaido and *Sagittaria trifolia* that was 30cm in height in Nara at 25 g ai/ha. Rinskor GR and NeoEC formulations provide excellent *Echinochloa spp* control and will become valuable products to improve the weed control practices and herbicide resistance weed management programs.

O-110

Rinskor™ Active + Penoxsulam 3.41% OD: A Novel Pre-Mixture Formulation For Post-Emergence Use In Transplanted Rice In Taiwan

Yi-hsiou Huang and Ta-I Huang

Dow AgroSciences Taiwan Ltd, Taiwan, Taiwan, Republic of China

A new pre-mix rice herbicide formulation, "Rinskor™ active + Penoxsulam 3.41% OD" (GF-3565), consists of 12.5 g ai/L of Rinskor + 20 g ai/L of Penoxsulam. Rinskor represents the latest member of a unique and new synthetic auxin herbicide chemotype, the arylpicolinates. Rinskor disrupts the plant growth regulation processes through binding to auxin receptors. Rinskor binds to the AFB5 receptor with high affinity and to the TIR1 receptor with lower affinity in the cell nucleus which makes it different from other auxin chemistries. Penoxsulam inhibits the plant enzyme acetolactate synthase (ALS) which is essential for the synthesis of the branched-chain amino acids valine, leucine, and isoleucine, subsequently inhibiting cell division. Rinskor will be positioned as a post-emergence product for the control of economically important grass, broadleaf and sedge weeds, including ALS, ACCase, HPPD, propanil, quinclorac, and glyphosate target site resistant biotypes. Penoxsulam, a triazolopyrimidine sulfonamide herbicide, is sold in over 45 countries for post-emergence broad-spectrum control of broadleaf weeds, annual sedges, and Echinochloa spp. grasses in rice. In Taiwan, efficacy and crop tolerance field trials of GF-3565 3.41% OD were conducted in transplanted rice from 2015 to 2016. In these trials, GF-3565 3.41% OD applied at 1.5, 2.0 and 2.5 L /ha (18.75 + 30, 25 + 40, and 31.25 + 50 g ai/ha of Rinskor + Penoxsulam) demonstrated 91% to 97% control of Echinochloa crus-galli (ECHCG); 96% to 97% control of Cyprus difformis (CYPDI); 95% to 99% control of Scirpus juncoides (SCPJU); 94% to 97% control of Scirpus maritimus (SCPMA); and 92% to 97% control of Ammannia multiflora (AMMMU) at 30 days after applications when applied at 4 to 5 leaf stages of ECHCG timing. No phytotoxicity on rice by GF-3565 3.41% OD was recorded in these trials. Registration trials of GF-3565 3.41% OD will be carried out in Taiwan in 2017. This product has a perfect fit for Asian-Pacific rice, controlling the most important susceptible and resistant weeds at post-emergence timing in this crop, with low use rates and a very friendly environmental, toxicological and eco-toxicological profile.

*TM Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow.

O-111

A new rice herbicide: cyclopyrimorate

Hiroshi Tamaru[1], Takashi Sakamoto[1], Kosuke Yoshino[1], Nobuko Imamura[1], Soichi Saeki[1], Takuya Ando[1], Sadafumi Koda[1], Yoshihisa Tsukamoto[1], Junji Kadotani[1], Kenta Ikemachi[2], Katsuya Kitahara[2], Chie Furuyama[2] and Ryoichi Aoyama[2]

[1]Mitsui Chemicals Agro, INC., 1358, Ichimiyake, Yasu, Shiga 520-2362, Japan
[2]National Federation of Agricultural Cooperative Associations, 4-18-1 Higashiyawata, Hiratsuka, Kanagawa 254-0016, Japan

Cyclopyrimorate, a pyridazine derivative, was discovered and is being developed as a rice herbicide. Cyclopyrimorate is bleaching herbicide and controls a wide range of sedges and broadleaf weeds including ALS (Acetolactate synthase) resistant weeds which are widely spread in paddy fields. Cyclopyrimorate also has a unique biological property which shows a synergy effect with pyrazolynate, rice herbicide known as a HPPD (4-hydroxyphenylpyruvate dioxygenase) inhibitor discovered and developed by Mitsui Chemicals Agro (formerly Sankyo Co., Ltd.). Pot and field trials were conducted to determine herbicidal activity against several paddy weed species and rice safety of cyclopyrimorate and its mixture with pyrazolynate. Cyclopyrimorate showed excellent efficacy against *Scirpus juncoides* and *Sagittaria trifolia* and a remarkable synergy effect with pyrazolynate against both species. The mixture of cyclopyrimorate and pyrazolynate showed excellent efficacy against paddy weed species such as *Monochoria vaginalis*, *Lindernia procumbens*, *Scirpus juncoides*, *Sagittaria pygmaea*, *Sagittaria trifolia*, *Cyperus serotinus* and *Scirpus nipponicus* at the rate of 300+600g a.i./ha because of its synergy effect even though cyclopyrimorate solo needs the rate of 1200g a.i./ha and pyrazolynate solo needs the rate of 3000g a.i./ha to show sufficient herbicidal efficacy. The mixture of cyclopyrimorate and pyrazolynate at 300+600g a.i./ha also provided outstanding weed controls on ALS resistant biotypes of *Scirpus juncoides* and *Sagittaria trifolia* which were widely spread in Japanese paddy fields. Little phytotoxicity was observed by the application of the mixture at 600+1200g a.i./ha on transplanted Japonica type rice. Cyclopyrimorate and its mixture with pyrazolynate showed excellent herbicidal efficacy against paddy weeds including ALS resistant weeds with high crop safety in rice. Cyclopyrimorate can offer new tools for weed management in rice production.

O-112

Rinskor™ Active Control of *Echinochloa spp* and Other Grasses in Rice Fields in Jiangsu Province of China

Zhen Wei YAO[1], Jia Xing YU[2], Li Yao DONG[2]

[1] Dow AgroSciences (China) Ltd., [2] Nanjing Agricultural University, China

Greenhouse studies were conducted to evaluate the herbicidal activity of Rinskor™ active, a new Arylpicolinate herbicide active on grass, broad leaf and sedge weeds in paddy rice. Seeds from eight populations of grasses, collected from rice fields in different areas of Jiangsu Province of China, were tested in this study. Populations included *Echinochloa crus-galli*, *E. crus-galli var. zelanensis*, *E. crus-galli var. mitis*, *E. colona*, *E. glabrescens*, *Leptochloa chinensis*, *L. panicea* and *Eragrostis japonica*. Collected seeds were sown in plastic pots filled with paddy soil and each contained 30 seeds covered by a thin layer of soil. Water was supplied to ensure the soil was fully saturated, with the trial maintained in the greenhouse under the condition with temperatures from 30 ± 5 °C (day time) to 25 ± 5 °C (night time). Five replications were run. Rinskor was applied at 0, 1.41, 2.81, 5.63, 11.25, 22.5 and 45 g ai/ha when grass weeds were at the 3 to 4 leaf stage. A thin water layer was established 24hrs after application and maintained thereafter. Above-ground biomass of survival plants was assessed at 21 days after treatment (DAT). Results showed that Rinskor provided excellent control of all the tested *Echinochloa* populations. The ED_{50} values ranged from 3.14 to 5.81 g ai/ha. The Rinskor ED_{50} values were 9.01 to 27.24 g ai/ha for *Leptochloa. chinensis* and *L. panicea* t. Rinskor did not control *E. japonica*, regardless of rate.

O-113

Triafamone (Council®) - A New Herbicide for Asia's Diverse Rice Cropping Systems

Ramisis Fulgencio[1], Juergen Echle[1], Silke Heibges[1], Hans-Peter Krause[1], Eva-Maria Franken[1], Christopher Rosinger[2], Wolfgang Schulte [2], Shinichi Shirakura[3]

[1]Bayer CropScience AG, Alfred-Nobel-Strafe 50. 40789 Monheim am Rheine, Germany
[2]Bayer CropScience AG, Industriepark Hoechst, H872, 65926 Frankfurt am Main, Germany
[3]Bayer CropScience KK, 1-6-5 Marunouchi, Chiyoda-ku, Tokyo 100-8262, Japan

Triafamone is a new selective sulfonanilide herbicide discovered and developed by Bayer CropScience AG for rice and sold as Council®. Target weeds of Triafamone include the most important grass in rice, *Echinochloa crus-galli*, key sedges and perennial weeds. The weed spectrum is further extended in combination with other herbicides.
Triafamone inhibits the enzyme acetolactate synthase (ALS) after rapid metabolization to the drug in weeds and is absorbed through roots and shoots. Active ingredient is distributed throughout the plant to the target site offering pre-emergence and post-emergence control of weeds.
Numerous field trials have shown that Triafamone at 10-50g ai/ha is safe to direct seeded and transplanted rice without negative effect on the yield. It provides good control of up to 3.5 leaf stage of *Echinochloa* species via spraying, shaker bottles, sand mix and granular application.

Several co-formulations products have been developed to suit country specific rice cropping conditions and weed management techniques. Examples are the mixture with Ethoxysulfuron (Council Activ®) which is a WG formulation that gives excellent residual control of annual weeds (*Echinochloa crus-galli, Monochoria vaginalis, Sphenoclea spp, Ludwigia spp, Cyperus spp,*) in south Asia and the SC or GR formulation with Tefuryltrione (Council Complete®) which provides anti-resistance broad spectrum control including hard to control perennial weeds (*Sagittaria spp., Eleocharis spp., Scirpus spp., Paspalum. distichum*) in northeast Asia. Local tank mixtures of solo Triafamone (Council Prime®) SC formulation with other mode of actions are being developed in China and Southeast Asia.

The features (e.g. wide window of weed control, broad rice selectivity, application and formulation flexibility) exhibited by Triafamone on different rice cropping systems provide farmers across Asia a new flexible weed management tool to enhance their productivity. Triafamone products have been launched in Japan, Korea and China and registrations in India and other Asian countries are expected soon.

O-114

Council Complete – Performance on hard-to-control weeds

Tatsuya Yamaoka[1], Nobuhiro Yamashita[1], Hidenori Hayakawa[2], Kenji Sugiura[3]

[1] Bayer CropScience K.K. (Japan), 2549, Osone otsu, Nankoku City, Kochi 783-0005, Japan
[2] Bayer CropScience K.K. (Japan), 1-6-5, Marunouchi, Chiyoda-ku, Tokyo 100-8262, Japan
[3] Bayer CropScience K.K. (Japan), 9511-4, Yuki, Yuki City, Ibaraki 307-0001, Japan

Triafamone is a novel rice herbicide discovered by Bayer. It shows excellent weed-control efficacy against *Echinochloa* spp. and some perennial weeds with good crop safety for rice.

Council Complete is a mixture of triafamone + tefuryltrione. It was developed as one-shot rice herbicide in Japan. The mixture has so far been confirmed to have a good potential to control hard-to-control perennial paddy weeds which are problematic in Japan.

Methodology

1. Herbicidal efficacy against *Bolboschoenus maritimus* was evaluated in the field trial where enough natural emergence of the weed was expected. Council Complete GR (triafamone + tefuryltrione 0.5+3%) at 10kg/ha was applied by one-shot application at 14 days after the plotting (DAP) as well as the sequential application with a pre-early post-emergence herbicide at 14 DAP, or a one-shot herbicide at 31 DAP.
2. *Paspalum distichum* L. was planted on paddy dyke in ca 2 months before the plotting to simulate the practical condition where its stolons infested from paddy dyke continually. Testing plots were prepared along the paddy dyke. Council Complete GR at 10kg/ha was applied at 5 or 15 DAP.

Results

1. Council Complete GR at 10kg/ha controlled *B. maritimus* effectively both by one-shot and the sequential applications. The GR strongly suppressed the growth of the terrestrial part and the formation of tubers.
2. Council Complete GR at 10kg/ha showed good efficacy against *P. distichum* L. which had already infested inside the plot. Besides, the GR strongly suppressed the infestation of the stolons from neighboring paddy dyke. The herbicidal efficacy was sustained until starting of the mid-season drainage (47 DAP).

Conclusion

Council Complete is expected to be an excellent tool to control *B. maritimus* and *P. distichum* L. which are problematic hard-to-control perennial paddy weeds for rice growing farmers in Japan.

O-115

The effects of Fenquinotrione on ALS-R broadleaf weeds under flooded conditions

Ken UEDA, Yuta AMANO, Atsushi NAGAMATSU, Masami KOBAYASHI

Life Science Research Institute, Kumiai Chemical Industry Co., Ltd., Kikugawa, Shizuoka 439-0031, Japan

Fenquinotrione is a new rice herbicide whose mode of action is inhibiting 4-HPPD (4-hydroxyphenylpyruvate dioxygenase). Fenquinotrione has enough safety for paddy rice and high herbicidal effects on a wide range of weeds including acetolactate synthase inhibitory-type herbicide-resistant (ALS-R) weeds except for *Echinochloa* spp.. In this study, the effects of Fenquinotrione on ALS-R broadleaf weeds under flooded conditions were investigated by the pot trial in the green house. Under flooded conditions, Fenquinotrione 300g a.i./ha showed excellent controls against pre/post-emergence ALS-R *Monochoria vaginalis*, *Monochoria korsakowii* and *Sagittaria trifolia*. In addition, the effects were also stable even if the paddy water overflowed . Fenquinotrione was considered to have large potential as the herbicide for resistant problems.

O-116

A new herbicide mixture for early post-emergent application timing in transplanted rice

Vinod Shivrain[1], Ari Budiawan[2], Ruediger Kotzian[3], Ajit Kumar[4], Gaylene Marsden[1], Tiffany Su[1], Pete Tsai[5], Nan Xu[3]

[1] Syngenta Asia Pacific Pte. Ltd., Singapore
[2] PT Syngenta Indonesia, Cikampek, Indonesia
[3] Syngenta Crop Protection AG, Basel, Switzerland
[4] Syngenta India Ltd, Karnal, India
[5] Syngenta Taiwan Limited, Pingtung, Taiwan

Grasses, sedges, and broad-leaf weeds cause significant yield losses in rice production systems. In recent years, herbicide applications in rice have shifted towards the late post-emergent application timing, driven by the introduction of newer active ingredients which are effective on older weeds. One of the key disadvantages of late applications is significant yield loss, due to early weed competition prior to herbicide application. Early-POST herbicide applications can reduce these yield losses.

Syngenta is developing a pre-mixture of pyriftalid and bensulfuron which can be applied at three to 10 days after transplanting of rice. This combination is highly effective on grasses, sedges, and broad-leaf weeds in transplanted rice production systems. In addition to controlling common grass weeds, this mixture is highly effective on tough-to-control Leptochloa sp. when applied before the two-leaf stage. Key features of this herbicide include flexibility in application method as well as complete tolerance of the crop.

O-117

Effectiveness of the rice herbicidal agent, Pyraclonil.

Takashi SHIGEFUJI, Yoshio USHIGUCHI, Katsuhiro TAKAHASHI, Takuma SASAKI, Takayuki UCHIDA

Kyoyu Agri Co., Ltd., Yamaman Building, Koami-cho 6-1, Nihonbashi, Chuo-ku, Tokyo, 103-0016, Japan

Pyraclonil was registered for use in paddy rice in Japan on December 28, 2007 by Kyoyu Agri Co., Ltd. (formerly Yashima Chemical Industry Co., Ltd.). Pot tests were used to evaluate (i), selective control between rice plants (*Oryza sativa* cv. Koshihikari) and *Echinochloa oryzicola*; (ii), herbicidal activity towards broadleaf weeds and (iii), the synergistic efficacy of a mixture of pyraclonil and benzobicyclon.

Pyraclonil application did not result in serious damage to the rice plants when transplanted at a depth of one cm, and treated at the one-leaf growth stage. Application before transplantation of the rice plant after puddling showed almost the same degree of damage to the rice as shown with the application of the herbicides pretilachlor and pentoxazone. Selectivity was approximately 32 times when a 40% control dosage was compared between *E. oryzicola* and rice plants. Pyraclonil also provided good control of the ALS-resistant annual broadleaf weeds (*Monochoria vaginalis*, *Lindernia procumbens*, *Lindernia angustifolia*) and perennial broadleaf weeds (*Sagittaria pygmaea*, *S. trifolia*), until the plants reached leaf stages 4.4, 2.2, 2.3, 2.5, 2.4, respectively. After dipping the roots of rice plants in pyraclonil, the content of protoporphyrin IX in the plants was approximately two to eight times less than in *E. oryzicola*, following two to eight hours of light irradiation (50,000 lux). The combination of pyraclonil and benzobicyclon synergistically improved and accelerated the herbicidal efficacy in *E. oryzicola* and *Schoenoplectus juncoides* and resulted in enhanced herbicidal efficacy in *E. oryzicola* and *M. vaginalis*.

Based on these combined results, we believe that pyraclonil has a wider window of application, controls a broader range of weeds and results in less damage to rice plants than existing paddy herbicides.

O-118

Metabolism of the Novel Herbicide Fenquinotrione.

Satoshi Usami, Mitsumasa Ikeda, Yudai Hotta, Yuji Ono

Life Science Research Institute, Kumiai Chemical Industry Co., Ltd., 276 Tamari, Kakegawa, Shizuoka, 436-0011, Japan

For safety assessment of fenquinotrione, the metabolic pathways in rice, soil and rat were clarified using three ^{14}C-radiolabeled compounds.

【Rice】Granular formulation of fenquinotrione was applied to the containers transplanted rice seedlings at 30 g a.i./10a for each ^{14}C-radiolabeled compound. Immature sample (forage) was harvested 15 days after 2nd application (DAA), and mature samples (straw, hulls, brown rice) were harvested 60 DAA. The amount of total radioactive residue (TRR) in forage and straw were largest (0.048-0.119 mg/kg, 0.051-0.109 mg/kg respectively), and its major component was fenquinotrione (0.017-0.067 mg/kg, 0.013-0.052 mg/kg respectively). TRR in brown rice were 0.010-0.035 mg/kg, and fenquinotrione was not detected. As the metabolites, M-2 and M-3 were identified in forage and straw. Fenquinotrione was metabolized to M-2, followed by oxidative decarboxylation of the carboxyl grope to produce M-3. Metabolites also formed bound residues, especially in rice hulls and brown rice.

【Soil】Fenquinotrione was applied to the soil at 0.3 mg/kg. Fenquinotrione degraded quickly with DT_{50} of 2.6-2.7 days at 25℃ under flooded aerobic condition. M-1, M-2 and M-7 were identified as minor metabolites. A large amount of bound residues were detected, and most of its were incorporated in the humin.

【Rat】An ADME study of fenquinotrione was conducted. The test substances were administered orally to the rats of 5 mg/kg or 200 mg/kg. Plasma and whole blood concentrations of ^{14}C were reached the maximum within 1 hour after administration and disappeared promptly thereafter. The main excretion route was feces, and more than 90% dose was excreted within 72 hours. The biliary excretion was 19-29% dose within 72 hours. The main metabolic pathway was demethylation of the methoxy group on the benzene ring.

O-119

Re-evaluation of the effectiveness of commonly used herbicides in wet seeded rice in Sri Lanka

D.D. Witharana[1], A.S.K. Abeysekera[2], H.M.S.D. Kulatunga[2] and W.M.U.B. Wikrama[2]

[1]Postgraduate Institute of Agriculture, Peradeniya, Sri Lanka.

[2]Rice Research and Development Institute, Batalagoda, Sri Lanka.

Weeds become the major biological pest in Sri Lankan rice cultivation and effect was most significant in wide adopted establishment method, randomly broadcast pre-germinated seed in puddle soil. Chemical weed control is the common practice adopted by more than 90% farmers. Continuous application of same mode of action and same chemical formulation herbicide allows the significant possibilities towards rise of herbicide resistant weeds. This study was conducted to re-evaluate the bio efficacy of commonly used herbicides for maintain the quality standard and to minimize the herbicide resistant development. Field experiment was conducted at the Rice Research and Development Institute, Sri Lanka. 90 days old rice variety Bg-300 was used in Randomized Complete Block Design, with three replicates. Evaluated herbicides; Propanil 360g/l EC (7500 ml/ha) *fb* Carfentrazone-ethyl 240g/l EC (120 ml/ha), Metamifop 10% EC (1250 ml/ha) *fb* Bensulfuron-methyl + Metsulfuron-methyl 8.25 + 1.75% WP (250 g/ha), Oxyfluorfen 240g/l EC (500 ml/ha), Fenoxaprop-p-ethyl + Ethoxysulfuron 69 + 20g/l OD (500 ml/ha), Fenoxaprop-p-ethyl 75g/l EW (350 ml/ha) *fb* Carfentrazone-ethyl 240g/l EC (120 ml/ha), Metamifop 10% EC (1250 ml/ha) *fb* MCPA 400 g/l SL (2800 ml/ha), Metamifop 10% EC (12500 ml/ha) *fb* MCPA 600g/l SL (1800 ml/ha) and un-weeded and weeded treatments used as control. Result showed that *Ischaemum rugosum* and *Isachne globosa* were poorly control by Fenoxaprop-p-ethyl + Ethoxysulfuron, while *Cyperus iria* and *Cyperus difformis* were poorly control by MCPA 400 and 600 g/l. It further indicates that Propanil can be confirmed as effective grass-killer and Oxyfluorfen as effective broad spectrum herbicides for continuity. Broad spectrum herbicide Fenoxaprop-p-ethyl + Ethoxysulfuron 69 + 20 g/l OD and broad-leaf, sedge killer herbicides Bensulfuron-methyl + Metsulfuron-methyl 8.25 + 1.75%, MCPA 400 g/l SL, MCPA 600 g/l SL showed comparatively low bio-efficacy and further studies to be needed for the conformation of development of herbicide resistance.

O-120

Indaziflam – An Innovative Base Herbicide for Plantation Crops in Asia

Ramisis Fulgencio[1], Joerg Oeser[1], Anne Helgers[1], Christopher Leake[1], MinSik Park[2]

[1]Bayer CropScience AG, Alfred-Nobel-Strafe 50. 40789 Monheim am Rheine, Germany
[2]Bayer (South East Asia) Pte Ltd, 63 Chulia Street, OCBC Centre East, 049514 Singapore

Indaziflam is an innovative herbicide developed by Bayer CropScience AG for use in mature plantation crops and sold as Alion® or Becano® 500SC in Asia. It is a highly effective cellulose biosynthesis inhibitor (CBI) belonging to the chemical class Alkylazine. Indaziflam affects meristem growth and act as a pre-emergence soil herbicide via inhibition of germination and emergence of major monocots and dicots weeds including species resistant to EPSP, ALS, and PSII inhibitors. Indaziflam offers post emergence weed control in mixture with foliar active herbicides.

Numerous multi-year studies in various locations showed good crop safety of Indaziflam on established perennial crops such as oil palm, banana, rubber, citrus, coffee, tea, grape, apple, and pear.

An application rate of 50-75g ai/ha of Indaziflam provides excellent residual control of economically important weeds in plantations such as *Echinocloa colonum, Eleusine indica, Digitaria spp., Euphorbia hirta, Ageratum conyzoides, Asystia intrusa*, *Synedrella nodiflora, Axonopus compressus, Ottochloa nodosa, Hedyotis verticillata*

Many trials demonstrated that at recommended doses under favorable field conditions, single application of Indaziflam or in tank mixture with other herbicides gave an average of 3-5months longer weed control duration than present commercial standards which significantly reduces the application frequency in spray programs.

Several co-formulations have been developed and are being evaluated for use on multi-year sugarcane in Thailand and on tea and grape-vines in India.

The favorable features (e.g. low dose and less frequent applications, extended residual activity, compatibility with other herbicides, flexibility in application timing, good crop safety, resistance management) exhibited by an Indaziflam based weed management strategy can enhance farmer productivity and resource savings in permanent crops.

First registration and sales of Indaziflam in Asia were obtained in 2012 in Philippines and it is currently marketed in Indonesia, Malaysia, Thailand, and Vietnam. Product launches in India, China and other Asian countries are expected soon.

O-121

Indaziflam – a residual and broad spectrum herbicide for turf

Shin Nakamura[1], Shigetoshi Obuchi[1]

[1]Environmental Science Division, Bayer CropScience K. K. 1-6-5, Chiyoda-ku, Tokyo 100-8262, Japan

An innovative active ingredient, indaziflam was granted a registration as a turf herbicide (Specticle® flowable, Bayer CropScience K.K.) in Japan on April 6th, 2012. This chemical is classified as an alklyazine derivative and works by inhibiting cellulose biosynthesis in weeds. A wide range of annual weeds including grass and broadleaved weeds are controlled at significantly low doses (40 – 60 g ai/ha). Furthermore, it also showed robust efficacy on one perennial weed, *Plantago asiatica* L. Residual activity on grass weeds such as *Poa annua* or *Digitaria* spp was confirmed to be longer than 150 days from a pre-emergence application. Post emergence activity on *P. annua* was satisfactory up to the 3 leaf stage. Indaziflam also provided consistent activity on various ecotypes of *P. annua* regardless of the locations collected across Japan. Some ecotypes were proven to have low susceptibility to other commercialized herbicides which has recently been a concern in turf maintenance. Thatch accumulation on turfgrass is generally considered to be one of the reasons that have adversely affected the soil herbicide efficacy. In the simulated pot trials, indaziflam can maintain the solid activity in spite of thatch build up on the soil surface. Through repeated field trials, indaziflam has been found to offer good synergy with foliar herbicide, like foramsulfuron to control emerged *P. annua* even after the flowering stage. The selectivity on Zoysiagrass was favorable even at high doses or high temperature conditions.

An overwhelming number of greenhouse and field trials revealed that indaziflam has advantageous biological properties as a new turf herbicide compared with the currently commercialized products. It offers a new tool for effective and low environmental impact weed management in golf courses, sports fields, parks, schools and other managed turf areas..

O-122

Indaziflam (Alion®) – A Novel Herbicide for Weed Management in Oil Palm (*Elaeis guineensis* Jacq.) : Crop Safety and Performance

Ho, S.H.[1]; Fulgencio R.[2], Xaviar, A.[1] and Hoe, C.K.[3]

[1]United Plantations Berhad, Teluk Intan, Perak, Malaysia
[2]Bayer CropScience AG,Monheim am Rhein,Germany
[3]Bayer Co. (Malaysia) Sdn. Bhd., Petaling Jaya, Selangor, Malaysia

Indaziflam (Alion®) is a novel pre-emergent herbicide active against both monocotyledonous and dicotyledonous weeds as a cellulose biosynthesis inhibitor. This paper highlights the extensive crop safety evaluations testing the effect of indaziflam on oil palm growth, nutrient uptake, fruit development, oil synthesis and crop yield over a four year period on mature oil palm.

Indaziflam at 75g (X rate), 150g (2X) and 300g (4X) a.i. per hectare were ground applied at the base of six year old mature oil palms at six monthly intervals over a four year period.

Annual growth parameters based on frond 17 length, leaflet number, leaf area, leaf dry matter, palm height and frond production rate were found to be unaffected by indaziflam even at the 4X rate over the entire trial period. Nutrient uptake of the major nutrients as well as the trace element boron were likewise not influenced by indaziflam application rates.

Indaziflam topically applied onto female flowers did not induce parthenocarpy and had no significant impact on oil or kernel content in the harvested fruit bunches. Bunch analyses at the end of the trial period evaluating a range of bunch and fruit characteristics also confirmed the safety of indaziflam on fruit set and bunch development.

The findings supported the hypothesis that indazaflam applied at up to four times the recommended rate does not impact crop yield, thus validating the safety of indaziflam for use in mature oil palm, whilst conferring the possibility of prolonged weed control.

Field trials have shown that application of indaziflam combined with post emergent herbicides can control weeds for an extended period in contrast to the standard herbicides. An indaziflam based weed management program therefore holds great promise to require fewer herbicide application rounds, reduce input of herbicidal compounds concomitant with increases in worker productivity.

O-123

Herbicidal efficacy of tolpyralate under various environmental conditions

Yu Naito[1], Yoshikazu Satake[1], Hiroyuki Okamoto[1], Hiroshi Kikugawa[1] and Shigeru Mitani[1]

[1]Ishihara Sangyo Kaisha, Ltd., 1-3-15, Edobori, Nishi-ku, Osaka, 550-0002, Japan

Tolpyralate is a corn herbicide that inhibits 4-hydroxyphenylpyruvate dioxygenase (HPPD). Foliar application of tolpyralate controls a wide range of annual weeds, and it has excellent crop selectivity. Corn is grown under various environmental conditions worldwide. Mesotrione is a widely used corn herbicide that has the same mode of action as tolpyralate. It was revealed that the herbicidal efficacy of mesotrione was influenced under various conditions, such as temperature, relative humidity, and carrier water pH and hardness (Johnson et al., 2002 and Devkota et al., 2016). To evaluate the effect of carrier water pH and hardness, temperature on the tolpyralate herbicidal activity and tolpyralate's rain fastness, we conducted greenhouse trials using giant foxtail (*Setaria fabeli*) and velvetleaf (*Abutilon theophrasti*). In the trials, tolpyralate 400SC (35.7% ai w/w) formulation was evaluated. Tolpyralate was applied at the rate of 30 g ai/ha with MSO adjuvant 0.5% v/v of the spray volume 300 L/ha. Under application conditions of different carrier water pH (4, 7, and 9) and water hardness values (0 to 150 mg/L), tolpyralate provided ≥90% and stable control of giant foxtail and velvetleaf at 21 days after treatment (DAT). When tolpyralate-treated giant foxtail and velvetleaf were kept under different temperatures (8 h day/16 h night: 32°C/25°C and 22°C/15°C), tolpyralate effectively controlled both weeds without any efficacy fluctuation (21 DAT). Rainfastness study results suggested that the rainfast time of tolpyralate is within 3 h, which is much shorter than that of topramezone 336SC, an HPPD inhibiting herbicide (21 DAT). These results demonstrate that tolpyralate is a herbicide with excellent application flexibility that can contribute to global corn production.

O-124

Biological performance of tolpyralate and tank mixture with atrazine as a post-emergence herbicide application for corn (*Zea mays*) production

Taketo Suganuma[1], Yoshikazu Satake[1], Yosuke Kobayashi[1], Yu Naito[1], Hiroshi Kikugawa[1] and Shigeru Mitani[1]

[1]Ishihara Sangyo Kaisha, Ltd., 1-3-15, Edobori, Nishi-ku, Osaka, 550-0002, Japan

Tolpyralate (code number, SL-573) is a pyrazole compound that inhibits 4-hydroxyphenylpyruvate dioxygenase (HPPD) and represents a novel post-emergence herbicide for corn (*Zea mays*) production. Although this compound controls many major annual weeds in corn fields (IWSC2016 Okamoto et al.), it has moderate efficacy against some broadleaved weeds such as morning glory (*Ipomoea* spp.), dayflower (*Commelina communis*), and sedges. Therefore, we evaluated the post-emergence herbicidal efficacy of tolpyralate and tank mixture with atrazine against dayflower and morning glory because atrazine provides good broadleaved weed control. This tank mixture exhibited an outstanding efficacy in controlling the aforementioned weeds in comparison with the individual application of each herbicide and was found to be perfectly safe for corn. Furthermore, this tank mixture also exhibited a synergistic effect, showing fast-acting and/or boosting efficacy against annual grass weeds [barnyard grass (*Echinochloa crus-galli*), large crabgrass (*Digitaria sanguinalis*), giant foxtail (*Setaria faberi*)] and annual broadleaved weeds [black nightshade (*Solanum nigrum*) and velvetleaf (*Abutilon theophrasti*)]. Field trials to evaluate the performance of the tank mixture confirmed that it provides excellent annual grass and broadleaf weed control without causing significant injury to corn. These findings indicate that tolpyralate with atrazine mixture has excellent herbicidal performance against a wide variety of weed species as well as a synergistic efficacy, similar to combinations of other HPPD and photosystem II inhibitors that were previously reported.

O-125

CONTROL OF MIXED WEED FLORA IN MAIZE WITH TEMBOTRIONE AND ITS TANK-MIX WITH ATRAZINE AND 2,4-D

Simerjeet Kaur[1], Makhan S Bhullar[1] and Tarundeep Kaur[1]

[1]Punjab Agricultural University, Ludhiana,141004, India

In northwest India, the continuous use of atrazine, a triazine herbicide, for more than two decades in maize has resulted in shift from predominantly annual broadleaf weeds to annual grass weeds and perennial sedge. Tembotrione, a triketone herbicide, has been introduced recently for control of grass and broadleaf weeds, and 2,4-D dimethyl amine, an auxinic herbicide, for control of sedges in this crop. The tank-mixture application of herbicides having different modes of action as well as target weed flora provides broad spectrum weed control, in a single pass, and saves time, labour and energy. The efficacy of tank-mix applications of tembotrione, atrazine and 2,4-D against weeds and on maize growth and yield was assessed in a field study in summer season in 2016. Atrazine 1000 g/ha alone was applied as pre-emergence, 2,4-D dimethyl amine salt 500 g/ha and tembotrione 120 g/ha with surfactant as post-emergence at 25 days after sowing, tank-mix application of tembotrione with atrazine 500 g/ha and 2,4-D dimethyl amine salt 500 g/ha as post-emergence. The tank-mix application of tembotrione 120 g with atrazine 500 g or 2,4-D dimethyl amine 500 g/ha recorded higher level of control of mixed weed flora as compared to when these herbicides were used alone, and were at par with hand weeding treatment. Tembotrione alone recorded fair control of broadleaf weeds and grasses, atrazine of broadleaf weeds, and 2.4-D amine of sedges and broadleaf weeds. The tank mix application of tembotrione with atrazine or 2,4-D dimethyl amine provided the highest maize grain yield which was similar to tembotrione used alone and two hand weedings but significantly higher than atrazine and 2,4-D amine used alone.

O-126

Herbicides effect growth and seed germination of broadleaf dock (*Rumex obtusifolius*)

Wiharti Oktaria Purba[1], Lisa Wasko DeVetter[1], Chris Benedict[2], Ian C. Burke[3], Timothy Miller[1]

[1] Washington State University, NWREC (Northwestern Washington Research and Extension Center), Mount Vernon, WA, USA.

[2] WSU, Whatcom County Extension, Bellingham, WA, USA.

[3] WSU, Department of Crop Science, Pullman, WA, USA.

Knowing which herbicides to use against a weed species coupled with a knowledge of when the seeds are most likely to germinate allows growers to devise successful control programs. To obtain these values for broadleaf dock (*Rumex obtusifolius* L.) growing under Pacific Northwest (PNW) environmental conditions, two field herbicide trials were established in a highly infested fallow field near Mount Vernon, Washington, USA, and a subsequent seed germination test was conducted. In the first trial, 16 herbicides registered in small fruit crops were applied May 23, 2016 to bolting broadleaf dock and, in a second trial, 18 herbicides were applied October 28, 2016 to broadleaf dock regrowth approximately one month after mowing. Seed from broadleaf dock plants surviving spring herbicide application was collected to assess the herbicidal impact to germination. In both herbicide trials, glyphosate at 3.86 kg ae/ha provided the greatest broadleaf dock control (94% at 8 weeks after spring treatment and 20% at 3 weeks after autumn treatment). Also in the spring trial, terbacil (2.69 kg ai/ha), diuron (2.69 kg ai/ha), and dichlobenil (4.39 kg ai/ha) gave 85%, 68%, and 65% control at 8 weeks after treatment, respectively. Autumn-applied pronamide (2.24 kg ai/ha) and dichlobenil (4.39 kg ai/ha) provided >85% control on April 21, 2017. Among spring-applied herbicides, only clopyralid (0.14 kg ae/ha) reduced seed germination compared to seed gathered from nontreated plants (26.81%), indicating that this herbicide applied to bolting broadleaf dock may slow the spread of this weed in PNW berry fields. Further, because broadleaf dock seed was shown to optimally germinate at 20^{o}C, it appears that preemergence herbicide treatments should be applied prior to the beginning of summer in the PNW to optimize control of germinating broadleaf dock seeds.

Keyword: broadleaf dock, efficacy, germination, preemergence

O-127

Evaluation of weed control measures in combination with seeding rates on chickpea (*Cicer arietinum* L.) weeds under rainfed conditions

Rahamdad Khan[1], Ijaz Khan Ahmad Khan[2], Syed Salim Shah[1]

[1]Bacha Khan University, Pakistan; [2]The University of Agriculture, Peshawar Pakistan, Pakistan

Weeds are considered to be a serious constraint to increase the yield of chickpea. For the purpose to increase the chickpea yield and to reduce the weeds infestation, field trials were conducted during two years i.e. 2012-13 and 2013-14 at Ahmad wala Research Station, District Karak, Khyber Pakhtunkhwa Pakistan. The experiment was laid out in Randomized Complete Block (RCB) design with split plot arrangement having four replications. There were four main plots assigned to seed rates i.e. 60, 70, 80 and 90 kg ha^{-1} and seven sub-plots included different weed control techniques i.e. s-metolachlor, pendimethalin, clodinafop, fenoxaprop-p-ethyl, hand weeding, parthenium extract and weedy check. The recorded parameters were weed density (m^{-2}), fresh weed biomass (kg ha^{-1}), plant height at maturity (cm), number of pods plant^{-1}, 100 seed weight (g) and seed yield (kg ha^{-1}). The results showed that during both the experimental years i.e. 2012-13 and 2013-14 the lowest weed density (115.18 and 64.40 m^{2}) was recorded in pendimethalin followed by s-metolachlor. In case of chickpea parameters highest 100 seed weight (18.66 and 26.49 g) and seed yield (1226.2 and 1411.5 kg ha^{-1}) were recorded in pendimethalin for both the years respectively followed by the application of s-metolachlor and hand weeding. Similarly among the chickpea seeding rates the outmost 100 seed weight (18.65 and 24.45 g) and seed yield (1268.8 and 1353.9 kg ha^{-1}) were observed for 70 kg ha^{-1} seed rate during the year 2012-13 and 2013-14. Hence, from the instant study it is concluded that the sowing of chickpea @ 70 kg ha^{-1} under the application of herbicides pendimethalin and s-metolachlor may be undertaken for achieving satisfactory weed control and maximum yield of chickpea under rainfed conditions in Pakistan.

O-128

Bio-efficacy and phyto-toxicity of BAS 835 UB H against weeds in groundnut and its residual effects on succeeding sorghum, wheat and maize crops

Malligawad Lokanath Hemaraddi[1]

[1] Professor of Agronomy and Head, Institute of Organic Farming, University of Agricultural Sciences, Dharwad 580 005, Karnataka, India

Weed control with pre-emergence herbicides in groundnut based sequence cropping system has certain limitations. Herbicides such as Imazethapyr and Imazamox (Imidazolinone group) and Bentazone (Benzothiadiazole group) are applied post-emergence in groundnut. However, the knowledge on efficacy and effects of these herbicides on weed control in groundnut and their residual effects on succeeding cereal crops are limited. Therefore, field trials were conducted at the University of Agricultural Sciences, Dharwad during 2015-16 to know the effect and efficacy of BAS 835 UB H (Imazethapyr 10 SL @ 23 g/l + Imazamox 12 SL @ 23 g/l + Bentazone 48 SL @ 460 g/l), Imazethapyr 10 SL, Imazamox 12 SL and Bentazone 48 SL on control of weeds in preceding groundnut (rainy season) and their residual effects on succeeding sorghum, wheat and maize crops (post-rainy season). Herbicides were applied 35 days after groundnut sowing. Cereal crops were sown 27 days after the harvest of preceding groundnut and 96 days after the post-emergence herbicides application in groundnut. Results indicated that the post-emergence application of either BAS 835 UB H (700, 759, 800 and 1518 g/ha) or Imazethapyr (100 g/ha) or Imazamox (34.50 g/ha) suppressed growth of annual grassy and broad leaved weeds. Regeneration of grassy weeds was observed in BAS 835 UB H, Imazethapyr and Imazamox treated plots. Post-emergence application of either BAS 835 UB H or Imazethapyr or Imazamox used for control of weeds in groundnut showed residual toxicity (stunted growth of emerged seedlings, death of fully emerged seedlings and gradual loss of population at later stages followed by complete crop loss) on sorghum, wheat and maize crops (succeeding season). The severity of BAS 835 UB H residual toxicity on succeeding cereal crops was increased with increasing rates of application and was severe on sorghum > wheat > maize.

Key words: Imidazolinone, BAS 835 UB H, Imazethapyr 10 SL, Imazamox 12 % SL and Bentazone 48 % SL, Residual-toxicity, Grassy weeds, Broad leaved weeds

O-129

Long Term Application of Herbicides on Weed Shift, Weed Control, Yield and Soil Properties in Transplanted Rice-Rice System at North Western Zone of Tamil Nadu

Chinnusamy Chinnagounder, N.K.Prabhakaran, P.Murali Arthanari, and P. Janaki

AICRP-Weed Management, Department of Agronomy,
Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India
e-mail:

Field experiments were conducted at the Wetland Farm of Tamil Nadu Agricultural University, Coimbatore from *kharif* 2000 to *rabi* 2014 in fixed plots to evaluate long term herbicidal weed management integrated with two different sources of nitrogen in transplanted rice-rice cropping system. Treatments included hand weeding, combined application of butachlor plus 2, 4-DEE for both seasons and the rotational use of butachlor plus 2.4-DEE and pretilachlor plus 2,4-DEE for *kharif* and *rabi* seasons, respectively under two sources of nitrogen viz., 100% N as inorganic for both kharif and rabi seasons and 75% inorganic + 25 % organic N during *kharif* and 100% N as inorganic in *rabi*. Results showed a shift in dominant weed species from grasses (*Echinochloa crus-galli*) and sedges (*Cyperus difformis*) to broad leaved weed (*Marsilea quadrifolia*). The *Echinochloa colonum* and *Leptochloa chinessis* which were present in first crop were completely absent in XXX crop. The application of butachlor + 2,4-DEE along with 75% inorganic N + 25% organic N during *kharif* seasons followed by pretilachlor + 2,4-DEE with 100% inorganic N during *rabi* seasons was effective in controlling of wide spectrum of weed flora, increasing yield and net return in rice-rice cropping system. The residues of all applied herbicides were found to be below the detectable level of 0.01 mg/kg in soil, rice grain and straw samples from throughout the study. Increase in organic carbon and available nitrogen in the post harvest soil was observed for combined application of inorganic and organic source of N. There was a build up in the status of major nutrients over initial level. Microbial load was numerically high in hand weeding with 75% inorganic N + 25% organic N applied plots and was not affected by the herbicide application at harvest.

O-130

Herbicide combinations for higher Productivity and Profitability of transplanted rice

Madhavi.M[1], S.Anusha[1], G.Pratibha[2] and T.Ramprakash[1]

1. AICRP on Weed Management, PJTSAU, Hyderabad, Telangana, India
2. Central Research Institute for Dryland Agriculture, Hyderabad, Telangana, India

Field experiment conducted in transplanted rice during *kharif,* 2015-16 with different herbicide combinations involving pretilachlor, bensulfuron methyl , penoxsulam, pyrazosulfuron ethyl, pendimethalin, azimsulfuron and bispyribac sodium as sequential application in randomized block design with three replications to study the weed control efficiency, profitability and environmental impact in transplanted rice at Professor Jayashankar Telangana State Agricultural University, Hyderabad, India. The broad spectrum weed flora consisted of *Echinochloa colona, Echinochloa crusgalli, Paspalum distichum, Panicum spp, Cyperus difformis, Cyperus iria, Scirpus spp, Eclipta alba* and *Ammania baccifera* respectively. Results of the experiment revealed that bensulfuron methyl + pretilachlor 6.6% G 0.66 kg ha^{-1} as preemerence followed by pyrazosulfuron ethyl 10% WP 20g ha^{-1} at 15-20 DAS recorded lowest weed density and weed dry matter and highest weed control efficiency compared to other treatments and it was followed by pretilachlor S 30.7% EC as pre emergence followed by tank mix application of penoxsulam 24% Sc + pyrazosulfuronethyl 10% WP 25 g ha^{-1} + 20g ha^{-1} as post emergence and found effective in influencing the growth and yield of rice. Growth parameters and yield attributes like plant height, number of tillers DMP, productive tillers, filled grains per panicle and test weight were also significantly influenced by the same treatments. Higher rice grain yield, higher monetory returns and B:C ratio and better energy use efficiency were reported with either sequential application of pre mix herbicides bensulfuronmethyl + pretilachlor 6.6% G 0.66 kg ha^{-1} as preemergence and pyrazosulfuron ethyl 10%WP at 15-20DAT or pretilachlor S at 0.5kg ha^{-1} as PE and tank mix application of penoxsulam 24SC 25g ha^{-1} + pyrazosulfuron ethyl 10%WP 20g ha^{-1} at 15-20DAT Hand weeding though effective in efficient weed control and realising higher grain yield was not cost effective due to higher labour wages and labour scarcity during critical period of weeding necessitating herbicidal usage.

O-131

Studies on the efficacy of pre-emergence and post-emergence herbicides on control of weeds in groundnut and soybean and their residual toxicity on succeeding crops

Shilpa H. D[1] and Malligawad Lokanath Hemaraddi[2]

[1] Ph D Scholar, Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Dharwad 580 005, Karnataka, India

[2] Professor of Agronomy and Head, Institute of Organic Farming, University of Agricultural Sciences, Dharwad 580 005, Karnataka, India

University of Agricultural Sciences, Dharwad, Karnataka State, INDIA

In the present day context, weed control with pre-emergence and post-emergence herbicides in groundnut and soybean based sequence cropping system assuming greater importance. However, the knowledge on efficacy and effects of these herbicides on control of weeds in groundnut/soybean and their residual effects on succeeding cereal, pseudo cereal, grain legume and oilseed crops are limited. Therefore, field trials were conducted at the University of Agricultural Sciences, Dharwad during two consecutive years (2015-16 and 2016-17) to know the effect and efficacy of five pre-emergence and four post-emergence herbicides on control of weeds in preceding soybean and groundnut during rainy season and their residual effects on succeeding sorghum, wheat, maize grain amaranth, chickpea and safflower crops during post-rainy season. Post-emergence herbicides were applied 32 to 35 days after groundnut/soybean sowing. Succeeding crops were sown 14 to 28 days after the harvest of preceding groundnut/soybean; and 71 to 96 days after the post-emergence herbicides application in groundnut/soybean. Results indicated that pre-emergence application of Alachlor 50 EC, Pendimethalin 30 EC, Butachlor 50 EC, Pendimethalin 38.7 CS and Oxyfluorfen 23.5 EC effectively controlled annual grassy and broad leaved weeds in groundnut/soybean and had no residual toxicities on all the succeeding crops. Post-emergence application of Quizalofop ethyl 5 EC, Propaquizafop 10 EC and Fenoxaprop-p-ethyl 9 EC effectively controlled only annual grassy weeds and they did not show any residual toxicities on all the succeeding crops. On the contrary, post-emergence application of Imazethapyr 10 SL (25 to 150 g/ha) although suppressing the growth and development of annual grassy and broad leaved weeds, but resulted in residual toxicities in succeeding crops. The severity of Imazethapyr residual toxicity on succeeding crops was similar with all the rates (25 to 150 g/ha) of application and was greater on grain amaranth > sorghum > wheat > maize > safflower > chickpea.

Key words: Pre-emergence herbicide, Post-emergence herbicide, Residual-toxicity, Dicot weeds, Monocot weeds

O-144

Growth and yield of soybean as affected by irrigation and weed management method

Md. Hazrat Ali[1], Jannatul Ferdous[1], Md. Shahidul Islam[1], Imtiaz Faruk Chowdhury[1], Md. Nazmul Haque[1], Sheikh Muhammad Masum[1&2]

[1]Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh

[2]United Graduate School of Agriculture Sciences, Kagoshima University, Japan

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka with a view to find out the influence of irrigation and weed management method on the growth and yield of Soybean cv. BARI Soybean 6. The experiment was carried out with four (4) irrigation treatments viz. no irrigation (control), one time (at 20 DAS, two times (at 20 and 40 DAS), three times (at 20, 40, and 60 DAS), and four weed management treatments i.e., no weeding (control), one time hand weeding (at 20 DAS), two times hand weeding (at 20 and 40 DAS) and chemical control by Whip Super® (Fenoxaprop-p-ethyl) @75g ha^{-1} at 20 DAS. Results showed that different types of weeds were found to infest experimental fields, among them *Echinochloa colona*, *Lindernia procumbens* and *Cynodon dactylon* had the highest relative density. It was also noticed that *Lindernia procumbens* created dominancy throughout the crop growth period even at the later stage of crop. Three times irrigation gave the highest seed yield on the other hand two times hand weeding gave the highest seed yield. Interaction effects showed the highest seed yield from the combination of three times irrigation and two times hand weeding which is statistical similar with the combination of three times irrigation and herbicide Whip Super® application. This was also observed that herbicide Whip Super® showed better performance to control grass weeds but failed to control *Lindernia procumbens*. However, crop plants treated with herbicide became mature one week earlier than other treated crop plants. Considering weed control methods, application of herbicide Whip Super® may be the best economic way for successful cultivation of soybean.

O-132

Bio-efficacy and phytotoxicity evaluation of pendimethalin + metribuzin (RM) Plat Form 385 for the control of weeds in wheat crop and its residual effect on succeeding crops

Satbir Singh
Department of Agronomy,
CCS Haryana Agricultural University, Hisar (India)

The large scale cultivation of dwarf cultivars of wheat led to dominance of grassy weeds such as *Phalaris minor* and *Avena ludoviciana*. After development of resistance in *P.minor* against isoproturon, alternate herbicides clodinafop, fenoxaprop and sulfosulfuron were recommended during 1997-2000. At present, farmers have started to use herbicide mixtures even at double to recommended doses. Present investigation was planned at Agronomy Research Farm of CCS Haryana Agricultural University, Hisar (India) during winters of 2014-15 and 2015-16 to study the effect of pre-emergence herbicide- Plat Form 385, a ready mix combination of pendimethalin 35% and metribuzin 3.5% SE developed by M/s GSP Crop Science Pvt. Ltd., Ahmadabad. Plat form-385 applied at 2, 2.5 and 3.0 litres/ha (product dose) as PRE (1 DAS) and early post emergence (10 DAS) was compared with recommended herbicides pendimethalin (5L/ha), sulfosulfuron 75 % WG (33.3 g/ha) and metribuzin 70% WP. To study the crop phytotoxicity, Plat Form at 6 L/ha was used as PRE and EPOE. Plat Form 385 applied as PRE 3.0 L/ha was very effective to control *P.minor, A. ludoviciana, C. didymus and R. dentatus*. At 90 DAS, WCE of this dose was 71.0, 85.4 % against *P.minor* and *A. ludoviciana* respectively and 100% against broadleaf weeds. During both years, leaf injury on tips/surface was observed at 30 days after crop sowing in Plat Form 385 applied as early post emergence at all application rates resulting yield penalty. No significant differences in most of the physico chemical properties and biological properties viz. population *Pseudomonas fluorescens*, and *Rhizobium* sp., *Trichoderma viride* and *Trichoderma harzianum* and actinomycetes was observed in soil samples analyzed at the time of crop sowing and at crop harvest. No residual carry over effect of plat form treatments was observed on succeeding sorghum, lady finger, bitter gourd, ridge gourd and bottle gourd.

O-133

Bio-efficacy of post emergence herbicides aloneand as tank mixtures on weed control ,growth and yield of roselle (*Hibiscus sabdariffaL.*)

A.S.Rao
Integrated Weed Management Unit,
Acharya N.G. Ranga Agricultural University,
Regional Agricultural Research Station ,
Lam, Guntur – 522034, Andhra Pradesh, India.
E.mail:atlurisrao@gmail.com

Abstract

A field experiment was conducted during rainy season of 2010-11 and 2011-12 atRegional Agricultural Research Station, Lam, Guntur – 522034, Andhra Pradesh, India to evaluate the bio-efficacy of post emergence herbicides alone and as tank mixtures on weed control,growth and fibre yield of roselle. The post emergence treatments applied at 20 days after sowing (DAS) include,fenoaxaprop ethyl 56, quizalofop ethyl 50,pyrithiobac 63g/haalone and tankmixtures of fenoaxapropethyl 56+pyrithiobac63g/ha,quizalofop ethyl 50+pyrithiobac63g/ha in comparison with standard herbicide, pendimethalin 750g/ha (pre emergence), hand weeding at 20 and 40 DAS and weedy check. All the treatments were replicated thrice in a randomized block design. Results indicated that post emergence tank mix application of pyrithiobac 63g/ha with quizalofop ethyl 50 or fenoxaprop ethyl 56g/ha reduced weed growth on par with pre emergence application of pendimethalin750g/ha both at 60DAS and harvest. Post emergence application of pyrithiobac 63g/ha either alone or as tank mixture with fenoxaprop ethyl 56,or quizalofop ethyl 50g/ha caused upto 40 % injury to roselle crop at 14 days after spraying. All the weed control treatments significantly influenced crop growth and fibre yield. Among the weed control treatments,maximum fibre yield(2363kg/ha) and benefit cost ratio(1.65)was obtained with preemergence application of pendimethalin750g/ha and was on par with alone post emergence application of fenoxaprop ethyl 56g/ha(2113kg/ha) and quizalofop ethyl 50g/ha(2026kg/ha).None of the treatments could reach the level of hand weeding at 20 and 40DAS,which significantly recorded the highest fibre yield(2906kg/ha). Season long weed competition caused 46% reduction in fibre yield of roselle. Thus,it can be concluded that the pre emergence application of pendimethalin750 g/ha was found to be effective and economical in controlling weeds in roselle .

O-134

Efficacy of pre-mix formulation of oxyfluorfen + glyphosate on weeds in non-crop areas

Ramesh Kumar Singh and Neelam Bisen

Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University,Varanasi, India

Weed management in non-crop lands is essentially required to deplete weed seeds reservoir and potential for weed problems in adjoining cropped lands. We evaluated pre-mix formulation of oxyfluorfen 2.5% an EPSP synthetase inhibitor and glyphosate 41% SC a protoporpyrinogen inhibitor during post rainy and rainy season against complex weed flora comprising perennial and seasonal weeds infesting road sides and bunds in non-crop situation. Three rates of mixture containing oxyfluorfen + glyphosate @ 65.625+1076.25, 78,125+1281.25 and 90.625+1486.25 g a.i./ha applied as post-emergence were compared with individual application of component herbicide oxfluorfen @ 250g a.i./ha and glyphosate @ 1230g a.i./ha. The major weed species infesting the target area were *Cyperus* spp. *Cynondon dactylon* (L.) Pers, *Argemone mexicana* L., *Ageratum conyzoides* L., *Parthenium hysterophorus* L., *Sonchus olerraceus* L. and *Digitaria sanguinalis*(L.) Scop. The interaction between oxyfluorfen and glyphosate was additive with regards to the control of all the weed species when compared with individual application of component herbicides. Weed control efficiency of herbicide mixture was greater and withhold weeds germination/regeneration for longer period than component herbicide in mixture. Oxyluorfen + glyphosate @ 78,125+1281.25 applied at active growth stage of different weed species recorded 85-90 % control of different weeds in infested area during both the season compared to 60-63% control of *Sonchus olerraceus, Cynondon dactylon* and *Digitaria sanguinalis* under alone application of oxyflourfen. The mixture holds great potential in management of complex weeds in non-crop areas.

O-135

Troublesome perennial grass weed, dallisgrass (*Paspalum dilatatum*) and cogon grass (*Imperata cylindrica*) control by foramsulfuron in turf

Shin Nakamura[1], Shigetoshi Obuchi[1], Hirohisa Ohtake[1]

[1]Environmental Science Division, Bayer CropScience K. K. 1-6-5, Chiyoda-ku, Tokyo 100-8262, Japan

Perennial grass weeds such as dallisgrass (*Paspalum dilatatum*) and cogon grass (*Imperata cylindrica*) have recently spread and dominated in turf fields across Japan. They are becoming increasingly difficult weeds to eliminate. Currently, strong effective tools are unavailable for their selective control by superintendents on their golf courses.

A new foliar herbicide, foramsulfuron (Tribute ® OD flowable, Bayer CropScience K.K.) belongs to the sulfonylurea chemical group, which has been characterized as a selective and consistent foliar herbicide on grass and broad leaved weeds in turf, forestry and crops like maize at a low dose rate. Study reports showing foramsulfuron to effectively kill troublesome weeds like dallisgrass or cogon grass are rare. In this research, the control with foramsulfuron and its mixtures was intensively investigated.

Dallisgrass showed various responses to the application of foramsulfuron, the application timings, the mixture with another herbicide and the sequential applications. The best application timing is assumed to be from June to October in the vegetative growth stage of dallisgrass. The herbicidal efficacy was greatest at the highest dose, 62.7 g ai/ha. When mixing with asulam, the residual activity was clearly prolonged to around two months in comparison with one month with the straight application of foramsulfuron. Furthermore, several field trials revealed that maximum efficacy was reached by the consecutive application with the mixture of foramsulfuron plus asulam in autumn and spring. The effective application method of foramsulfuron on cogon grass was similar to that on dallisgrass.

Foramsulfuron has been already recognized to show robust activity on critical grass weed, *Poa annua* in turf. In addition, it could be a promising solution for the tough perennial weeds, dallisgrass and cogon grass.

O-136

Burn down effect and clorosis of transgenic and conventional corn varieties due to potassium glyphosate 660 g/l at different time of application

Denny Kurniadie[1], Uum Umiyati[2], Dedi Widayat[3]

[1]Agrotechnology, Padjadjaran University; [2]University Padjadjaran Bandung Indonesia; [3]University Padjadjaran Bandung Indonesia

NK 603 is transgenic corn variety which consisted of CP4 EPSPS (*5-enolpyruvyl shikimate-3-phosphate synthase*) gene, as a result from the isolation of soil bacterium, *Agrobacterium tumefaciens* CP4 strain that has resistance to glyphosate herbicide. Potassium glyphosate 660 g/l herbicide belongs to systemic herbicide and non selective and was recommended to control weed of transgenic corn variety of NK 603. The purpose of this experiment was to find out the burn down effect and clorosis due to different application of herbicide potassium glyphosate 660 g/l. The experiment was carried out in research station belongs to Agriculture Faculty Padjadjaran University Jatinangor Bandung Indonesia from December 2015 until April 2016. The experiment design used was randomized block design (RBD) with twenty treatments and each treatment was replicate two times. The treatments that used are application of herbicide potassium glyphosate 660 g/l on five transgenic corn varieties (C7 RR, 979 RR, 77 RR, 85 RR, 95 RR) and conventional corn varieties (C7, 979, 77, 85, 95) at 15 day after planting and 20 day after planting. The result of this experiment showed that the herbicide of potassium glyphosate 660 g/l was effective to control weed on both transgenic corn varieties and conventional corn varieties. All transgenic corn varieties did not show any clorosis and burn down effect after being spraying by potassium glyphosate 660 g/l herbicide, on the other hand the clorosis and burn down effect was found on all conventional corn varieties. The yield of transgenic corn varieties were higher than the conventional corn varieties.
Keywords : conventional corn, transgenic corn, potassium glyphosate, burn down, clorosis.

O-137

A new micro emulsion of propaquizafop 2.5%+imazethapyr 3.75% for weed control in Cluster bean (*Cyamopsis tetragonaloba* L.)

Ramesh K. Singh, Vishal Tyagi and Neelam Bisen

Department of agronomy, Institute of Agricultural Sciences, Banaras Hindu University, India

Cluster bean is an important crop of arid and semi-arid regions of India. It is used for human consumption, cattle feed, medicinal and industrial purpose as well as for soil improvement. Being rainy season crop and initial slow growth cluster bean suffers severe yield losses due to luxuriant growth of weeds. Micro emulsion presents a unique class of herbicides formulation. Due to ultralow interfacial tension, large interfacial area, and thermodynamic stability reduces the rate of herbicides application and consequently improves the environmental safety. This study evaluated the bio-efficacy of pre-mix micro emulsion of propaquizafop 2.5% + imazethapyr 3.75% at 46.88 + 70.31, 50+75 and 53.13 + 79.68 g/ha active ingredients in comparison to propaquizafop 10% EC at 75 g/ha, imazethapyr 10% SL at 150 g/ha as post- emergence and pendimethalin 30 % EC at 1500 g/ha as pre-emergence against important weeds in cluster bean. The crop was infested with *Echinochloa colona* (L) Link, *Digitaria sangunalis* (L) Scop, *Digera arvensis* L. *and Amaranthus viridis* L. Results revealed that post-emergence application of pre-mix micro emulsion of propaquizafop 2.5% + imazethapyr 3.75% @ 50 + 75 g /ha was most effective in controlling weeds with maximum weed control efficiency than alone application of component herbicides in mixture and pre-emergence treatment of pendimethalin. Cluster bean yield and profitability was also maximum in this treatment.

O-138

Inhibitory Effect of Some Herbicides on Three Soil Borne Diseases

Pruchya Ekkathin[1] Chanya Maneechote[1] Yurawan Anantanamanee[1]
Suneerat Seemadua[1] Assiri Klangsawad[1]

[1]Plant Protection Research and Development office Department of Agriculture

Abstract

In Thailand, three important soil borne diseases (*Phytophthora melonis*, *Ralstonia solanacearum* and *Sclerotium rolfsii*) caused severe damage in many economic crops such as cassava, melon and ginger. Fungicides were sometimes ineffective and expensive. However, some herbicides could have inhibitory effects on those pathogens. This study aimed to determine whether some pre and post emergence herbicides would be effective on those three diseases. Poison food techniques were assayed with 9 herbicides i.e. acetochlor, alachlor, diuron, flumioxazin, glyphosate, glufosinate-ammonium, metribuzine, paraquat, s-metolachlor at the recommended field rates. Three separate laboratory experiments were arranged in RCBD with four replications. The results indicated that acetochlor was effective only on *P. melonis* with 100% control whereas paraquat gave very good control of *P. melonis*, *R. solanacearum* and *S. rolfsii* with 95%, 100% and 100% inhibition, respectively. In addition, glyphosate and glufosinate-ammonium showed 70% inhibition on those three pathogens. However, alachlor diuron flumioxazin metribuzin s-metrolachlor glyphosate paraquat and glufosinate-ammonium gave poor control (40%) of *P. melonis*. As some herbicides had different levels of disease inhibition. Hence, inhibition of those soil borne disease by some potential herbicides should be further evaluated in the glasshouse and field conditions.

Keywords: herbicides, soil borne diseases, *Phytophthora melonis*, *Ralstonia solanacearum* and *Sclerotium rolfsii*

O-139

Sorption and Dissipation of Pyrithiobac sodium in Cotton Growing soils of India

Ramprakash T*, Madhavi M and Leela Rani P

AICRP on Weed Management, PJTSAU, Rajendranagar, Hyderabad-500030, Telangana State, India

(trapkash@gmail.com)

Sorption behavior and dissipation of pyrithiobac sodium was studied in cotton growing soils India. Red soil was neutral with low organic carbon status, sandy loam texture. CEC was 15.91 c mol (P^+)/kg. Whereas black soil was slightly alkaline in reaction with higher clay content, higher CEC (24.2 c mol (P^+)/kg) and medium organic carbon status. Adsorption experiment was conducted adopting batch equilibrium protocol. Adsorption isotherms were mainly parabolic in nature with 'S' shaped character in both soil samples. Freundlich equation fitted well for the adsorption data. The Freundlich constants $K_{f,}$ 'n' and other adsorption parameters (K_d, K_{doc}, K_{foc}) were computed for the red and black soils. K_d and K_{doc} values for the red and black soils were 0.17 and 39.41; 0.38 and 71.45 respectively. The K_f values for the red soil was 0.260 and for the black soil 0.542. The lower K_{doc} value in red soil (39.4) and higher K_{doc} value in black soils (71.45) indicated affinity of pyrithiobac sodium for organic carbon and clay humus complexes in soil. The lower K_d / K_{df} values indicate lower sorption tendency of pyrithiobac sodium. Dissipation of pyrithiobac sodium was studied in laboratory in incubated soil samples at constant temperature and two soil moisture contents (Field capacity and 50% field capacity). DT_{50} of pyrithiobac sodium in red soil at field capacity was 46.2 days and at 50 % field capacity was 49.5 days, where as in black soil the persistence half-life was 53.30 days at both moisture levels (field capacity and 50 % field capacity). Low sorption and prolonged half-life of pyrithiobac sodium indicated the herbicide's potential mobility and carryover capacity to crops grown in rotational sequence.

O-140

Nano encapsulated formulations to improve absorption and translocation of herbicide for season long weed control

C.R.Chinnamuthu[1], N.Viji[2] and T.Pradeeshkumar[3]

[1] Professor (Agronomy), [2] Research Scholar, Agricultural College and Research Institute, Tamil Nadu Agricultural Univerrsity, Madurai-625104, [3]Assistant Professor, Vanavarayar Institute of Agriculture, Pollachi, Tamil Nadu 642103.

Weeds, a plant out of place, grow so luxuriantly, chokes out all other plants and interferes with the utilization of natural resources besides affecting the human welfare. Among the weeds *Cyperus rotundus* considered as one of the world's worst weed propagates mainly by producing a complex underground system of rhizomes, basal bulbs and tubers. The tubers remain viable for more than three years. Owing to the difficulties encountered in the conventional methods, a search on the new approach to control the weeds was begin recently. Degrading phenolic compounds responsible for dormancy of weeds with suitable functionalized nanoparticle would be an intelligent solution for the exhausting the weed seed bank.

Encapsulated glyphosate with TiO_2 nanoparticles recorded higher herbicide translocation to the primary tubers. Encapsulated glyphosate conjugated with iron oxide, silver and titanium dioxide nanoparticles controlled the production of secondary tubers. Thus the spread of the perennial weed the *C.rotundus* L. could be checked effectively with the new encapsulated glyphosate formulation conjugated with catalytic metal nanoparticles.

The performance of herbicides in tropical environments can sometimes be erratic and inefficient. This is particularly true for soil-applied herbicides where high temperatures, intense rainfall, low soil organic matter and microbial activity results in rapid breakdown and loss through leaching. Further the irrgation process reduces the herbicide concentration lead to reduced weed control efficiency coupled with leaching and potential ground water pollution. Thus the half-life period for many soil applied herbicides remains very short period ranging from few hours to couple of weeks.

By controlling structure precisely at nanoscale dimensions, one can control and tailor the properties of nanostructures, such as nanocapsules, in a very accurate manner for slow release herbicide to achieve season long weed control. Among the nano structures fabricated solvent evaporation was found to be longer in releasing the encapsulated pendimethalin herbicide molecules consistently upto the study period of 40 days under controlled environmental condition. This confirms that the herbicide entrapped inside the polymer was well protected from the environmental factors and released in slow manner based on the moisture availability. Besides the steady release and season long weed control, the nanoencapsulated herbicides offers several advantages compared to commercial form. It prevents the enlarging of weed seed bank, avoids harbouring of pest and diseases, conserve the soil nutrients and moisture, facilitate easy harvest operation and improve the quality of harvested material.

O-141

Alleviation of quinclorac toxicity by salicylic acid in rice seedlings based on visible/near-infrared hyperspectral imaging

Lan Li, Jian Wang , Chong Yang, Su Yang , Weijun Zhou*

Institute of Crop Science and Zhejiang Key Laboratory of Crop Germplasm, Zhejiang University, Hangzhou 310058, China

ABSTRACT

Hyperspectral imaging (380-1030 nm) was used to determine the herbicide induced toxicity in rice cultivars. Three different treatments of two rice cultivars (XS 134 and ZJ 88) were studied, including a control group, a group treated with quinclorac and a group that was pre-treated with salicylic acid (SA) under quinclorac stress. A physiological analysis showed that SA alleviated the quinclorac toxicity by stimulating enzymatic activity and reducing the level of reactive oxygen species (ROS). A principal component analysis (PCA) analysis using full spectra data indicated that the groups could be classified. Full-spectra-based support vector machine (SVM) models and optimal-wavelength-based SVM models of roots obtained better results performances than did those for the corresponding aboveground parts, with classification accuracies over 80% in calibration and prediction. The SVM models for ZJ 88 obtained better results than did the SVM models for XS 134, indicating the differences between cultivars. The prediction maps of sample status under different treatments were formed by applying the SVM models using optimal wavelengths on hyperspectral images, which provided direct visual information of rice growth status under pesticide stress. The results in this study would help develop a monitoring system for detecting herbicide toxicity detection by using hyperspectral imaging.

Keywords: Rice; quinclorac; salicylic acid; antioxidant; SVM model; hyperspectral imaging

O-142

Comparative transcriptome and iTRAQ proteome analyses of rice leaf responses to salicylic acid under quinclorac stress

Jian Wang, Lan Li, Meijuan Long, Mengting Lv, Weijun Zhou
Institute of Crop Science and Zhejiang Key Laboratory of Crop Germplasm, Zhejiang University, Hangzhou 310058, China

Abstract

To uncover the mechanism of salicylic acid (SA) alleviation under herbicide quinclorac stress, leaf samples of *Oryza sativa* (ssp. *japonica*) under quinclorac stress with and without SA pre-treatment were subjected to RNA sequencing and isobaric tags for relative and absolute quantification (iTRAQ) to determine the differentially expressed genes (DEGs) and proteins (DEPs), respectively. Results showed that quinclorac induced 2207 DEGs (1427 up-regulated, 780 down-regulated) and 147 DEPs (98 down-regulated, 49 up-regulated), these genes and proteins were enriched in GSH metabolism, porphyrin and chlorophyll metabolism, biosynthesis of secondary metabolites, glyoxylate and dicarboxylate metabolism and so on. It also influenced AP2-EREBP family, MYB family and WRKY family transcription factors. After SA pre-treatment, 697 genes and 124 proteins were differentially expressed. Pathway analysis showed similar enrichments in GSH, glyoxylate and dicarboxylate metabolism. Transcription factors were distributed in bHLH, MYB, Tify and WRKY families. Correlation analysis between transcriptome and proteomics exhibited that under quinclorac stress, correlated proteins mainly inhibited synthesis of chlorophyll. Other interesting genes and pathways that were impacted by quinclorac and modulated by SA were also discussed based on transcriptome and proteomics results.

Keywords: *Oryza sativa* L.; quinclorac; salicylic acid; RNA-Seq; iTRAQ; DEGs; DEPs; transcription factor

O-145

Influence of herbicides on plant parasitic nematodes infecting Aerobic rice

Nethi Somasekhar, B. Sreedevi* and K. Shivakrishna
ICAR-Indian Institute of Rice Research, Hyderabad, 500030, India

Plant parasitic nematodes are one of the important biotic constraints in aerobic rice cultivation worldwide. Plant parasitic nematodes are exposed to variety of agrochemicals including herbicides used in aerobic rice besides chemical nematicides that are directly targeted against them. Nevertheless, studies on influence of pre and post emergence herbicides on plant parasitic nematodes in aerobic rice ecosystem are meagre. We have addressed this by conducting a series of laboratory, glasshouse and field experiments using most commonly used pre-emergence (pendimethalin 30 EC @ 1.5 kg a.i./ha) and post-emergence (bispyribac sodium 10 EC @ 25 g a.i./ha) herbicides in rice. In a field experiment evaluating the efficacy of various weed management treatments, nematode analyses revealed that the population of plant parasitic nematodes was significantly low (204.5 nematodes/100 cc soil) in plots applied with bispyrebac-sodium compared to the untreated control (402.5 nematodes/100 cc soil). In laboratory bioassays, both herbicides showed *in vitro* nematicicdal activity. The mortality of second stage juveniles of rice root-knot nematode *Meloidogyne graminicola* when exposed to pendimethalin (1%) was 10.53, 28.88 and 33.31% after 24, 48, 72 h of exposure respectively, while in case of bispyribac-sodium (0.05%), it was 16.45, 28.88 and 35.60% after 24, 48, 72 h of exposure respectively. No nematode mortality was observed in untreated control. In glasshouse experiments, application of pendimethalin to soil in nursery trays day before sowing moderately reduced the root galls (16.32%) caused by the nematode compared to control. However, nematode development and reproduction was completely arrested in pendimethalin treated soil & seedlings in nursery at later stages. Similarly, spraying of bispyribac- sodium four day old seedlings significantly reduced the root galls (53.16%) and nematode multiplication (52.22%) compared to control. Our findings suggest that pre and post emergence herbicides applied to aerobic rice crop have the potential to suppress plant parasitic nematodes.

Topic: Herbicide

Paper to be presented in The 26 th Asian-Pacific Weed Science Society Conference 2017, Kyoto, Japan

*Presenting Author and Contact Author

P-001

Rinskor™ Active 2.7% NeoEC: A Novel Formulation of Auxin Herbicide For Post-Emergence Use In Transplanted Rice In Taiwan

Ta-I Huang and Yi-hsiou Huang

Dow AgroSciences Taiwan Ltd, Taiwan, Taiwan, Republic of China

Rinskor™ active represents the latest member of a unique and new synthetic auxin herbicide chemotype, the arylpicolinates. Rinskor disrupts the plant growth regulation processes through binding to unique auxin receptors. Rinskor binds with the AFB5 receptor with high affinity and with the TIR1 receptor with lower affinity in the cell nucleus which makes it different from other auxin chemistries. Rinskor will be positioned as a post-emergence product for the control of economically important grass, broadleaf and sedge weeds, including ALS, ACCase, HPPD, propanil, quinclorac, and glyphosate target site resistant biotypes in rice. In Taiwan, efficacy and crop tolerance field trials of Rinskor were conducted in transplanted rice from 2014 to 2016. From these trials, Rinskor applied at 30, 35 and 40 g ai/ha demonstrated 94% to 99% control on Echinochloa crus-galli (ECHCG); 86% to 98% control on Cyprus difformis (CYPDI); and 59% to 84% control on Ammannia multiflora (AMMMU) at 30 days after applications when applied at 4 to 5 leaf stages of ECHCG timing. There was no phytotoxicity on rice by Rinskor observed in these trials. Registration trials of Rinskor will be carried out in Taiwan in 2017.

P-002

2,4-Di-tertbutylphenol isolated from *Pennisetum purpureum*: A potential natural preemergence herbicide

Chuah T.S.[1] , Naimah, A.H.[1], Wan Nur Suzani Sazleen W.S.[1], Mazira C.M.[1], Norhafizah M.Z.[2], Shamsul Bahri, A.R.[1]

[1]School of Food Science and Technology, Universiti Malaysia Terengganu
[2]Faculty of Agro Based Industry, Universiti Malaysia Kelantan

The intensive use of synthetic herbicide has been the cause for the evolution of herbicide-resistant weeds, besides having a serious threat to human health and the environment. The need for new and more environmental friendly herbicides becomes obvious to solve the dilemma of the continued demand for herbicides. 2, 4-Di-tertbutylphenol (DTBP) was successfully isolated and identified from culm plus leaf tissue of *Pennisetum purpureum* extract as a potential natural herbicide through phytotoxicity tests of seed germination, leaf disc discoloration and seedling growth. 2,4-DTBP acts by inducing oxidative stress through the generation of reactive oxygen species which cause lipid peroxidation and membrane damage in root tissues and chloroplast in leaf tissues, thus leading to increased levels of antioxidant enzymes. Ultrastructural damage to chloroplasts was evident, with a disorganised thylakoid system and undulating membranes, coupled with the absence of starch grains and an increased number of plastoglobuli. Damage to the chloroplast ultrastructure subsequently reduced the leaf greenness, quantum yield and stomatal conductance values. The plant roots were severely damaged with the root nodes turned brown while symptoms of lamina wilting and necrosis were evident. 2, 4-DTBP has been formulated successfully and exhibited great pre-emergence herbicidal activity without injuring crop plants depending on growth stages and crop species. Persistence test has revealed that 2,4-DTBP is biodegradable and it has low persistence in soil. These findings imply that 2,4-DTBP compound has the potential to be developed as natural pre-emergent herbicide

P-003

Rinskor™ Active GR, a Novel Herbicide for Water injection market in Korea

Jeehwan Yi[1)], Kyehwan Lee[2)], Won Hur[2)], Ikuo Shiraishi[1)], Mauricio Morell[1)]
[1)]Dow AgroSciences LLC, [2)]Kyungnong Corporation

Rinskor™ active (Code# XDE-848, NRH-1317) is the newest arylpicolinate synthetic auxin herbicide from Dow AgroSciences with global utility in water-seeded, dry direct-seeded and transplanted rice, as well as utility in other crops. Rinskor has demonstrated unique and broad-spectrum weed control including important grass, sedge, and broadleaf weed species in rice, and has a novel attribute to control ALS-, ACCase-, propanil-, and quinclorac target site-resistant weeds due to its differentiated receptor binding characteristics.

In Korea, herbicides can be applied either directly into flooded paddy or foliar sprayed at post emergence timings. Granular formulations have been widely used in Korean transplanted rice since 1983 to control annual and perennial weeds (water injection at 10~15 days after transplanting). These formulations have been successful in water injection application as mobility in water system is an important factor to consider.

Dow AgroSciences has conducted trials with Rinskor since 2012 in Korea, as a product for the mid one-shot application segment compared with most important commercial standards. This report summarizes results of 13 field trials with Rinskor granule formulation (GR) conducted from 2012 to 2016. Rinskor GR at 25 to 200 gr ai ha^{-1}, was applied at 5 to 30 days after transplanting (DAT), when the growth stage of *Echinochloa crus-galli* (ECHCG) was from 1.0 leaf stage to 1 to 2 tiller stage. Regarding weed control, Rinskor GR showed over 95% control at 40 days after application against broad leaf weeds, including *Monochoria vaginalis* (MOOVA), and *Lindernia Dubia* (LIDDU) and sedge weeds such as *Cyperus difformis* (CYDPI) even at a low tested dose (25 gr ai ha^{-1}). Rinskor GR demonstrated good performance (over 95% control at 40 days after application) against *Echinochloa crus-galli* (ECHCG) at 50 gr ai ha^{-1}. Control observed on *Scirpus juncoides* (SCPJU) and *Eleocharis kuroguwai* (ELOKU) was lower than the standards. In terms of rice safety, slight phytotoxicity was observed at early application (5 DAT) and high dosage (> 100g ai/ha); however, rice fully recovered after 20 to 40 DAA and there was no significant influence in grain yield.

™ Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow.

P-004

Herbicidal Characteristics of Secondary Metabolites from *Streptomyces* sp. KRA14-329 and Their Possible Mode of Action

Hyun-Suk Yeom[1], Jung Sub Choi[1], Young Kwan Ko[1], Young Sook Kim[1], Hun Tak Sin[2], Kee Woong Park[2]

[1]Eco-friendly New Materials Research Center, Korea Research Institute of Chemical Technology, Daejeon, 34114, Republic of Korea

[2]Department of Crop Science, Chungnam National University, Daejeon 34134, Republic of Korea

Approximately 600 Actinomycete strains were isolated from soil samples collected from forests in Korea. The isolates were assessed for their herbicidal activities, and KRA14-329 was found to have strong herbicidal activity. Based on 16S rRNA gene sequence analysis and morphological characteristics, KRA14-329 was confirmed to be *Streptomyces* sp. NMR and ESI-MS analyses of the *Streptomyces* identified cyclohexamide compounds, 329-M1 and 329-M2, which contained glutarimide moiety in their structures. This study was conducted to determine characteristics and mode of action of these two active herbicidal compounds isolated from KRA14-329. To evaluate herbicidal activity of the isolates, 329-M1 and 329-M2 were applied at 62.5, 125, 500 μg mL^{-1} as a foliar application to four grass species, *Sorghum bicolor*, *Echinochloa crus-galli*, *Agropyron smithii*, and *Digitaria sanguinalis*; and four broadleaf species, *Solanum nigrum*, *Aeschynomene indica*, *Xanthium strumarium*, and *Calystegia japonica*. Application of 329-M2 at 125 μg mL^{-1} provided complete control of broadleaf species by seven days after treatment while, at 250 μg mL^{-1}, it provided complete control of all treated plants. Plants treated with 329-M2 showed visible symptoms of herbicidal effect within 24 hours, starting with wilting which advanced to burndown followed by desiccation and death. Levels of electrolyte leakage, chlorophyll contents, and malondialdehyde production were measured in the 329-M2 treated plants and compared to those of plants treated with non-selective herbicides, paraquat and glufosinate-ammonium. The effects of 329-M2 were found to be dose- and time-dependent in all three measurements and were approximately half the levels of effects caused by paraquat or glufosinate-ammonium. Thus, the herbicidal action mechanism of 329-M2 does not appear to be direct disruption of cell membranes. The results of this study showed that 329-M2 isolated from *Streptomyces* KRA14-329 has potential as a biocontrol agent and may be used as a lead compound for development of a natural herbicide.

P-005

Council Complete - Field performance (efficacy, selectivity) in rice

Kenji Sugiura[1], Tatsuya Yamaoka[2], Masaaki Sase[3], Shinichi Shirakura[3]

[1]Bayer CropScience K.K. (Japan), 9511-4, Yuki, Yuki-shi, Ibaraki
[2] Bayer CropScience K.K. (Japan), 2549, Osone-otsu, Nankoku-shi, Kochi
[3] Bayer CropScience K.K. (Japan), 1-6-5, Marunouchi, Chiyoda-ku, Tokyo

Triafamone is a novel rice herbicide discovered by Bayer. Triafamone has unique efficacy against grass (*Echinochloa* spp.) and perennial weeds. Council Complete is a pre-mixed rice herbicide containing triafamone and tefuryltrione.

Methodology

1. Field trial was conducted in transplanted rice. Triafamone 0.5% GR 10 kg/ha was applied at four timings, just after and 5 days after transplanting, 3 leaf stage and 4 leaf stage for *Echinochloa crus-galli*.
2. Field trial was conducted in transplanted rice. Council Complete GR (triafamone + tefuryltrione 0.5+3.0%) 10kg/ha was applied at three timings, 5 days after transplanting, 3 leaf stage and 3.5 leaf stage for *Echinochloa crus-galli*.
3. Field trial was conducted in direct seeded rice. Iron coated seeds were sown on wet soil surface. Council Complete GR 10kg/ha was applied at three timings, just after sowing and 1 leaf stage for rice and 3 leaf stage for *Echinochloa crus-galli*.

Results

1. Triafamone showed good efficacy against annual grass (*Echinochloa crus-galli*), annual sedges (*Cyperus* sp., *Scirpus* sp.) and perennial weeds (*Cyperus* sp., *Sagittaria* sp. and *Eleocharis* sp.). Triafamone showed good selectivity in transplanted rice at all application timings.
2. Council Complete GR 10kg/ha showed good efficacy against annual weeds (*Echinochloa crus-galli*, *Monochoria* sp., *Lindernia* sp., and *Scirpus* sp.) and perennial weeds (*Cyperus* sp., *Sagittaria* sp. and *Eleocharis* sp.) for 6 weeks after application. Council Complete GR showed good selectivity in transplanted rice at all application timings.
3. Council Complete GR 10kg/ha showed good efficacy against annual weeds for 8 weeks after sowing. Furthermore, Council Complete GR showed good selectivity in direct seeded rice at all application timings.

Conclusion

Council Complete is a broad spectrum and long lasting one shot herbicide for transplanted and direct seeded rice cultivations. Council Complete is a very versatile and convenient product for farmers on account of its wide application window.

P-006

Study on the methodology to evaluate weed-control efficacy of rice herbicides against *Paspalum distichum* L. (knotgrass)

Shinichi Shirakura[1], Rika Matsuura[2], Tatsuya Yamaoka[2], Chieko Ueno[3], Hidenori Hayakawa[1], Kenji Sugiura[4]

[1] Bayer CropScience K.K. (Japan), 1-6-5, Marunouchi, Chiyoda-ku, Tokyo
[2] Bayer CropScience K.K. (Japan), 2549, Osone-otsu, Nankoku-shi, Kochi
[3] Bayer CropScience K.K. (Japan), 1500-41, Mukouueno, Chikusei-shi, Ibaraki
[4] Bayer CropScience K.K. (Japan), 9511-4, Yuki, Yuki-shi, Ibaraki

Paspalum distichum L. is a perennial grass and known as a hard-to-control weed due to strong regrowth ability as well as invasion from paddy dyke into neighboring fields.

In this study, availability of a new methodology was investigated in order to evaluate the performance of rice herbicides on *P. distichum* L. preliminary grown on paddy dyke, which was designed to simulate continuous invasion of the weed under practical paddy fields in Kochi Prefecture, Japan.

Materials and methods

In February 2016, overwintered shoots of *P. distichum* L. collected from paddy fields were grown in pots up to ca. 50cm under greenhouse conditions, then planted on paddy dyke in early April. When the dyke was fully covered with the weed, test field was puddled and small plots (2mx2.7m/plot) were prepared. Tefuryltrione+triafamone GR (3+0.5%) was applied at 5 and 15 days after the plotting (DAP). Herbicidal efficacy was evaluated by visual observation, measuring shoot length and estimating weed coverage in comparison to the commercial products.

Results

Tefuryltrione+triafamone GR applied at 10 kg/ha strongly inhibited the growth of the weed infested inside the test plots and well depressed the continuous invasion from the paddy dyke. The control efficacy continued until starting the mid-season drainage (47 DAP).

In contrary, one commercial product, having registration label for *P. distichum* L., showed slight suppression of the weed infested inside the plots, while little control efficacy on the invasion. The other commercial product, having no registration label for the weed, showed no efficacy.

Conclusion

By using *P. distichum* L. preliminary grown on paddy dyke, the new methodology investigated here was considered to be useful for evaluating the efficacy of rice herbicides on the weed not only infested in the paddy fields but also continuously invaded from paddy dyke into the paddy fields.

P-007

Bio-efficacy evaluation of herbicides in rice cultivation in Sri Lanka

H.M.S.D. Kulatunga[1], D.D. Witharana[2], A.S.K. Abeysekara[2], U.B. Wickrama[2]

[1]Postgraduate Institute of Science, University of Peradeniya

[2]Rice Research and Development Institute, Batalagoda, Sri Lanka 60500

**Email: sakindadulwan@gmail.com*

Rice is the staple food and weeds are the major biotic stress in the rice cultivation. Chemical weed control is the major practice (>90%) by farmers. The field experiment was conducted to evaluate six herbicides for their weed control ability and phytotoxicity to rice at the Rice Research and Development Institute (RRDI), Sri Lanka. The trial design was Randomized Complete Block (RCBD), with three replicates. The herbicide formulations; Fenoxaprop-p-ethyl 69 g/l EC (250 ml/ha), Bispyribac-sodium 20% WP (225 g/ha), Metamifop 10% EC (1000 ml/ha), Pendimethalin 455 g/l CS (2000 ml/ha), Oxadiazon 20% EC (1800 ml/ha), Bentazone 48% SL (2500 ml/ha), were selected along with commonly used herbicides Fenoxaprop-p-ethyl 69% + Ethoxysulfuron 20% OD (500ml/ha), Propanil 36% EC (7500 ml/ha) followed by MCPA 60% SL (1800 ml/ha) with non-weed and weeded used as control. The weed density and dry weight of grasses, broad-leaf and sedges were measured and growth characters, yield and yield components of rice were obtained. Data was analyzed using SAS statistical software. Major weeds in experimental site were *Leptochloa chinensis*, *Isachne globosa*, *Echinochloa crus-galli*, *Monochoria vaginalis* and *Marsilea quadrifolia*. Generally efficacy of herbicides is low in minor seasons in Sri Lanka due to higher temperatures and poor water availability. Result showed that Fenoxaprop-p-ethyl 69 g/l EC and Metamifop 10% EC had the highest controlling efficacy for grasses followed by Pendimethalin 455 g/l CS. Bispyribac-sodium 20% WP and Oxadiazon 20% EC are effective broad spectrum herbicides and Bentazone 48% SL as an effective broad-leaf and sedge killer herbicide in wet seeded rice fields. of the tested herbicides Fenoxaprop-p-ethyl 69 g/l EC and Oxadiazon 20% EC showed slight phytotoxicity (leaf tip burn) to the rice crop which recovered within 3-4 days after application and not indicated in the grain yield. All herbicide treatments gave significantly higher yield than non-weeded treatment.

P-008

Control of weedy-rice in Japan using mixtures including pyrazoxyfen and flucetosulfuron

Yousuke Kobayashi[1], Taketo Suganuma[1], Megumi Miyashita[1], Shigeru Mitani[1]

[1]Bioscience Research Laboratory, Ishihara Sangyo Kaisha, Ltd.

Weedy-rice (*Oryza sativa*) is rice other than cultivated rice transplanted or seeded in paddy fields for the purpose of cultivation. It competes with cultivated rice and contaminates seeds at harvest, resulting in decreased yields and quality(1) . Weedy-rice has been spreading in some regions of Japan with the spread of direct-sowing cultivation systems. Therefore, it is very important to control weedy-rice. We will report on the control of weedy-rice using herbicides that were developed by Ishihara Sangyo Kaisha, such as SL-498 (a pyrazoxyfen, pretilachlor, and simetryn mixture), SL-0604 (a flucetosulfuron, benfuresate, and simetryn mixture), and SL-0701 (a flucetosulfuron, carfentrazone-ethyl, cafenstrole, and benzobicyclon mixture).
The herbicidal efficacy of the mixtures was evaluated in pot-scale trials. When the weedy-rice reached a predetermined leaf stage (pre-emergence, early post-emergence, or one-leaf stage), each mixture was applied under water-logged conditions. SL-0701 showed excellent herbicidal efficacy when applied pre-emergence and early post-emergence, whereas SL-498 and SL-0604 performed well only when applied pre-emergence.
The herbicidal activity at different emergence depths of weedy-rice seeds was evaluated in pot-scale trials. Weedy-rice seeds were sown manually on the soil surface and covered with soil to sowing depths of 1, 2, 3, or 5 cm. The pre-emergence application of SL-498 and SL-0604 had excellent herbicidal efficacy on weedy-rice sown 1 cm below the soil surface, while SL-0701 controlled weedy-rice sown 3 cm below the surface. With early post-emergence applications, SL-0701 killed weedy-rice that germinated 1 cm below the soil surface.
The biological performance of the mixtures in the field was evaluated in Japan Association for Advancement of Phyto-regulators. The mixtures were effective in the field trials; they were safe for rice and did not affect yield. These results suggest that SL-498, SL-0604, and SL-0701 will be excellent tools for managing weedy-rice in paddy fields.

(1) Zassou to sakumotu no Seigyo, vol 12, 2016, p8

This study was reported at The 54th Weed Science Society of Japan.

P-009

Study on the mode of action and metabolic detoxification of a novel herbicide, fenquinotrione

Shunsuke Yamamoto, Yoshitaka Tanetani, Kiyoshi Kawai

Life Science Research Institute, Kumiai Chemical Industry Co., Ltd., 276 Tamari, Kakegawa, Shizuoka, 436-0011, Japan

Fenquinotrione is a novel triketone-type HPPD (4-hydroxyphenylpyruvate dioxygenase)-inhibiting herbicide having an oxoquinoxaline ring for use in paddy rice. Fenquinotrione provides excellent efficacy on resistant weeds to ALS-inhibiting herbicides as well as broadleaf weeds in paddy field.

In this study, we evaluated the inhibition of plant HPPD by fenquinotrione and elucidated its selectivity mechanism on rice. Fenquinotrione potently inhibited recombinant HPPD activity with IC_{50} of 24 nM for rice and 20 nM for *Arabidopsis thaliana*, respectively. In addition, considering high similarity in the amino acid sequence of HPPD among plants, it was assumed that fenquinotrione selectivity was not due to the difference in the sensitivity of HPPD.

Therefore, we examined the factor to determine the selectivity of fenquinotrione between rice and susceptible weeds from the viewpoint of metabolism. Specifically, we focused on rice cytochrome P450, CYP81A6 which was known as involved in herbicide metabolism. To elucidate the direct involvement of CYP81A6 to metabolism of fenquinotrione, we estimated the efficacy of fenquinotrione to the transgenic rice plants in which CYP81A6 expression levels are repressed by RNA interference. As a result, the sensitivity to fenquinotrione was approximately 20-fold higher than that of wild type (Nipponbare). In addition, O-demethylated fenquinotrione, the main metabolite in rice seedlings, was detected in the reaction of fenquinotrione with recombinant CYP81A6 prepared from transformed *E. coli*. On the other hand, CYP81A6 didn't possess metabolic activity against other well-known HPPD-inhibiting herbicides. Furthermore, our research showed that sequence of CYP81A6 gene has 100% identity among rice cultivars containing feed rice for which other HPPD-inhibiting herbicides can't be used, and the expression level of CYP81A6 gene in those cultivars was equal or higher compared to that in Nipponbare.

These results strongly indicate that CYP81A6 is greatly involved in the selectivity of fenquinotrione to rice cultivars including feed rice.

P-010

Comparison of the physiological effects of five different auxinic herbicides on *Arabidopsis thaliana* mutants

Toshiki Komai[1], Yukari Sunohara[1], Hiroyuki Kawano[1], Satoshi Iwakami[2], Ken-ichiro Hayashi[3] Hiroshi Matsumoto[1]

[1]University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8572, Japan
[2]Kyoto University, Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan
[3]Okayama University of Science, 1-1 Ridai-cho, Okayama, Okayama 700-0005, Japan

Six TIR1/AFB auxin receptors involved in the perception of auxinic herbicides have been reported in *Arabidopsis thaliana*. Previous studies suggested that the receptors TIR1, AFB2, and AFB3 play important roles in 2,4-dichlorophenoxyacetic acid (2,4-D)-induced root-growth inhibition, whereas AFB4 and AFB5 are related to picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid)-induced root-growth inhibition in *A. thaliana*. However, the physiological effects and receptors of quinclorac (3,7-dichloro-8-quinolinecarboxylic acid), haven't clarified yet. In this study, root-growth inhibition and ethylene production in *A. thaliana* were determined to compare the physiological effects of five auxinic herbicides using *tir1/afb* mutants. The auxinic herbicides used in this study were 2,4-D; DMPA (2-(2, 4-dichloro-*m*-tolyloxy) propionic acid), which is an active compound of clomeprop; quinclorac; quinmerac (7-chloro-3-methyl-8-quinolinecarboxylic acid); and picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid). The mutants *tir1* and *afb2* showed resistance to the quinolinecarboxylic acid herbicides, quinclorac and quinmerac, and the aryloxyacetate herbicides, 2,4-D and DMPA 5 days after treatment, whereas *afb4* and *afb5* showed resistance to the picolinate class herbicide, picloram. Quinclorac- or 2,4-D-induced ethylene production was suppressed in *tir1*, *afb2*, and *tir1/afb2*, whereas ethylene induction by picloram was suppressed in *afb4* and *afb5*. These results suggest that TIR1 and AFB2 are involved in the perception of synthetic auxins belonging to the quinolinecarboxylic acid and aryloxyacetate group of auxinic herbicides and their effects on root-growth inhibition and ethylene production, whereas AFB4 and AFB5 are involved in picloram-mediated effects in *A. thaliana*.

P-011

Identification of Genes Potentially Associated with Nicosulfuron Tolerance in Maize via Bulked Segregant RNA-Seq

Xiaomin Liu, Guiqi Wang, Xian Xu, Binghua Li, Huanhuan Zhang, Zhizun Qi

Institute of Cereal and Oil Crops, Hebei Academy of Agriculture and Forestry Sciences, Shijiazhuang, P.R.China, 050035

Nicosulfuron is one of the most widely used post-emergence herbicides in maize fields in China. But recently, a great number of reports have shown that some maize hybrids and inbred lines can be severely injured or killed after application of nicosulfuron. In our previous study, we have identified two nicosulfuron tolerant inbred lines HB05, HB09, and two nicosulfuron susceptible inbred lines HB39, HB41. A combined approach of bulked segregant analysis and RNA-seq was then employed to identify candidate genes involved in nicosulfuron tolerance. Two groups of 3000 F2 population derived from a cross of HB39×HB05 and HB41×HB09 were constructed respectively. RNA-Seq reads were generated from pools of 100 nicosulfuron tolerant and 100 nicosulfruon susceptible individuals identified from the above two groups, separately. RNA-Seq reads were trimmed and aligned to the B73 reference genome to obtain the SNPs in the tolerant and susceptible bulks. In total, 77,951 and 69,304 SNPs were identified and used for the BSR-Seq analysis. Via the BSR-Seq analysis, the nicosulfuron tolerant gene was located to an 1.1~15.3M and 0.5~18.2M intervals on the short arm of chromosome 5, which included 706 and 837 annotated genes. To identify the potential associated genes within these regions, the annotated genes were further screened based on their expression pattern within the bulks. A total of 43 and 119 differentially expressed genes were found with 18 genes in common, which suggested that these genes could be potentially involved in nicosulfuron tolerance in maize. qRT-PCR was performed for these genes using individual plants, and the data confirmed the qualitative values of the RNA-Seq. The study may contribute to the understanding of the molecular mechanism of sulfonylurea herbicides susceptibility in maize and thus helps to guide the breeding programs.

P-012

Response of Soybean applied with Flumioxazine 50% soluble concentrate and its residual effect on Sunflower and Pearl millet

***R.Thirumalaikumar[1], R.Kalpana[2], N.S.Venkataraman[3], K. Balakrishnan[4] and R. Babu[5]**

[1]Research Scholar, Dept. of Agronomy, AC&RI, TNAU, Madurai - 625 104, Tamil Nadu, India

[2] Associate Professor, Dept. of Agronomy, AC&RI, TNAU, Thiruvannamalai - 606 753, Tamil Nadu, India

[4]Professor and Head, Dept. of Agronomy, AC&RI, TNAU, Madurai - 625 104, Tamil Nadu, India

[4]Professor, Dept. Seed science & Technology, AC&RI, TNAU, Madurai - 625 104, Tamil Nadu, India

[5] Professor and Head, Dept. of Farm Management, AC&RI, TNAU, Madurai-625 104, Tamil Nadu, India

***Corresponding author' E-mail**: *thiruhid@gmail.com*

Abstract

A Field experiment was conducted at Agricultural Research Station, Bhavanisagar of Tamil Nadu Agricultural University during *Rabi* 2013-14 to study the response soybean applied with pre emergence application of flumioxazine 50% SC ant it is residual effect on succeeding crops. The experiment was laid out in a Randomized Block Design (RBD) replicated thrice with eleven treatments. Weed flora of the experimental field comprised of five species of grasses, a sedge and ten species of broadleaved weeds. At all the stages of crop growth, the major proportion of the weed flora was dominated by grasses. Pre-emergence application of flumioxazine at 250, 150 and 125 g ha^{-1} and pendimethalin at 1.0 kg ha^{-1} reduced the total weed density and dry weight. Among the treatments, pre-emergence application of flumioxazine at 112.5 g ha^{-1} recorded increased yield and economic returns in soybean. Hence, the pre-emergence application of flumioxazine at 112.5 g ha^{-1} can reduce the weed density and dry weight below the economic threshold level and increase the yield and net return in soybean without any phytotoxic effect on the crop and residual effect on the succeeding crop. It could be concluded that the application of flumioxazine at 112.5 g ha^{-1} as pre emergence herbicides provides an option to farmers to manage weeds effectively along with improved growth leading to higher productivity of soybean.

P-013

Nicosulfuron: A new herbicide for weed control in corn fields in Thailand

Hiroyuki Okamoto, Satoko Fujii, and Hiroshi Kikugawa

Ishihara Sangyo Kaisha, Ltd., 1-3-15, Edobori, Nishi-ku, Osaka, 550-0002, Japan

In Thailand, a non-selective herbicide, Paraquat, and pre-emergence herbicides, such as Atrazine and Acetochlor, have been the primary herbicides used for weed control in corn. Grass weeds are common in the corn fields of Thailand, as they are in other countries; however, Thai corn glowers needed to use limited types of herbicides with less application flexibility to control grass weeds. We predicted that Nicosulfuron, a corn herbicide that has been widely used since the 1990s, could be an option to improve the flexibility of weed management practices for Thai corn growers. Therefore, we conducted several studies to evaluate the performance of Nicosulfuron under Thai field conditions. We evaluated the efficacy of Nicosulfuron to control common weeds in Thai corn fields, *Echinochloa colona*, *Eleusine indica*, *Trianthema portulacastrum*, and *Amaranthus viridis,* at different growth stages. Nicosulfuron applied at a rate of 30–45 g ai/ha provided good to excellent weed control on weeds that were at the 2- or 4-leaf stages by 15 days after treatment (DAT), whereas it was less effective on weeds at the 6-leaf stage. The results of field trials in Lopburi province, Thailand, revealed that 45 g ai/ha of Nicosulfuron applied at 10 days after sowing (DAS) was effective at controlling grass weeds but not broad-leaved weeds (30 DAT). Over-the-top application of Nicosulfuron, at a dose of 45–75 g ai/ha, at 10 and 15 DAS caused slight phytotoxicity in corn at 3 DAT; however, the symptoms disappeared by 15 DAT. These results indicated that Nicosulfuron was a new tool for weed management in corn fields in Thailand. Nicosulfuron was registered in Thailand in 2014, and it was launched onto the market in 2016.
We would like to express our deepest gratitude to T.J.C. Chemical Co., Ltd., Thailand for cooperation with conducting studies in Thailand.

P-014

[Title]

Selection of appropriate herbicides for establishment of weed control system and occurrence of invasive exotic weeds in adzuki bean

[Authors]

Jae-Bok Hwang*, Tae-Seon Park, Hong-Kyu Park, Hak-Sin Kim, In-Bae Choi, Bon-Il Koo, Hee-Soo Bae

[Affiliation]

Crop Production and Physiology Division, National Institute of Crop Science, RDA, Hyeoksin-ro, Wanju-gun, Jeollabuk-do 55365, Korea

[Abstract]

It is essential that crop protection materials help prevent weeds in farm products in order to maintain productivity and quality. But, now there is no herbicide applicable to Adzuki beans in Korea. To select appropriate herbicides for adzuki bean, a series of experiments was carried out in both field and pot from 2014 to 2016.

Pre-emergence herbicides showed relatively low phytotoxicity were s-metolachlor, metazachlor, for adzuki bean. In s-metolachlor, weed control was 99% in the recommended rate and 97% in the half application rates at 30 days after seeding(DAS). In metazachlor, weed control was 98% in the recommended rate and 96% in the half application rates at 30 DAS. But, both herbicides were not controllable to *Digitaria sanguinalis* and *Portulaca oleracea.* The herbicides, which was low phytotoxicity but not efficacy of chemicals, were napropamide, metribuzin, and trifluralin. Systematic treatment is needed to control gramineous weeds during growth. Post-emergence herbicides showed no external phytotoxicity for adzuki bean were clethodim, fenoxaprop-P-ethyl, fluazifop-P-butyl, and sethoxydim.

The exotic weed emerged in the field of adzuki were *Ipomoea hederacea*, *Abutilon avicennae,* and *Celosia argentea*. As for the growth characteristics of exotic weeds, the plant height were *Ipomoea hederacea* (259 cm), *Abutilon avicennae* (98 cm), and *Celosia argentea*(76 cm), respectively. Also the weight of fresh were *Ipomoea hederacea* (850 g), *Celosia argentea* (66 g), and *Abutilon avicennae* (101 g), respectively.

P-015

Assessment of different weed control methods on growth and yield of wheat

Mohammad Shamim Hasan Mandal[1], Md. Hazrat Ali[2], A.K.M. Ruhul Amin[2], Sheikh Muhammd Masum[2], Hasan Mehraj[3]

[1] Graduate School for International Development and Cooperation (IDEC), Hiroshima University, Japan
[2] Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh
[3] The United Graduate School of Agricultural Science, Ehime University, Japan

A field experiment was conducted at Agronomy research field, Sher-e-Bangla Agricultural University, Bangladesh to find out the impact of different weed control methods on growth and yield of wheat. The experiment was carried out with four weed control methods viz. W_0= control (no weeding), W_1= two hand hoe weeding at 20 DAS and 40 DAS, W_2= Topstar 80WP (Oxadiargyl 800 g/kg) @ 75 g/ha as postemergence and W_3= Sunrice 150WG (Ethoxysulfuron 150 g/kg) @ 100 g/ha as early post-emergence herbicide using completely randomized block design with three replications. Among the weed control methods Sunrice 150WG (W_3) showed minimum total number of weed (29.8/m^2), weed biomass (6.5 g/m^2), maximum weed control efficiency (57.8%), grain yield (3.9 t/ha), straw yield (5.3 t/ha), biological yield (9.2 t/ha) and harvest index (41.3%). Effective weed control method could be used for the better production of wheat.

P-016

Expanding pre-emergence weed control options in safflower (*Carthamus tinctorious*)

Clair L. Keene[1] and Caleb D. Dalley[2]

[1]North Dakota State University Williston Research Extension Center, Williston, ND, USA
[2]North Dakota State University Hettinger Research Extension Center, Hettinger, ND, USA

Safflower is an oil seed crop well suited to the semi-arid Northern Great Plains of western North Dakota and eastern Montana. Safflower adds diversity to crop rotations dominated by small grains. A major factor limiting safflower production is the lack of herbicide options that offer consistent weed control and crop safety. An experiment was conducted at two locations in 2016 in western North Dakota to review pre-emergent herbicide options for weed control efficacy and crop safety. A randomized complete block design with 4 replications was used to evaluate injury and weed control in safflower variety Cardinal. Herbicide treatments included Prowl H2O (pendimethalin), Zidua (pyroxasulfone), three rates of Zidua SC, two rates of Outlook (dimethenamid), Spartan (sulfentrazone), and Spartan Charge (sulfentrazone + carfentrazone-ethyl). Visual ratings of injury were generally higher at Williston than at Hettinger. The only significant difference in injury at 5 weeks after emergence (WAE) was Spartan Charge showing greater injury than all other treatments at Hettinger. Plant heights were similar across treatments at Williston and Hettinger, with the exception of the weedy check having shorter plants at Hettinger at 6 WAE. At both sites, stand counts at 5 WAE were similar across herbicide treatments and were only reduced in the weedy check at Hettinger. Only the weedy check plots had lower yields than all other treatments at both sites. Results demonstrate that Cardinal safflower can grow out of early season injury that may result from the herbicides tested without yield loss. Regarding weed control, the highest rate of Zidua SC provided the best control at Williston. At Hettinger, weed control was poor regardless of herbicide tested due to lower than normal rainfall May through August. However, wild oat control was better with Zidua (either formulation) and Outlook compared to either Prowl H2O or Spartan.

P-017

Herbicidal Efficacy of Metamifop Granule or Emulsifiable Concentrate to *Leptochloa chinensis* (L.) Nees

Ken-ichi Sudo[1], Masahiro Akazawa[1], Yoshihito Asanuma[2] and Kentaro Shirouzu[2]

[1] Japan Association for Advancement of Phyto-Regulators, 1-26-6 Taito, Tokyo Taito-ku 110-0016, Japan
[2] Kaken Pharmaceutical co., LTD., 2-28-8, Honkomagome, Tokyo Bunkyo-ku 113-8650, Japan

Leptochloa chinensis (L.) Nees (Chinese sprangletop), an annual plant belonging to the family of Poaceae, is important weed which grows in paddy, upland and levee in southwest of Japan. We investigated the herbicidal efficacy of Metamifop granule (MG) and Metamifop Emulsifiable Concentrate (MEC) against different height stage Chinese sprangletop. Seed samples of Chinese sprangletop were collected from field of Japan Association for Advancement of Phyto-Regulators (JAPR) Okayama (Onoue, Kita-ku, Okayama-shi, Okayama) in 2015. Seeds of Chinese sprangletop were placed on soil surface in 64 mL square plastic pots on May 15, June 1 and June 20, 2016. The plants were grown in a rain shade green house. At July 7, the different height stage weeds of Chinese sprangletop were transplanted to paddy field (MG : 10cm, 20cm and 30cm, MEC : 30cm, 45cm and 60cm). MG or MEC were treated on 3 days after transplanting. Herbicide efficacy was evaluated by weighting the biomass of weed in comparison with the untreated control weed on 40 days after treatment. MG had a good herbicidal efficacy against Chinese sprangletop in up to 20cm height, and less efficacy 30cm height. On the other hand, MEC had a good herbicidal efficacy in up to 60cm height. In conclusion, MG and MEC are capable of controlling Chinese sprangletop in paddy field.

P-018

Efficacy of herbicides for weed control and their residues in sweet corn

Amornpan Koysungnoen[1], Avishek Datta[1], Tosapon Pornprom[2]

[1] Department of Food, Agriculture and Bioresources, School of Environment, Resources and Development, Asian Institute of Technology, Pathum Thani 12120, Thailand
[2] Department of Agronomy, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140, Thailand

Weeds are one of the major problems in crop production and are responsible for significant crop yield reduction. The most common method of control of any weed species has been by herbicides. The use of herbicides by Thai farmers is highly inefficient and has led to chemical contamination in the food stuffs. The improper and overuse of herbicides may lead to an increase in herbicide-resistant weeds and create environmental pollution. The objective of the study was to evaluate the efficacy of selected pre-emergence herbicides for weed control and determine their residues in sweet corn. The highest level of weed control and the greatest crop yield was obtained with alachlor at 1,080 g a.i./ha. A similar level of weed control was obtained with pendimethalin at 522.50 g a.i./ha. The herbicides used in this study degraded with time and no residues were detected in the soil and grain when analyzed by the in-house method and gas chromatography-mass spectrometry (GC-MS). No significant herbicide residues on grain (MRLs < 0.01 ppm) were observed for all herbicides used in this study. The results of this study showed that the application of alachlor at 1,080 g a.i./ha was efficient to provide satisfactory broad-leaf weed control and gave the highest crop yield and profit. In addition, pendimethalin at 522.50 g a.i./ha can provide a similar level of weed control as an alternative to reduce herbicide dosage. This indicates that the soil treated with pre-emergence herbicides had no phytotoxic effect on the growth and crop yield of sweet corn. These herbicides can safely be used by sweet corn growers to increase yield and profitability, and minimize environmental impact.

P-019

Effects of formulation and soil moisture conditions on efficacy of soil applied herbicides to a grass weed dominating in rice fields of tropical savanna

Akiko Usui[1], Atsushi Ogawa[1], Chiharu Sone[1] , and Hirohiko Morita[12]

[1] Akita Prefectural University, 241-438 Kaidobata-Nishi Nakano Shimoshinjo Akita 010-0195, Japan

[2]Japan Association for Advancement of Phyto-Regulators, 860 Kashiwada, Ushiku 300-1211, Japan

In flooded plains of Republic of Ghana in Sub-Saharan Africa, a rice culticvation system of no-till direct sowing using flood in rainy season, without mechanization such as tractor and irrigation schemes, has been studied (Sakagami et al. 2012, Morita 2014).Under the rain fed condition, emergence and growth of weeds and rice plants are affected by soil moisture drastically changingat the end of dry season. Butachlor herbicide is one of major weed-control means in no-tilling direct sawing, and its liquid formulation is popularly used for rice fields in Ghana (Uchino *et al*. 2013). In order to adopt this herbicide in the cultivation system, differences in the effects of butachlor between two formulations, granule and emulsion, on the grass weeds growing under several soil moisture conditions. Seeds of *Digitaria longiflora,* a troublesome species in rice fields of northern Ghana were sown in plastic pots filled with andosol and grown in a growth chamber. *Echinochloa crus-galli* var. *crus-galli* from Akita, in northern Japan was included as a standard grass weed in Japan. At 0.3, 1.0 and 1.5 leaf stage, plants were treated with butachlor 1.5 kg a.i. / ha. 5% granule or 32% emulsion under 38% and 60% of soil moisture rates and saturated soil condition. Butachlor emulsion had higher effects of killer rate compared to granule, especially in 0.3 leaf stage of *D. longiflora*. Herbicidal efficacy was tended to increase with soil moisture in both agents. Compared with granules, emulsion is not influenced by soil moisture rate. Herbicidal efficacy was effective at the young leaf stage and that was clear in *D. longiflora.* The herbicidal efficacy of granules was more stable and effective than emulsion. In *D. longiflora,* herbicidal efficacy might be affected under saturated condition at emergence time. We need further studies including phyto-toxicity to young rice plants.

P-020

Antagonism of herbicides with different mode of action for the management of *Digitaria insularis*

Camila Ferreira de Pinho[1], Jéssica Ferreira Lourenço Leal[1], Amanda dos Santos Souza[1], Samia Rayara de Sousa Ribeiro[1], Gabriella Francisco Pereira Borges de Oliveira[1], André Lucas Simões Araujo[1], Joyce de Aguiar Carvalho [1], Caio Victor Lopes Pereira[1]

[1] UFRRJ - Federal Rural University of Rio de Janeiro - Institute of Technology - Department of Engineering - BR 465, km 7 - Seropédica-RJ/Brazil

Digitaria insularis is the most important weed in crop areas in Brazil. To manage areas with this weed and other broadleaves species, a sequence of herbicides with different mode of action is necessary. The objective of this study was to evaluate the antagonism antagonistic effect between ACCase-inhibitor herbicides and ALS- inhibitor herbicides or auxin mimetics herbicides. Two experiments were carried out: the first one (EI) was conducted using (A) haloxyfop-P methyl (62 g a.i. ha^{-1}) and (B) cloransulam-methyl (40 ga.i. ha^{-1}); the second one (EII) was conducted using (A) and (C) 2,4-D dimethylamine salt (670 g a.e. ha^{-1}). The experimental design was randomized complete block with four replications, reaching the total of ten treatments: untreated, A, B, A + B and sequential of A + B and sequential of B + A for EI and untreated, A, C, A+C, sequential of A+C and sequential of C+A for EII. The interval between sequential applications were of 3, 6 and 12 days. Chlorophyll *a* fluorescence evaluations were performed at 7, 21 and 35 days after application (DAA) and dry matter of root and aerial part were evaluated at 35 DAA. Means were compared by ANOVA and Tukey test at 5% probability. It was possible to observe antagonism between herbicides in both experiments. A hundred percent control of the plants was observed when the haloxyfop-P methyl was applied before the cloransulam-methyl or 2,4-D in the interval of 6 and 12 days. The chlorophyll *a* fluorescence evaluations at 7 and 21 DAA showed a decrease of photosynthetic performance index and high-energy dissipation as heat. The photosynthetic parameters were stabilized for the other treatments, except haloxyfop-P methyl alone. Therefore, the haloxyfop-P methyl should be applied before 2,4-D or cloransulam-methyl with the minimum interval of 6 days.

Keywords: herbicides interaction, ACCase-inhibitor herbicides, ALS- inhibitor herbicides, auxin mimetics herbicides

P-021

Carryover of diclosulam on corn in crop rotation

Camila Ferreira de Pinho[1], Samia Rayara de Sousa Ribeiro[1], Gabriella Francisco Pereira Borges de Oliveira[1], Amanda dos Santos Souza[1], Jéssica Ferreira Lourenço Leal[1], Luane Lima Souza[1], Marcelo Pereira Sampaio[1], Alex Sandro da Cruz Damasceno[1]

[1] UFRRJ - Federal Rural University of Rio de Janeiro - Institute of Technology - Department of Engineering - BR 465, km 7 - Seropédica-RJ/Brazil

Pre-emergence herbicides are widely used for weed control owing mostly to its long residual effect that prevents weed competition, avoiding successive applications of the herbicides. However, herbicides residues are a concern of agricultural production. In some cases, they may persist in soil for a long time, resulting in growth and development of crops in succession/rotation. The aim of this study was to evaluate the residual activity of diclosulam in corn cultivated in corn-soybean succession 100 days after the herbicide application. The experiment was carried out in the Federal Rural University of Rio de Janeiro - Seropédica/RJ/Brazil, from September to April 2017, using a randomized complete block design with four replications. The treatments were rates of diclosulam herbicide (0, 17.5, 35, 52.5 and 70 g a.i.ha^{-1}). Plant height, root length, dry matter of aerial part, and antioxidant enzymes activity were evaluated at 60 days after the corn emergence. The antioxidant enzymes analyzed were glutathione reductase (GR), catalase (CAT), ascorbate peroxidase (APX), guaiacol peroxidase (GPOD) and glutathione S-transferase (GST). It was observed an enzymatic activity increase in plants that received diclosulam at 35 g a.i. ha^{-1}. However, the herbicide rates were, not sufficient to change the characteristics of height, dry matter of the aerial part, and root length of the plants, showing that the interval after diclosulam application is safe for corn in corn-soybean succession).

Keywords: *Zea mays*, carryover, diclosulam, antioxidant enzyme

P-022

Effects of benomyl and diuron mixed application on their degradation in tea field soil and impacts on soil bacterial community

Po-Yu Lai[a], Zhi-Zhan Li[b] and Jui-Hung Yen[b]

[a]*Master Program for Plant Medicine , National Taiwan University, Taipei, Taiwan*

[b]*Department of Agricultural Chemistry, National Taiwan University, Taipei, Taiwan*

Abstract

In Taiwan, many pesticides are used to control weeds, diseases, and insects in the tea field to keep the highest quality and quantity of tea. To reduce the cost of pesticide application, mixed or sequential pesticide application is often used in field. The interaction between pesticides can affect the persistence of fungicides, insecticides, and herbicides in environment, and can also interact with soil microorganisms. In this study, the effect of mixed application of a fungicide, benomyl, with a herbicide, diuron, on the persistency of these pesticides in the soil was investigated. Furthermore, changes in the soil bacterial community were also analyzed. In tea field soil, diuron dissipated more slowly in sterilized soil compared with unsterilized soil, which indicated that diuron dissipates mainly through microbial degradation. Results of diuron 50% dissipation time (DT_{50}) in treatments of different dosages of diuron (D) and benomyl (B) showed that the DT_{50} of diuron is slightly increased from 125 (D) to 141 days (B+D) in 10-fold field application rate, and from 167 (D) to 231 days (B+D) in 50-fold field application rate. The diuron metabolite N'-(3, 4-Dichlorophenyl) - N, N' - methylurea (DCPMU) was detected in 10-fold field application rate treatments, while DCPMU and N'-3, 4-dichloro-phenylurea (DCPU) were detected in 50-fold field application rate during the experimental period. Benomyl may inhibit the degradation of diuron, therefore the amount of DCPMU product in B+D treatment is less than other treatments in 50-fold field application rate. The denaturing gradient gel electrophoresis (DGGE) results indicated that B+D treatment might change the bacterial community composition in 10 and 50-fold field application rates. The impact on bacterial community may inhibit the degradation of diuron and therefore increase the persistence of diuron in environment. Thus there are assessments when applying diuron with benomyl simultaneously in tea field soil.

P-023

Effect of green manure amendment on the dissipation of pendimethalin and changes in soil microbial communities

Chung-An Tan[a], Wen-Ching Chen[b], Fang-Yu Hsu[a], and Jui-Hung Yen[a]

a. *Department of Agricultural Chemistry, National Taiwan University, Taipei, Taiwan*
b. *International Bachelor Program of Agribusiness, National Chung-Hsing University, Taichung, Taiwan*

Abstract

Pendimethalin is a selective and pre-emergence herbicide that can control most annual grasses and many annual broad-leaved weeds. Since the time period for application of pre-emergence herbicides is close to the manure-plowing period in agricultural practice, the addition of manure may greatly affect the dissipation rates of pre-emergence herbicides. Furthermore, amendment of green manures may ameliorate detrimental effects of herbicide application on soil microbial communities since manure amendment is often considered as an option in ameliorating pesticide pollution. In this study, two common green manures, *Lupinus luteus* (L) or *Cosmos bipinnatus* (C) was applied to pH 5.2 and 7.7 soils (Sankengtzu [Sk] and Erhlin [Eh] soil, respectively) for 110 days to determine changes in pendimenthalin dissipation and the microbial community composition. The microbial community composition was examined with denaturing gradient gel electrophoresis (DGGE). The half-life of pendimethalin in Sk soil was 49.0, 54.9, and 62.2 days for L, C, and blank treatments respectively, while the half-life in Eh soil was 46.3, 52.6, and 34.8 days respectively. This showed that the addition of green manure only increased dissipation of pendimethalin in acidic soils, and soil pH can greatly affect dissipation rates. Both pendimethalin and green manure application changed the microbial community composition in both soils after 110 days. However, amendment with L manure alleviated the impact of pendimethalin on the microbial community composition in Eh soils. This study shows that soil pH and amendment of green manure are two factors in the dissipation rate of pendimethalin, and changes in soil microbial community composition.

P-024

Microbial degradation of oxadiazon and thiobencarb by dissimilatory metal reducing bacteria *Shewanella* spp. KR12 under anoxic condition

Yu-Hsin Hsiung and Jui-Hung Yen

Department of Agricultural Chemistry, National Taiwan University, Taipei, Taiwan

Abstract

The genus *Shewanella* is a rising star in bioremediation field because of its outstanding ability of dissimilatory metal reduction and facultative anaerobic growth. Dissimilatory metal reducing bacteria can oxidize simple carbohydrates like formate, lactate and citric acid as electron donors and utilize various materials including kinds of metal ions as electron acceptors in anaerobic conditions to gain energy. Several previous studies showed that particular *Shewanella* strains could form metallic bio-nanoparticles on their cell walls or periplasm during the dissimilatory metal reduction process. Moreover, *Shewanella* strains have shown to be able to use azo dyes as electron acceptors for anaerobic respiration, resulting in degrading or decolorizing it. However, in some cases the presence of soluble metal ions such as iron (III) could enhance the performance of dye decolorizing by *Shewanella* bacteria. The *Shewanella* spp. KR12 was isolated from the sediment of Ke-Ya river in Hsinchu, Taiwan by our laboratory. Additionally, we observed that oxadiazon and thiobencarb were the most frequently detected herbicides from the results of pesticide residues annual monitoring of rivers. Both were expected low potential for leaching to groundwater but accumulate in sediments of bodies of water. In this study, we investigated whether facultative anaerobe *Shewanella* spp. KR12 can degrade oxadiazon and thiobencarb under anaerobic condition. The results indicate KR12 strain shows degrading ability of both herbicides even without ferric citrate as terminal electron acceptor and external carbon source. Besides, in the treatment of ferric citrate existed, KR12 strain utilized ferric citrate primarily and oxadiazon afterwards to obtain energy. This study offers a new bioremediation material toward oxadiazon and thiobencarb pollution in anaerobic environments.

P-025

Evaluation of paraquat residue in rice fields based on a long-term experiment for 35 years

Naoki Nakamura, Junichi Okuno, Yoshitsugu Odanaka, Ayako Kawata, Shigeru Gonda and Masao Yokoyama

Japan Association for Advancement of Phyto-Regulators, 860 Kashiwada, Ushiku, Ibaraki 300-1211, Japan

Paraquat is one of the most widely used nonselective post-emergence herbicides which is popularly and repeatedly applied in arable and non-arable land. There is concern that paraquat accumulates in the soil and residues in the crop through the soil, by applied for many years in a row. In order to investigate paraquat residue in rice fields we carried out a long-term field experiment where the paraquat was applied before tilling in March every year from 1974. Since the second year, the residual amount of paraquat was measured yearly for soil samples from the experiment fields before applied on March. After the soil sampling and paraquat application, the fields were flooded for rice cropping every year. Paraquat in the soil sample was extracted by heated and reflux adding sulfuric acids, then the extract was purified on a cation exchange column. The amount of paraquat was measured with a spectrophotometer by adding a reductive coloring reagent. The results indicated that the paraquat residue in the soil increased linearly during the first 10 years, slowly increased during the next 10 years and reached at an approximately constant value of 18 mg/kg after the 20th year. In order to evaluate the tendency of paraquat residue in the soil, the yearly residual rate was calculated from the field residue data using the following equation. In addition, the mean yearly residual rate was calculated, which varied between 0.7 and 0.9, but it changed little after the 10th year. The residual amount obtained from the long-term field experiment for 35 years agreed well with the residual amount of paraquat estimated by the mean yearly residual rate of 10th year. It was suggested that the paraquat residue after the repeated every year application was possible to predict by using the mean yearly residual rate for about 10th year.

$A=M_{t+1} / (M_t + M_{add})$

where, A: the yearly residual rate, M_{t+1}: the residual amount of the current year, M_t: the residual amount of the previous year, M_{add}: the amount of applied of the current year

P-026

Evaluation of leaching of imazapyr+imazapic herbicides considering the different soil moisture

Gabriella Francisco Pereira Borges de Oliveira [1], Amanda dos Santos Souza[1], Jéssica Ferreira Lourenço Leal[1], Samia Rayara Ribeiro[1], Raíza Ritielle Carvalho Scalzer[1], Guilherme Araujo Rocha[1], Eduardo Souza de Amorim[1], Camila Ferreira de Pinho[1]

[1] UFRRJ - Federal Rural University of Rio de Janeiro - Institute of Technology - Department of Engineering - BR 465, km 7 - Seropédica-RJ/Brazil

The commercial mixture of imazapyr+imazapic herbicides belongs to the chemical group of imidazolinones and its adsorption capacity on soil is considered low, showing that leaching may increase with the moisture content. The objective of this work was to evaluate the residual effect of the imazapyr+imazapic through the simulation of different soil moisture conditions. The experiment was carried out in leaching columns in randomized generalized block design with four replications. The treatments were arranged in 3x3 factorial: factor A was irrigation (field capacity (FC), 30% above of the FC, and 70% of the FC) and factor B were imazapyr+imazapic doses (untreated, 52.5 + 17.5 (commercial dose), and 105 + 35 (double dose) g a.i. ha-1). The columns were opened vertically at 120 days after application and were divided into top and bottom. Watermelon was used as bioindicator plant. Dry matter of aerial part and root were evaluated at 45 days after emergence. The means were compared by ANOVA and Tukey test at 5% probability. Considering the plants from the top, the dry matter from aerial part showed interaction between factors. The untreated and commercial dose did not differ between them in soils at FC and 70% of the FC, but both differed at double dose, showing an intense decrease of dry matter. Considering the plants from the bottom, data of dry matter of aerial part and root showed a significant difference comparing to irrigation. The treatments using FC and 70% of the FC obtained higher yield of dry matter than 30% above FC. Therefore, water availability interfered in the imazapyr+imazapic herbicides persistence in the soil and the herbicides stayed retained on the surface in soils with water availability below the field capacity.

Keywords: imidazolinones, leaching, bioindicator plant

P-027

Comparison of transcriptome analysis of japonica and indica type rice (*Oryza sativa* L.) using next generation sequencing (NGS) by benzobicyclon treatment.

Sangsu Kim[*1], Yonghwan Lee[1], Sungwoo Kim[1], Yejin Kim[1]

[1]Department of Crop Life Safety, National Academy of Agricultural Science, RDA, 166, Nongsaengmyeong-ro, Iseo-myeon, Wanju-gun, Jeollabuk-do, 55365, Republic of Korea

This study was conducted to clarify characteristics of transcriptome analysis on rice with or without benzobicyclon treatment. In general, 4-HPPD (4-hydroxy phenylpyruvate dioxygenase) inhibiting herbicides (benzobicyclon, mesotrione, tefuryltrione) are known to cause phytotoxicity symptoms to indica-type rice in Korea. Recently, however, phytotoxicity symptoms have been reported in japonica-type rice in Korea.

The five rice varieties were grown for 2 to 3 leaf stage on seedling trays and then transplanted into plastic pot: 4-Japonica type (Sangjubyeo, japonica type, HPPD inhibiting resistance; Sambaekbyeo, japonica type, HPPD inhibiting sensitive; Sanduljinmi, japonica type, HPPD inhibiting sensitive; and Kumyoung, japonica type, HPPD inhibiting sensitive) varieties and 1-Indica type variety (IR8, indica type, HPPD inhibiting sensitive). We tested 140 g a.i. ha^{-1} dose of benzobicyclon treatment at 10 days after transplanting in order to cause phytoxicity. The absolute value of fold change value 2 or more genes is 1,446 (Sangjubyo), 2,882 (Sambaekbyeo), 1,076 (Samduljinmi), 1,081 (Kumyoung) and 3,875 (IR-8).

The genes of decreased expression level/the gene name of most volume is 931/Os12g0420400 (Similar to Photosystem I reaction center subunit XI, chloroplast precursor (PSI- L) (PSI subunit V)), 1,702/ Os01g0910900 (Conserved hypothetical protein), 544/ Os08g0460000 (Similar to Germin-like protein 1 precursor), 447/ Os02g0160500 (Hypothetical conserved gene) and 1,936/ Os01g0600900 (Similar to Chlorophyll a-b binding protein 2). The genes of increased expression level is 535/ Os11g0707000 (Non-protein coding transcript), 1,180/ Os11g0171350 (Non-protein coding transcript), 532/ Os11g0247300 (Similar to Alpha-tubulin), 634/ Os10g0150400 (Protein of unknown function DUF1210 family) and 1,939/Os01g0600900 (Hypothetical gene).

P-028

Effects of Fluazifop-P-butyl on Chlorophyll Fluorescence Characteristics of *Acanthospermum hispidum* Seedlings

Xiaoyong Luo[1]*, Yuhong Shang[1], Congjun Yang[1], Zhihang Liu[1], Fei Zhou[1], Hiroshi Matsumoto[2]

[1] College of Agronomy and Plant Protection, Qingdao Agricultural University, Qingdao 266109, China
[2] University of Tsukuba, 1-1-1 Tennodai, Tsukuba 305-8571, Japan
[*] Corresponding author: luo-xiaoyong@163.com.

Acanthospermum hispidum DC., a compositae weed, was very susceptible to fluazifop-P-butyl (FB), but tolerant to other AOPP herbicides, such as haloxyfop-P-methyl (HM). However, the other compositae weeds were all tolerant to FB. Our previous research indicated that the membrane lipid peroxidation by increasing the levels of active oxygen species (ROS) was an action mechanism of FB in *A. hispidum*, which was different from acetyl-CoA carboxylase (ACCase) inhibition in gramineous plants. To further clarify the herbicidal mechanism of FB in sensitive *A. hispidum* seedlings, the effects of herbicides on chlorophyll fluorescence characteristics (CFCs) were studied. The chlorophyll fluorescence spectrum determination and fluorescence imaging experiments showed that CFCs in sensitive *A. hispidum* seedlings were markedly affected by FB, with the dark fluorescence yield (Fo), maximal fluorescence yield (Fm), maximal PS II quantum yield (Fv/Fm), effective PS II quantum yield [Y(II)], and quantum yield of regulated energy dissipation [Y(NPQ)] declining evidently, quantum yield of nonregulated energy dissipation [Y(NO)] rising, and chlorophyll fluorescence image being weaker and weaker, but all the indexes were not changed in non-sensitive *Bidens pilosa*. The effects of FB on chlorophyll fluorescence properties were observed on the growing point before the mature leaves about 4-6 h. HM, a control herbicide, had no effects on CFCs of both non-sensitive plants *A. hispidum* and *B. pilosa*. These results suggested that the primary site of FB action in *A. hispidum* is in the apical meristem and the effects on CFCs may be the results of secondary action.

This work was supported by the National Natural Science Foundation Project (31272066) of China.

P-029

Basic research of effect of soil organic matter on glyphosate sorption onto a soil

Hirotatsu Murano, Masayuki Sano, Shiho Orii, Mari Miyata, Toshiyuki Isoi

Meijo University, 1-501 Shiogamaguchi, Tempaku, Nagoya 468-8502, Japan

Glyphosate, N-(phosphonomethyl)glycine, is a broad-spectrum systemic herbicide especially for annual broadleaf weeds and grasses. The research of glyphosate sorption onto soil has been studied by many researchers. It has been reported that glyphosate mainly sorb onto soil minerals, such as kaolinite, illite, goethite or gibbsite. It is adsorbed in soil by ligand exchange through the phosphoric acid moiety in a way similar to the sorption of phosphate. Soil organic matter (SOM) is generally believed not to influence the sorption of glyphosate in soil, but some reports show that SOM are responsible for the strong sorption of glyphosate in soils. However, the effect of respective effects of each humic substances (HS) fraction, i.e., humic acids (HAs), fulvic acids (FAs), and humin (HM), on the sorption of glyphosate. In this research we study the effect of HS on glyphosate sorption onto a soil by batch experiments.

The sorption amount of glyphosate onto soil increased when the SOM was removed from the soil, but when the amorphous or paracrystal aluminosilicates or amorphous iron (hydro)oxides was removed by acidic oxalate treatment, the amount of sorption decreased. Furthermore, when HSs were added to the SOM removed soil, its adsorption amount decreased. The sorption amount was higher than the addition of HM. It should be due to the differences of addition amount and chemical structures of each HS. Our results support that the soil adsorption of glyphosate predominantly to minerals by the ligand exchange and suggest that HS compete sorption site with glyphosate.

P-030

Influence of cow bonechar addition on reduce bioavailability of aminocyclopyrachlor and mesotrione in an agricultural soil

Kassio Ferreira Mendes, Ricardo Ferraz Silveira, Rodrigo Floriano Pimpinato, Valdemar Luiz Tornisielo.

Ecotoxicology Lab, Center for Nuclear Energy in Agriculture, University of São Paulo, Brazil

Bonechar can contribute to sequestration of atmosphere carbon, improvement of soils quality, and mitigation of environmental contaminations, such as aminocyclopyrachlor and mesotrione that have low sorption coefficient and high leachability. However, there are not reports on the elution behavior of herbicides using bonechar made of cow biomass. Aminocyclopyrachlor (6-amino-5-chloro-2-cyclopropylpyrimidine-4-carboxylic acid) and mesotrione (2-(4-mesyl-2-nitrobenzoyl)cyclohexane-1,3-dione) are weak acid herbicide applied sugarcane and maize in pre-emergence for the control of woody weeds, some grass and broad-leaved weeds. The objective of this research was to evaluate the effect of a cow bonechar amendment on the sorption-desorption of the aminocyclopyrachlor and mesotrione to a clay soil. We used the batch-equilibrium method to determine the concentration of ^{14}C-aminocyclopyrachlor (pyrimidine-2-^{14}C-aminocyclopyrachlor) and ^{14}C-mesotrione (cyclohexane-2-^{14}C-mesotrione) in a pseudo-steady state with bonechar, soil, and bonechar-soil systems (1, 5, and 10% bonechar by weight). Bonechar [$C+(Ca_{10}(PO_4)_6(OH)_2)$] produced from cow bone feedstock was purchased from Bonechar Carvão Ativado Ltda (Maringá, PR, Brazil) and was used as soil amendments. We observed that aminocyclopyrachlor and mesotrione are mobile in soil, with GUS index of 4.45 and 3.29, respectively. Sorption coefficient (K_d) values of aminocyclopyrachlor and mesotrione ranging of 4.50-60.57 and 3.95-46.42 L Kg^{-1} in bonechar amended soil and in unamended soil was 0.28 and 0.76 L Kg^{-1} respectively. This bonechar reduced the aminocyclopyrachlor (69-99%) and mesotrione (76-96%) concentration, so it would be practical remediation media due to the low application rates required to reduce the concentration by 50% (7,760.84 and 10,837.34 kg ha^{-1}, respectively). This was the first study to assess the practical use of animal bonechar as a remediation tool to reduce bioavailable and leachable aminocyclopyrachlor and mesotrione in soil.

P-031

Bonechar as an adsorbent for removing hexazinone, diuron, ametryn and sulfometuron-methyl from drinking water contaminated

Kassio Ferreira Mendes, Rosana Maria de Oliveira Freguglia, Rodrigo Floriano Pimpinato, Valdemar Luiz Tornisielo

Ecotoxicology Lab, Center for Nuclear Energy in Agriculture, University of São Paulo, Brazil

Bonechar has been used extensively as an adsorbent. However, bonechar as an adsorbent to remove herbicides in water has been not reported. The aim of this research was evaluating animal bonechar added as an adsorbent for removing hexazinone, diuron, ametryn and sulfometuron-methyl from drinking water contaminated. Drinking water samples (10 mL) were collected from a cold water faucet, which are used regularly for human consumption. Bonechar produced from cow bone feedstock was purchased from Bonechar Carvão Ativado Ltda (Maringá, PR, Brazil) and was used as adsorbent in drinking water contaminated with herbicides. Concentration at 5 μg mL^{-1} for each herbicide was prepared and added directly in drinking water contaminating with all herbicides. This drinking water was amended at 0 (control – unamended), 0.01, 0.1, and 1 g of cow bonechar, and supernatants were analyzed at 1 and 7 d by high-performance liquid chromatography (HPLC), equipped with a UV-Vis detector. Among the herbicides, greater removal of these by the addition of bonechar in contaminated drinking water in the laboratory followed the order: diuron > ametryn > sulfometuron-methyl > hexazinone. At 7 d after application of bonechar, no herbicide desorbed this carbonaceous material, remaining strongly retained. The highest dose (1 g) of bonechar added in drinking water was able to remove ~100% of all herbicides. Cow bonechar is an excellent absorbent for the removal of hexazinone, diuron, ametryn and sulfometuron-methyl from drinking water contaminated. Additionally, the strategy becomes easier in terms of implementation facility and low cost, and it can be used in large-scale in water treatment plants or in domestic filters.

P-032

Geographical distribution of ALS inhibitor resistant paddy weeds in Gyeonggi and Gangwon provinces of Korea

Soo-Hyun Lim, Minjung Yook, Yeon-Ho Park, Hyejin Yu, and Do-Soon Kim

Department of Plant Science, College of Agriculture and Life Sciences, Seoul National University, Seoul 08826, Korea (E-mail: dosoonkim@snu.ac.kr)

ALS (acetolactate synthase) inhibitor resistant paddy weeds have caused many issues for weed management in Korean rice fields. The continuous use and heavy reliance on ALS inhibitors for paddy weed management has eventually made many paddy weed species more resistant to these herbicides. Gyeonggi and Gangwon provinces are located in the northern part of Korea and accounts for 16.7% of rice cultivation area in Korea. It is assumed that herbicide resistance in paddy weeds may be continuously increasing and wide-spreading in rice growing area. Therefore, this study was conducted to investigate geographical distribution of ALS inhibitor resistant paddy weeds in the Gyeonggi and Gangwon provinces using paddy soil test. We collected paddy soil samples from 397 sites in paddy fields in Gyeonggi and Gangwon provinces in March and April. Soil samples were stored in a cold chamber maintained at 4ºC until soil test. Soil test was conducted in plastic pots. Puddled soil placed in plastic pot was flooded with water and kept in a plastic house for 15 days after puddling to allow weeds to establish up to 3 leaf stage (for *Echinochloa* species), and treated with imazosulfuron + pyriminobac-methyl mixture at its recommended dose rate. As a results, we found ALS inhibitor resistant weeds including *Monochoria vaginalis*, *Scirpus juncoides*, *Cyperus difformis*, and *Echinochloa* species. Based on this assay, we could visualize geographical distribution of ALS inhibitor resistant paddy weeds in the two northern provinces, Gyeonggi and Gangwon provinces, of Korea. This work was carried out with the support of “Cooperative Research Program for Agriculture Science & Technology Development (Project No. 01245702)” Rural Development Administration, Republic of Korea.

P-033

Evaluation of different per-emergence herbicides in comparison with glyphosate for effective weed control in glyphosate-resistant cotton

Nadeem Iqbal[1], Bhagirath S. Chauhan[2], Sudheesh Manalil[2] and Steve Adkins[1]

[1]School of Agriculture and Food Sciences (SAFS). The University of Queensland, The University of Queensland, Gatton 4343, Queensland, Australia
[2]Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, Gatton 4343, Queensland, Australia

Cotton (*Gossypium hirsutm* L.) is the most important fibre crop grown around the world and covers an area of 2.5% of the arable land in over 100 countries. Weeds are one of the most important biological constraints to the successful production of cotton which can severely reduce its yield. The risk of development of herbicide resistance in weeds has increased in glyphosate-tolerant cotton. A study was conducted at the Gatton farm of the University of Queensland to evaluate the performance of different herbicides on weed control in glyphosate-tolerant cotton. The experiment was laid out in a randomised complete block design with three replications. Different herbicide treatments were weedy (control), glyphosate applied once, glyphosate applied twice, metolachlor, glyphosate + metolachlor, pendimethalin, glyphosate + pendimethalin, and glyphosate + haloxyfop. Significant differences were observed in herbicide efficacy. Soil residual herbicides pendimethalin and metolachlor provided effective weed control as compared glyphosate alone. Results revealed that pre-emergence application of pendimethalin and metolachlor provided higher weed suppression of 100 and 99%, respectively, at 20 days after sowing as compared to all other treatments. Seed cotton yield was also higher in these two treatments. Pendimethalin treatment provided maximum increase in yield (320%) over the weedy control treatment followed by metolachlor (277%). Findings of this study will decrease pressure on single reliance of glyphosate, which will help to slow the evolution of new glyphosate-resistant weed populations in seed cotton.

P-034

Benefits of narrow-row spacing in weed suppression in glyphosate-resistant cotton

Nadeem Iqbal[1], Bhagirath S. Chauhan[2], Sudheesh Manalil[2] and Steve Adkins[1]

[1]School of Agriculture and Food Sciences (SAFS). The University of Queensland, The University of Queensland, Gatton 4343, Queensland, Australia
[2]Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, Gatton 4343, Queensland, Australia

Cotton is the most important fibre crop of the world. Today, the world uses more cotton than any other fibre. Weeds are one of the major threats to the successful production of cotton, which can severely reduce its yield from 34-90%. Evolution of glyphosate-resistant weed populations is another burning problem in cotton that is increasing at an alarming rate. In Australia, cotton is generally grown on 1-m rows. A study was conducted at the Gatton farm of the University of Queensland to evaluate the impact of row spacing (50 cm and 100 cm) and weed infestation period [no weeds (weed-free); weeds growing up to 3, 6, 9, and 12 weeks after planting; and weeds growing up to crop harvest) on the yield of glyphosate-tolerant cotton. The experiment was laid out in a split-plot design with crop rows as the main plots and weed infestation period as the sub-plots. Each treatment was replicated thrice. Results revealed that 100_cm row spacing had a greater weed biomass as compared to the 50_cm row spacing. In the treatment, where weeds were allowed to grow up to 3 weeks after planting, weed biomass in the 100_cm row-spaced cotton was 33% higher than that for weeds growing in the 50_cm row-spaced cotton, and the same trend was observed for all other weed control-timing treatments. Seed cotton yield was higher in the 50_cm row spaced cotton as compared to 100_cm planted cotton at all the different weed control-timing treatments.

P-035

Control and cross-resistance of barnyardgrass to ALS- and ACCase-inhibitors in rice field in Korea

Tae Seon Park, Jae Bok Hwang and Hong Kyu Park

National Institute of Crop Science, RDA, Wanju-gun, Jellabuk-do, Korea

Barnyardgrass(*Echinochloa crus-galli* var. *crus-galli*) is the most difficult to control weed that infests rice fields in Korea. The objectives of this research were to confirm ALS(acetolactate synthase)- and ACCase(Acetyl-CoA carboxylase)-inhibiting herbicide-resistant barnyardgrass in Korea and to determine sensitivity and efficacy of rice herbicides applied for control of resistant and susceptible barnyardgrass biotypes. The putative seeds of ALS- and ACCase-resistant barnyardgrass biotype were collected from rice fields in fall 2010. The response of barnyardgrass biotypes to 10 rates (0 to 10×) of ACCase inhibitors, cyhalofop-butyl and metamifop, and ALS inhibitors, priminobac-methyl, penoxsulam and flucetosulfuron, was evaluated in a dose–response bioassay in a greenhouse. On the basis of the values at at GR_{50}(concentration of respective herbicides required for 50% inhibition of dry weight), the analysis showed about 19 to 42-fold resistance depending upon the type of ALS- and ACCase-inhibiting herbicides being investigated and susceptible biotype used for comparison. The resistant biotype had a reduced sensitivity to ALS- and ACCase-inhibiting herbicides. These results suggested a cross-resistance between ALS- and ACCase-inhibiting herbicides that resulted ineffectiveness for control of barnyardgrass. Barnyardgrass biotypes were effectively controlled(≥ 90%) with mefenacet, and fentrazamide by 2 leaf stage, where as oxadiazon, thiobencarb and butachlor provided over 90% control by l leaf stage of the resistant biotype

P-036

Penoxsulam resistance in barnyardgrass (*Echinochloa crus-galli*) in rice fields of China

Guoqi Chen, Qiong Wang, Wei Zhang, Jiapeng Fang and Liyao Dong*

College of Plant Protection, Nanjing Agricultural University, Nanjing 210095, China

Barnyardgrass (*Echinochloa crus-galli*) proliferation seriously threatens rice production worldwide. We conducted whole-plant bioassays to test the sensitivity to penoxsulam of total 52 barnyardgrass populations and the resistance of 6 penoxsulam-resistant populations to 12 other herbicides commonly used in rice fields. Moreover, we studied the genetic diversity and structures of 16 *E. crus-galli* populations with resistance index (RI) >10 by 8 SSR markers. Among the 48 populations escaped of penoxsulam control in rice fields, 8.3% showed very high resistance (RI > 100), 58.3% showed high resistance (RI 11–100) and 10.4% showed moderate resistance (RI 6–10). Multiple resistance was confirmed in all 6 penoxsulam-resistant populations further tested, which exhibited at least moderate resistance to 6-10 of the total 13 herbicides tested. Most of the 6 penoxsulam-resistant populations showed at least moderate resistance to bispyribac-sodium, quinclorac, metamifop, cyhalofop-butyl, and oxadiazon; 3 populations hold at least moderate resistance to oxyfluorfen and pretilachlor; 2 populations hold at least moderate resistance to pyrazosulfuron-ethyl, pyribenzoxim and fenoxaprop-p-ethyl; but RIs of the 6 populations to pendimethalin were all < 4. Totally 89 alleles were amplified from the eight microsatellite loci among the 16 penoxsulam-resistant *E. crus-galli* populations. The heterozygosity values of the 16 penoxsulam-resistant populations of *E. crus-galli* ranged from 0.010 to 0.135, and their Shannon's information indices ranged from 0.016 to 0.213. Pairwise Nei's genetic distances ranged from 0.013 to 0.197, with an average value of 0.088. The analysis of molecular variance (AMOVA) indicated that 24%, 36%, and 40% of the genetic diversity occurred among regions, among populations, and within populations, respectively. Furthermore, according to the STRUCTURE results, the 16 populations clearly clustered into three groups corresponding to the three regions of population sampling.

**Correspondence to*: Liyao Dong, E-mail: dly@njau.edu.cn.
Funding for G. C. was provided by China Postdoctoral Science Foundation (2015M571763), and for L. D. by the Special Fund for Agroscientific Research in the Public Interest (201303022).

P-037

Proactive herbicide resistant weed management through synergetic integration of chemical and non-chemical tools in wheat

VK Sindhu, Samar Singh, SS Punia, Samunder Singh and Anil Duhan

Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana-125004, India

Today, the facts regarding herbicide resistance in India as follows: 5 herbicide-resistant (HR) weed species, 1 multiple HR weed, resistance to 13 different herbicides, all are post-emergence (POE) herbicides, resistance documented in wheat crop and in north-western region only. *Phalaris minor*, most notorious weed of wheat, has evolved multiple resistance to different MoAs (C2/7, A/1 and B/2), while *Rumex dentatus, Polypogon monspeliensis, Avena ludoviciana* and *Chenopodium album* are swift addition to HR weeds. Sole reliance on POE herbicides, in absence of other non-chemical measures, has exploded herbicide resistance in wheat weeds and the cost of managing HR weeds is escalating in the region. Gladly, HR weeds are sensitive to pre-emergence (PRE) herbicides but a single application is insufficient to control all cohorts. Field studies were conducted at CCSHAU, Regional Research Station, Karnal, during winter 2014-15 and 2015-16 with an objective to combine PRE herbicides and other non-chemical measures for proactive control of HR weeds. The results revealed that synergistic integration of zero-tillage + higher seeding density (125 kg/ha) + PRE herbicide mixture (pendimethalin 1.5+metribuzin 0.210 kg/ha, applied beneath the mulch) + 8 t/ha rice straw mulch provided excellent control of weeds and higher wheat productivity. Herbicide residue analysis confirmed that dissipation of PRE herbicides reduced under mulch as compared to bare soil. In wheat sown with a turbo happy seeder (ZT + rice residue), application of pendimethalin/pyroxasulfone + metribuzin either as PRE with high carrier volume (1000 L/ha) or immediately before first irrigation (20 days after sowing) improved herbicide penetration through mulch and provided satisfactory weed control. Convincingly, the combination of ZT + PRE herbicides mixture + mulch + higher crop density, is a novel strategy customized to RW system to manage and mitigate HR weeds in wheat.

P-038

Fitness of BC3F2-BC3F4 generations of crosses between two herbicide-resistant transgenic oilseed rape and wild *Brassica juncea*

Xiaoling Song[1], Xiaolei Wang[1], Qingling Zhang[1], Jian Wang[1], Sheng Qiang[1, 2]

[1]Weed Research Lab, Nanjing Agricultural University, Nanjing 210095, China

[2] Corresponding author. This project was supported by the Natural Science Foundation of China (31270579)

A major concern regarding the release of herbicide resistant transgenic oilseed rape (*Brassica napus*,) is the possible escape of transgenes to wild *B. juncea*. Persistence of the transgenes would depend on the fitness of the hybrids and succeeding generations. Therefore, the fitness components of BC3mF2- BC3mF4 and BC3pF2- BC3pF4 generations (in which m and p denotes backcross progeny obtained with wild *B. juncea* as maternal and paternal plants, respectively.) after hybridization between glyphosate resistant (RR) or glufosinate-resistant (LR) transgenic oilseed rape and wild *B. juncea* were compared under two densities and three planting proportions in field. In pure stands, the composite fitness of BC3F2-BC3F4 was similar to that of wild *B. juncea*. In mixed stands，at low density, the composite fitness of BC3F2 carrying the RR transgene was significantly lower under the 4:1 proportion but under the 3:2 and 1:1 proportions similar to that of wild *B. juncea*. However, the composite fitness of BC3F2 with the LR transgene was lower than that of wild *B. juncea* under 4:1and 3:2 proportions. At high density, the composite fitness of BC3F2 carrying either transgene was significantly lower than that of wild *B. juncea*. BC3F3 and BC3F4 with the RR transgene were as fit as wild *B. juncea* regardless of density and proportion. Conversely, among generations carrying the LR transgene, the composite fitness of BC3pF3 regardless of density and BC3F4 at high density was inferior to that of wild *B. juncea*. Therefore, BC3F2-BC3F4 generations with either resistance transgene have the potential to become established in field. In preventing transgene escape, initial hybridization should be avoided as well as the establishment of the backcross generations. Moreover, the ecological risk of transgene flow from RR is higher than LR transgenic oilseed rape. The reason may be due to different genotypes or insert location of transgenes.

P-039

Resistance of *Fimbristylis miliacea* (L.) Vahl populations to acetolactate synthase-inhibiting herbicides

Rudjana Phinyosak[1], Tosapon Pornprom[1]

[1] Department of Agronomy, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140, Thailand

Tall fringe rush (*Fimbristylis miliacea* (L.) Vahl) sedge is one of the most serious and widespread weeds of rice and can cause more than 60% yield losses. It can be controlled by acetolactate synthase (ALS)-inhibiting herbicides. Recently, farmers in the areas of Suphanburi and Chainat Provinces, the central region of Thailand, did not obtain a satisfactory control of tall fringe rush populations with metsulfuron-methyl + chlorimuron-ethyl (ALS-inhibiting herbicides). This study was conducted to determine the level of resistance of tall fringe rush to ALS-inhibiting herbicides. Seeds of tall fringe rush were collected from fields to determine the degree of resistance of tall fringe rush to ALS-inhibiting herbicides under greenhouse conditions. The experiment was designed in split plot in a completely randomized design with four replications. The main plot was metsulfuron-methyl + chlorimuron-ethyl at six rates (0, 3.75, 7.5, 15, 36 and 72 g a.i./ha) and the sub-plot was the resistant and susceptible biotypes of tall fringe rush. The rice variety RD 41 was used. The pots were treated with herbicides at 7 DAS. Both the resistant and susceptible tall fringe rush biotypes were investigated for I_{50} based on its visual injury and GR_{50} based on plant height and fresh weight. The resistance index of the resistant tall fringe rush was 32.5–298.3 folds higher than that of the susceptible biotype. This information can enhance the understanding of the physiological response of tall fringe rush to ALS-inhibiting herbicides, which can help devise better weed management in rice to prevent further spread of resistant weeds. Subsequently, cross- and multiple-resistance of the resistant biotype of tall fringe rush sedge should be determined across various groups of herbicides.

P-040

Responses to several herbicides in multiple herbicide resistant biotypes of *Echinochloa crus-galli* var. *formosensis*

Akira Uchino[1], Satoshi Iwakami[2], Masato Hashimoto[3], Kenshiro Hamamura[3], Ken-ichi Matsushima[4], Hiroaki Watanabe[3],

[1] Central Region Agricultural Research Center, NARO, 360 Kusawa, Anou, Tsu 514-2392, Japan
[2] Kyoto University, Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan
[3] The Japan Association for Advancement of Phyto-Regulators, 860 Kashiwada-cho, Ushiku 300-1211, Japan
[4] Tokyo University of agriculture, 1737 Funako, Atsugi 243-0034, Japan

Biotypes of *Echinochloa crus-galli* var. *formosensis* with resistance to cyhalofop-butyl, an acetyl-CoA carboxylase (ACCase) inhibitor, have been found in dry-seeded rice fields at Okayama, Japan. We collected two lines with suspected resistance (Ecf27 and Ecf108) from dry-seeded rice fields and investigated their sensitivity to cyhalofop-butyl and other herbicides.

Seeds were collected from a single plant in each field in 2010, and the lines were self-propagated for at least one generation before experiments. Whole plant responses were examined in pot experiments using 200 cm^2 polystyrene pots in 2013-2016. Cyhalofop-butyl and penoxsulam were sprayed at the 4-leaf stage using a commercial formulation at several rates of the recommended field doses. Other herbicides were applied using a commercial formulation at the recommended field doses at appropriate times.

Ecf27 and Ecf108 exhibited approximately 7-fold higher resistance to cyhalofop-butyl than a susceptible line. Ecf108 was susceptible to penoxsulam, an acetolactate synthase (ALS) inhibitor. On the other hand, Ecf27 showed resistance to penoxsulam and other ALS inhibitors: flucetosulfuron, propyrisulfuron, pyriminobac-methyl, and pyrimisulfan. The alternative herbicides butachlor, thiobencarb, and bispyribac-sodium effectively controlled the both lines. One shot herbicides including fentrazamide, oxaziclomefone, or pyraclonil also exhibited high efficacy to the both lines. Thus, sequential application with the above alternative herbicides was preferable to prevent the propagation of the lines that are resistant to both cyhalofop-butyl and penoxsulam.

P-041

Effects of enantioselective imazapyr on resistant strain *Arabidopsis thaliana* GH90

Bo-You Liao, Yu-Ling Hsiao and Jui-Hung Yen

Department of Agricultural Chemistry, National Taiwan University, Taipei, Taiwan

Abstract

Imazapyr is a chiral compound used as an herbicide for the prevention of many annual grasses and annual broad-leaved weeds, and acts by inhibiting acetolactate synthase (ALS), an enzyme involved in the production of important amino acids. Although imazapyr is sold as a racemate product, the different imazapyr enantiomers were previously shown to exhibit different effects on wild type *Arabidopsis thaliana*. In this study, we investigated the effects of enantioselective imazapyr on a mutant strain of *A. thaliana* named GH90, which is resistant to imazapyr. GH 90 contains imazapyr-resistant ALS as a result of a mutation in the *csr1* gene. The effects of imazapyr and its enantiomers on mutant strain *A. thaliana* GH90 resulted in significant difference in physiological features. However, no effects were found on plant shoots with 0.01 mg L^{-1} of (R,+)-imazapyr, (S,-)-imazapyr, and racemate-imazpyr. With 0.1 mg L^{-1} herbicide concentration, total chlorophyll content was greater with (S,-)-imazapyr than rac- and (R,+)-imazapyr and did not differ from control treatment. At 1 mg L^{-1} (R,+)-imazapyr, shoot stems and leaves became purple and plants were smaller than with control or other treatments. Also, proline and malonaldehyde (MDA) content, which are well known stress indicators, increased with increasing concentration of imazapyr in the order of (R,+)-imazapyr > rac-imazapyr > (S,-)-imazapyr, with (R,+)-imazapyr treatment resulting in much greater amounts of proline and MDA than the other forms. This study explains the enantioselective effects of imazapyr toward imazapyr-resistant *A. thaliana* GH90, and showed that (R,+)-imazapyr caused more stress to mutant strain *A. thaliana* GH90 plants than did rac- and (S,-)-imazapyr.

P-042

Alteration in the *EPSPS* promoter might be involved in the regulation of the expression of *EPSPS* in goosegrass, *Eleusine indica*.

Chun Zhang, Li Feng, Xing-shan Tian

Institute of Plant Protection, Guangdong Academy of Agricultural Sciences, Guangdong Provincial Key Laboratory of High Technology for Plant Protection, Guangzhou 510640, China

Despite the overexpression of the 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) gene being one of the major molecular mechanisms conferring resistance against glyphosate in weeds, not much is understood about the transcriptional regulation of this gene. To gain a better insight into this regulation, two upstream regulatory sequences, Epro-S (862 bp) (GenBank accession number: KX018288) and Epro-R (877 bp) (GenBank accession number: KX018289), of the *EPSPS* were obtained by high-efficiency thermal asymmetric interlaced polymerase chain reaction (HiTAIL-PCR) from goosegrass. The Epro-S and Epro-R sequences were 99% homologous and contained a 12 base mutation in the 5′-UTR-Py-rich stretch element. The 5′-UTR-Py-rich stretch element in Epro-R and Epro-S contained 35–39 base (L-5UPS) and 23–27 base (S-5UPS), respectively. The 5′-UTR Py-rich stretch was found to exist in the S-5UPS and L-5UPS forms in the sensitive (S) and resistant (R) goosegrass biotypes, using polyacrylamide gel electrophoresis and silver staining methods. The promoter activity of Epro-S and Epro-R, as assessed using an *Arabidopsis thaliana* protoplast transfection system, showed that the nucleotide mutations present in the 5′-UTR Py-rich stretch resulted in significant enhancement of the Epro-R promoter activities. In conclusion, the nucleotide mutation involved in the 5′-UTR-Py-rich stretch enhances the activity of the *EPSPS* promoter, which might be responsible for the upregulation of the expression of *EPSPS* in the resistant goosegrass population collected from orchards in South China.

Acknowledgement: This work was supported by the Agricultural Science Programs from Guangdong Province, China (2016LM3165).

P-043

Amino acid substitutions in ALS genes of *Cyperus brevifolius* biotypes resistant to sulfonylurea herbicides from several golf courses, Japan

Junichi Okuno[1], Satoshi Iwakami[2], Akira Uchino[3], Koji Nakamura[4], Ryoya Nakamura[4], Kunio Tsuchida[1], Masao Yokoyama[1]

[1] Japan Association for Advancement of Phyto-Regulators, 860 Kashiwada-cho, Ushiku, Ibaraki 300-1211, Japan
[2] Kyoto University, Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan
[3] Central Region Agricultural Research Center, NARO, 360 Kusawa, Anou, Tsu 514-2392, Japan
[4] SHIN CHUGOKU Turfgrass Research Institute, 1083 Happonmatsuchohara, Higashihirosima, Hiroshima 739-0151, Japan

Cyperus brevifolius is a perennial weed in turf grass on golf courses. Recently, several populations of *C. brevifolius* have been found to survive after application of sulfonylurea herbicides (SU) in turf grass. In this research, acetolactate synthase (ALS) genes were investigated in *C. brevifolius* accessions sampled from the survived populations in turf grass of four golf courses. Analysis of ALS genes revealed that the ALSs of the four accessions have different amino acid substitutions; Asp376Glu substitution in accessions from golf course A in Yamanashi prefecture and course D in Saga prefecture, Pro197Ser from course B in Kagawa prefecture and Trp574Leu from course C in Shizuoka prefecture. All the four accessions survived after the treatment of halosulfuron methyl and flazasulfuron at recommended doses where the degree of growth inhibition varied between 10 and 40%, while an accession of the susceptible biotype from Ibaraki prefecture was completely controlled. To investigate variation of the resistant ALS genes within each golf courses, 27 accessions of *C. brevifolius* were sampled from eighteen playing halls of course B and nine halls of course C. Plants of each samples were treated with halosulfuron at the four times of recommended dose. Survived fourteen and seven accessions from courses B and C were analyzed on their ALS gene. The results indicated that the all resistant accessions from course B had Pro197Ser substitution, and the all resistant accessions from course C had Trp574Leu substitution, concluding that variation of the resistant ALS genes was little within each golf courses. It is suggested that the resistant population originated from a mutant plant spread to all playing halls in each course.

P-044

Copy Number Variation in Acetolactate Synthase Genes of Thifensulfuron-Methyl Resistant *Alopecurus aequalis* (Shortawn Foxtail) Accessions in Japan

Satoshi Iwakami[1,2,3], Yoshiko Shimono[1], Yohei Manabe[1], Masaki Endo[4], Hiroyuki Shibaike[5], Akira Uchino[2,6], Tohru Tominaga[1]

[1] Kyoto University, Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan
[2] NARO Agricultural Research Center, 2-1-18, Tsukuba 305-8666, Japan
[3] University of Tsukuba, 1-1-1, Tennodai, Tsukuba 305-8572, Japan,
[4] Institute of Agrobiological Sciences, NARO, 2-1-2, Kannondai, Tsukuba 305-8602, Japan,
[5] National Institute for Agro-Environmental Sciences, NARO, 3-1-3, Kannondai, Tsukuba 305-8604, Japan
[6] Central Region Agricultural Research Center, NARO, 360 Kusawa, Anou, Tsu 514-2392, Japan

Severe infestations of *Alopecurus aequalis* (shortawn foxtail), a noxious weed in wheat and barley cropping systems in Japan, can occur even after application of thifensulfuron-methyl, a sulfonylurea herbicide. In the present study, nine accessions of *A. aequalis* growing in a single wheat field in Kyushu, Japan were tested for sensitivity to thifensulfuron-methyl. Seven of the nine accessions survived application of standard field rate of thifensulfuron-methyl, indicating that severe infestations likely result from herbicide resistance. Acetolactate synthase (ALS) is the target enzyme of sulfonylurea herbicides. Full-length genes encoding ALS were therefore isolated to determine the mechanism of sulfonylurea resistance. As a result, differences in *ALS* gene copy numbers among accessions were revealed. Two copies, *ALS1* and *ALS2*, were conserved in all accessions, while some carried two additional copies, *ALS3* and *ALS4*. A single-base deletion in *ALS3* and *ALS4* further indicated that they represent pseudogenes. No differences in ploidy level were observed between accessions with two or four copies of the *ALS* gene, suggesting that copy number varies. Resistant plants were found to carry a mutation in either the *ALS1* or *ALS2* gene, with all mutations causing an amino acid substitution at the Pro197 residue, which is known to confer sulfonylurea resistance. Transcription of each *ALS* gene copy in both shoot and root was confirmed by reverse transcription PCR, supporting involvement of these mutations in sulfonylurea resistance. The information on the copy number and full-length sequences of *ALS* genes in *A. aequalis* will aid future analysis of the mechanism of ALS inhibitor resistance.

P-045

The use of molecular genotyping as a tool to manage herbicide resistant ryegrass (*Lolium* spp.) in South Africa

Hestia Nienaber[1]

[1]ARC - Small Grain, Private Bag X29, Bethlehem, 9700, South Africa

Annual ryegrass (*Lolium* spp.) is an invasive weed of small grain production areas of the Western Cape, South Africa. Ryegrass hampers effective and profitable crop production. Over the past 5-10 years a number of weed resistance cases have been studied at the DNA level. The primary advantage of DNA-based tests for herbicide resistance is a yes/no answer for a specific mutation which confers resistance to a particular group of herbicides with the same mode of action and can be obtained within 48 hours. The aim of this study was to screen a number of ACCase and ALS codon amino-acid substitution mutations to determine if PCR-based tests can be used to speedily and accurately identify herbicide resistance in invasive ryegrass in the South African wheat industry. DNA extracted from green leaf material was quantified, followed by dCAPS PCR and specific restriction enzyme digests. Samples were run on a 2% Agarose gel at 100 volts for three hours. Digital photos were taken and allele sizes visually compared and scored against a 100bp molecular weight ladder. The two most occurring mutations identified were the ALS 197 mutation, which confers high levels of resistance to sulfonylureas and triazolopyrimidines and low levels of resistance to imidazolinones and the ACCase 2078 mutation, which confers resistance to all aryloxyphenoxypropionates herbicides and all cyclohexanedione herbicides (including Clethodim). Research concluded that the PCR-based test for detecting ACCase and ALS herbicide resistance in ryegrass is proving to be fast and accurate in determining the resistance status of invasive ryegrass biotypes.

P-046

The Target-site Resistance of *Eclipta Prostratain* to Acetohydroxyacid Synthase Inhibitors in China Paddy field

Hailan Cui, Dan Li, Xiangju Li

Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing 100193, China

With successive and wide use of chemical herbicides, weed resistance develops rapidly worldwide. *Eclipta prostrata*., is a common annual broadleaf weed belonging to the Asteraceae family, which infect rice, maize and cotton in China. AHAS inhibitors are widely employed in agriculture production since their first commercialization, with their benefits of highly efficiency at a low rate, safety to mammals, and benignity to the environment. However, local farmers have complained that the AHAS inhibitors failed to control *E. prostrate* under field rate in partial paddy fields in China, since pyrazosulfuron-ethyl and bensulfuron-methyl have been applied for over 20 years in paddy fields. The aims of this study were to detect the resistance of *E. prostrata* populations from the main occurrence areas in Shandong, Hubei, Jiangsu and Anhui paddy fields, to confirm the target-site resistance. The results of single dose pyrazosulfuron-ethyl to 31 *E. prostrata* populations showed that one suspected resistant population could survive at 30 g a.i.ha^{-1} of pyrazosulfuron-ethyl, and others were susceptible and killed effectively. The AHAS isolated from the resistant population was much less susceptible than that from susceptible population. Compared with susceptible population, the RI values to pyrazosulfuron-ethyl, bensulfuron-methyl, tribenuron-methyl are 116.8, 177.6, 77.3; the RI values to pyroxsulam, penoxsulam are 293.3, 27.8; the RI value to bispyribac-sodium is 196.5; the RI values to imazethapyr, imazapic are 11.8, 18.3 in the resistant population, respectively. Compared with the *AHAS* in susceptible population, one point mutation was detected in this resistant population. CCC was replaced by TCC at position 197 (the amino acid numbers standardized to the *Arabidopsis thaliana)* within *AHAS*, causing the substitution of Pro to Ser.

This research was financed by the Special Fund for Agro-scientific Research in the Public Interest (201303031). Corresponding to: Hailan Cui, E-mail: cuihailan413@163.com

P-047

CAPS markers developed for detecting mutatons at 376 and 574 sites of ALS in tribenuron-resistant flixweed

Xu Xian, Liu Xiaomin, Li Binghua, Shen Beibei, Wang Guiqi

Cereal and Oil Crops Institute, Hebei Academy of Agriculture and Forestry Sciences, Shijiazhuang 050035, China

Flixweed (*Descurainia sophia*) is one of the malignant weeds in wheat field. The results of our earlier studies showed that flixweed has evolved resistance to tribenuron. Flixweed ALS 376 amino acid changed from D to E and 574 amino acid changed from W to L were induced flixweed evolved resistance to tribenuron. Whole-plant assay, ALS activity assay and ALS sequence analyse were the main methods to evaluate if one flixweed population has evolved resistance to tribenuron, which need more time and labor. In order to rapid detection tribenuron-resistant flixweed populations, CAPS markers were developed for quickly detecting tribenuron-resistant flixweeds. Primer1(F:5’-GCATGGGACGGTGTATGCGAA-3’；R: 5’- CTTCCCAATCTCAGCCGAGTCA -3’) was designed to PCR a 158bp length sequence of flixweed ALS gene, which included ALS 376 amino acid site and had only one HpyCH4IV (A^CGT) particular restriction enzyme site. There had two bands (about 80bp and 158bp) in ALS376 E tribenuron-resistant flixweed population, and only one band (158bp) in ALS376 D tribenuron-susceptible flixweed population. Primer2(F:5’-TGCAAGAGCTAGCCACAATCCGT -3’；R: 5’- TGTGCTGGGTCCCCGAGAAATG -3’) was designed to PCR a 145bp length sequence of flixweed ALS gene, which included ALS 574 amino acid site and had only one MfeI (C^AATTG) particular restriction enzyme site. There had two bands (about 80bp and 145bp) in ALS 574 L tribenuron-resistant flixweed population, and only one band (145bp) in ALS 574 W tribenuron-susceptible flixweed population. The two CAPS marks were 100% accuracy, which were high efficient methods to detecting tribenuron-resistant flixweed populations mutated at ALS 376 and 574 positions.

P-048

Tribenuron-methyl resistance and mutation diversity of the AHAS gene in shepherd's purse (*Capsella bursa-pastoris* (L.) Medik.) in Henan Province, China

Jinxin Wang, Lele Zhang, Weitang Liu

Key Laboratory of Pesticide Toxicology and Application Technique, College of Plant Protection, Shandong Agricultural University

Shepherd's purse is a troublesome dicot weed that occurs in the major wheat-producing areas in China. Twenty-eight shepherd's purse populations were collected from winter wheat-planting areas in Henan Province and used to evaluate tribenuron-methyl resistance and acetohydroxyacid synthase (AHAS) gene-mutation diversity. The results indicate that all 28 shepherd's purse populations were resistant to tribenuron-methyl at different levels compared with the susceptible population. Mutation of the 197 codon (CCT) changed proline (Pro) into tyrosine (Tyr), histidine (His), leucine (Leu), serine (Ser), arginine (Arg), alanine (Ala) and threonine (Thr), whereas mutation of the 574 codon (TGG) changed tryptophan (Trp) into leucine (Leu). Among these amino acid changes, a co-concurrence of Pro197Leu and Trp574Leu substitutions was identified for the first time in resistant weed species. Furthermore, Pro197Tyr, Pro197Arg and Pro197Ala substitutions have not been previously reported in shepherd's purse. The results of the in vitro AHAS assay suggest that an insensitive AHAS is likely involved in the resistance to tribenuron-methyl in the R populations with AHAS gene mutations, and the non-target-site based resistance might exist in some populations.

P-049

Sagittaria trifolia resistant to ALS inhibitors and its population dynamics in paddy fields of Korea

Ok Jae Won[1], Jong Chan Won[2], Young Tae Kim[1], Jeongran Lee[3], Jeung Ju Lee[2], Kee Woong Park[1]

[1] Department of Crop Science, Chungnam National University, Daejeon 34134, Korea
[2] Department of Plant Medicine, IALS, Gyeongsang National University, Jinju 52828, Korea
[3] National Institute of Agricultural Sciences, RDA, Wanju 56365, Korea

Repeated use of sulfonylurea (SU) herbicides in the transplanting paddy fields led development of herbicide resistant *Sagittaria trifolia* biotypes at Gimhae region in Gyeongnam province of Korea. Therefore, studies were conducted to examine resistance of *S. trifolia* to SU herbicide, cyclosulfamuron and cross-resistance to other acetolactate synthase inhibitors and to determine the physiological and molecular basis for herbicide resistance. Whole-plant bioassay using tubers of R and S biotypes confirmed that the biotype was highly resistant to the SU herbicide, cyclosulfamuron (R/S ratio 250), moderately resistant to the imidazolinone (IMI) herbicide, imazaquin (R/S ratio 8), and slightly resistant to the triazolopyrimidine (TP) herbicide, penoxsulam (R/S ratio 2.7), when compared with the susceptible population. The nucleotide and amino acid sequence analysis of the *als* gene demonstrated a single-point mutation from CCC to TCC and/or CTC, conferring the exchange of the amino acid proline to serine and/or leucine at position 197 in the resistant biotype. The results of this research indicate that the resistance of *S. trifolia* to SU, IMI, and TP herbicides is due to an altered target site and caused by a point mutation in the *als* gene. Cloning and sequencing of *als* gene was conducted using eight progenies produced from a resistant *S. trifolia* tuber to investigate the population dynamics of resistance in the *S. trifolia*. Four progenies had both serine and leucine amino acid substitutions, three progenies had only serine amino acid substitution, and one progeny had serine and proline substitutions at position 197. Because *S. trifolia* is diploid species, it can be proposed that two different resistant individual *S. trifolia* plants developed in the same site and then crossed among them and susceptible plants. The mixed population is still going on and will be evolved from both tubers and seed.

P-050

Induction of Glufosinate-resistance in Sri Lankan rice (*Oryza sativa* L.) varieties via scutellum-derived callus mutagenesis

SHYAMA R WEERAKOON[1], R.A.D. DESHANI LAKSHIKA[1], SENEVIRATNE SOMARATNE[1]

[1]DEPARTMENT OF BOTANY, THE OPEN UNIVERSITY OF SRI LANKA

Herbicide-resistant (HR) technologies, combining with post-emergent broad-spectrum herbicides (PEBSHs) minimize the need of crop rotation, labor, time and energy (less fuel consumption) over conventional chemical weed control. HR technologies are risk free of phyto-toxicity and are highly compatible with direct-seeded and conservation tillage practices used in paddy cultivation. HR rice facilitates controlling hard-to-control noxious weeds with diverse dormancy patterns and provides the possibility of selective control conspecific weedy rice (*Oryza sativa* f. *spontanea*) with characteristic phylogenetic and morphological resemblance to cultivated rice. Herbicide-resistance can be achieved through less controversial classical breeding techniques. In this study, attempts were made to induce glufosinate (PEBSH) resistance in selected Sri Lankan rice varieties by inducing functional mutations in scutellum-derived calli with the chemical mutagen, Ethyl methane sulfonate (EMS).

Glufosinate-susceptible, traditional rice varieties; *Kaluheenati*, *Kuruluthuda* and *Handiran* were selected for the study. Glufosinate-resistant traditional rice varieties; *Ma wee* and *Pachchaperumal* were used as references. Calli were obtained from scutellar region of the rice seeds and treated with 0.2% (v/v) EMS. Treated calli were exposed to 0.2% (v/v) glufosinate and assessed the viability of mutated calli with 1% 2,3,5-Triphenyltetrazolium (TTC). Amplified Fragment Length Polymorphism (AFLP) analysis was performed on EMS treated calli. The highest survival percentage of EMS treated calli was recorded from *Kuruluthuda* (65%) and the lowest from *Handiran* (48%). A remarkable change in percentage of resistance towards glufosinate was noted after the mutation of earlier susceptible rice varieties (*Kaluheenati*-75%, *Kuruluthuda*-72%, *Handiran*-65%). The results of AFLP analysis indicated that, the primer combination, M31E10 is a potential AFLP marker to authenticate glufosinate-resistance in rice varieties. These findings predict the potentiality of inducing glufosinate-resistance in rice varieties by integrating classical breeding techniques and bio-technology as a novel approach for weed management in rice fields in Sri Lanka.

Key words: *Oryza sativa* L., Induced glufosinate-resistance, EMS, Calli, AFLP

P-051

Non-target site resistance to glyphosate in *Lolium multiflorum* in Japan

Kouhei Kurata, Yoshiko Shimono, Satoshi Iwakami, Masahiro Miyashita and Tohru Tominaga

Graduate School of Agriculture, Kyoto University, Kitashirakawa-oiwake-cho, Sakyo-ku, Kyoto, 606-8502, Japan

Glyphosate has been used for weed control in levees of rice and wheat fields in Japan. The spread of naturalized *Lolium multiflorum* Lam. in farmland is a serious problem in Shizuoka, Japan and glyphosate has been widely used to control *L. multiflorum* for about 20 years in this area. As a result, glyphosate resistant *L. multiflorum* populations have emerged. Dose-response experiments showed that the resistant population had five-fold resistance compared to susceptible population on the basis of LD_{50} (Niinomi *et al.*, 2013). From the results of a cDNA sequencing analysis and a qPCR analysis of 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) gene, neither point mutations conferring glyphosate resistance nor amplification of the gene were observed in both biotypes (Niinomi *et al*., 2013).

In this study, we investigated the mechanisms of non-target site resistance. The amount of glyphosate and its metabolite, aminomethylphosphonic acid (AMPA) in a treated leaf and non-treated parts were measured by using LC-MS/MS. Translocation of glyphosate was significantly limited in the resistant biotype and more glyphosate was detected in the non-treated parts in the susceptible biotype than in the resistant biotype. No significant differences in the absorption of glyphosate were observed between the resistant and the susceptible biotypes. There was also no difference between both biotypes in the metabolism. Little AMPA was detected not only in a treated leaf but also in non-treated parts in both biotypes, which means that glyphosate was hardly metabolized to AMPA. These results showed that the resistant mechanism was neither metabolism nor limiting absorption of glyphosate, but limited translocation of glyphosate. We will discuss the transcriptome analysis of both biotypes by RNA-Seq for investigating the molecular mechanism of glyphosate resistance.

P-052

Investigation of the resistance mechanisms to several ACCase inhibitors in multiple-herbicide resistant *Echinochloa phyllopogon*

Yoshitaka Kamidate[1], Satoshi Iwakami[2], Yukari Sunohara[1], Masaki Endo[3], Seiichi Toki[3], Akira Uchino[4], Hiroshi Matsumoto[1]

[1] University of Tsukuba, 1-1-1 Tennodai, Tsukuba 305-8572, Japan
[2] Kyoto University, Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan
[3] Institute of Agrobiological Sciences, NARO, 2-1-2, Kannoudai, Tsukuba 305-8602, Japan
[4] Central Region Agricultural Research Center, NARO, 360 Kusawa, Anou, Tsu 514-2392, Japan

Echinochloa phyllopogon populations found in California, USA, are known to exhibit resistance to multiple herbicides such as ALS inhibitors and two FOP ACCase inhibitors (fenoxaprop-P-ethyl and cyhalofop-butyl). From biochemical and physiological studies, the resistance mechanisms to these herbicides were suggested as enhanced herbicide metabolism. Previously, we identified two cytochrome P450 genes whose overexpressions are associated with the resistance to the ALS inhibitors (Iwakami et al. 2014). Meanwhile, the genes involved in the resistance to ACCase inhibitors remains to be clarified. For the better understanding of resistance mechanism of ACCase inhibitors in the multiple-herbicide *E. phyllopogon*, we examined susceptibilities of a multiple-herbicide resistant line to four ACCase inhibitors from three chemical classes: fenoxaprop-P-ethyl; diclofop-methyl; tralkoxydim; pinoxaden. The multiple-herbicide resistant line exhibited significantly reduced susceptibilities to all the four herbicides compared to a susceptible line. P450 genes were isolated from the resistant line and introduced into rice via Agrobacterium-mediated transformation. Transgenic rice calli expressing either of the genes grew vigorously on media containing diclofop-methyl, tralkoxydim or pinoxaden while the growth of negative control, GFP-expressing rice, was severely suppressed. However, fenoxaprop-P-ethyl resistance was not observed in the P450 expressing rice calli. We regenerated rice plants from the transgenic calli. Herbicide responses of the regenerated rice plants were similar to those of the rice calli. Therefore, the P450 genes may be involved in diclofop-methyl, tralkoxydim and pinoxaden resistances in the multiple-herbicide resistant *E. phyllopogon* while other mechanisms are suggested in the resistance to fenoxaprop-P-ethyl. Further research is required to elucidate the ACCase inhibitor resistance in *E. phyllopogon.*

P-053

Salinity-induced redox homeostasis and hormonal modulation reduce herbicide 2,4-D efficacy in *Echinochloa crusgalli*

Faisal Islam, Muhammad A. Farooq, Jian Wang, Theodore M. Mwamba, Weijun Zhou

Institute of Crop Science and Zhejiang Key Laboratory of Crop Germplasm, Zhejiang University, Hangzhou, 310058, China

Distinct salinity levels have been reported to enhance plants tolerance to different types of stresses. The aim of this research is to assess the interaction of saline stress and the use of 2,4-D as a means of controlling the growth of *E. crusgalli*. The resultant effect of such interaction is vital for a sustainable approach of weed management and food production. The results showed that 2,4-D alone treatment reduces the chlorophyll contents, photosynthetic capacity, enhanced MDA, electrolyte leakage, ROS production (H_2O_2, $O_2^{\cdot -}$) and inhibited the activities of ROS scavenging enzymes. Further analysis of the ultrastructure of chloroplasts indicated that 2,4-D induced severe damage to the ultrastructure of chloroplasts and thylakoids. Severe saline stress (8 dS m^{-1}) followed by mild saline stress treatments (4 dS m^{-1}) also reduced the *E. crusgalli* growth, but had the least impact as compared to the 2,4-D alone treatment. Surprisingly, under combined treatments (2,4-D and salinity), the phytotoxic effect of 2,4-D was reduced on saline stressed *E. crusgalli* plants, especially under mild saline + 2,4-D treatment. This stimulated growth of *E. crusgalli* is related to the higher activities of enzymatic and non-enzymatic antioxidants and dynamic regulation of IAA, ABA under mild saline + 2,4-D treatment. This shows that 2,4-D efficacy was affected by salinity in a stress intensity-dependent manner, which may result in the need for greater herbicide application rates, additional application times, or more weed control operations required for controlling salt affected weed.

P-054

Heterologous production and characterization of CYP81A enzymes from a multiple herbicide-resistant weed, *Echinochloa phyllopogon*

Takuya Yamaguchi[1], Satoshi Iwakami[2], Yukari Sunohara[1] and Hiroshi Matsumoto[1]

[1] University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8572, Japan
[2] Kyoto University, Kitashirakawa-oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan

Herbicide-resistant *Echinochloa phyllopogon* (Stapf.) Koss. has been found in the Sacramento Valley in California, USA. The plant exhibits resistance to multiple herbicides with different modes of action such as acetolactate synthease (ALS) inhibitors and acetyl-CoA carboxylase inhibitors. Iwakami et al. (2014) showed that over expression of two genes encoding cytochrome P450 81A12 and 81A21, which catalyze *O*-demethylation of BSM, are associated with resistance to ALS inhibitors, bensulfuron-methyl (BSM) and penoxsulam in *E. phyllopogon*. In addition, *E. phyllopogon* has other seven putative functional genes encoding CYP81A enzymes (CYP81A14, CYP81A15, CYP81A18, CYP81A22, CYP81A23, CYP81A24, and CYP81A26). However, enzymatic properties of these CYP81A enzymes including CYP81A12 and CYP81A21 are largely remained unclear due to the lack of an efficient microbial production system. In this study, we heterologously produced CYP81A enzymes together with their redox partner, cytochrome P450 reductase (AtCPR1) from *Arabidopsis thaliana* (L.) Heynh in budding yeast and elucidated their enzymatic properties toward BSM.

Each *CYP81A* was cloned into the pYeDP60 vector and transformed into *Saccharomyces cerevisiae* WAT11, which has a genomically integrated *AtCPR1*. The transformants were cultured and expression of each gene was induced by galactose. To evaluate the yeast expression system, whole-cell activity assay was performed and reaction products were analyzed using an LC–MS system. The transformants carrying CYP81A12 and CYP81A21 expression plasmids produced *O*-demethylated BSM from BSM, indicating that our cytochrome P450 expression system is sufficient to elucidate enzymatic activities of CYP81As. In addition, CYP81A14, CYP81A15, CYP81A18, and CYP81A24 catalyzed the *O*-demethylation of BSM. These enzymes likely have potential to metabolize BSM as well as CYP81A12 and CYP81A21 in *E. phyllopogon*. In the presentation, we will also show substrate specificity of CYP81As toward the other herbicides.

P-055

Quinclorac resistance in *Echinochloa crusgalli* var. *zelayensis*

Liyao Dong[1*], Yuan Gao[1], Jangyan Xu[2], Guoqi Chen[1]

[1] College of Plant Protection, Nanjing Agricultural University, Nanjing 210095, China
[2] College of Science, Nanjing Agricultural University, Jiangsu Key Laboratory of Pesticide Science, Nanjing 210095, China

Echinochloa crusgalli var. *zelayensis*, a variety of *E. crusgalli* (L.) Beauv., is widespread in China, which is controlled by quinclorac in past three decades. Because of its economy, efficiency, and low toxicity, quinclorac had been favored by farmers. However, our research showed that *E. crusgalli* var. *zelayensis* biotypes collected from different paddy fields in Jiangsu and Shanghai, China had developed resistance to quinclorac. The S_{SX}-R, J_{CW}-R, J_{TJ}-R and J_{ZD}-R biotypes were resistant to quinclorac compared to the sensitive J_{NX}-S, with ED_{50} values 2457.79 ± 46.59, 355.85 ± 22.97, 227.69 ± 18.97 and 122.10 ± 9.36 g a.i.·ha^{-1}, respectively. Understanding the mechanisms undergoing the quinclorac resistance in *E. crusgalli* var. *zelayensis* is of great significance to its management. In susceptible (J_{NX}-S) and low resistant biotypes (J_{CW}-R, J_{TJ}-R and J_{ZD}-R), the activities of superoxide dismutase (SOD), catalase (CAT), peroxidase (POD), ascorbate peroxidase (APX) and glutathione reductase (GR) were increased firstly and decreased later after treated by quinclorac with label dose; while in highly resistant biotype (S_{SX}-R), activities of the above antioxidases showed a smooth trend. This indicates that the sensitive and low resistant plants may undergo oxidative stress and then antioxidant stress processes, while the high resistant population is not affected by oxidative stress. Furthermore, in susceptible (J_{NX}-S) and low resistant biotypes (J_{CW}-R, J_{TJ}-R and J_{ZD}-R), quinclorac-stimulated ethylene was increased, while in the highly resistanct biotype (S_{SX}-R) quinclorac-stimulated ethylene did not increase. Conclusion: *E. crusgalli* var. *zelayensis* in east China has evolved resistance to quinclorac. At least two mechanisms are involved in quinclorac resistance in *E. crusgalli* var. *zelayensis*: 1) inhibition in the ethylene response pathway, and 2) maintaining stable, high level of antioxidant enzyme activity to avoid damage caused by oxidative stress.

* Correspondence to: Liyao Dong, dly@njau.edu.cn.
The presentworkwas funded by theOpen Research Fund Program of Jiangsu Key Laboratory of Pesticide Science (NYXKT201203) and Funded by Special Fund for Agro-scientific Research in the Public Interest (201303022).

P-056

Ecological characteristics during growth and dormancy stages in the phytophagous beetle *Gastrophysa atrocyanea* Mots.

Hiroshi Tsuyuzaki, Daiki Goto, Yūsuke Kamata, Miki Ono and Makoto Abe

Faculty of Bioresource Sciences, Akita Prefectural University, 010-0444, Akita, Japan

Rumex obtusifolius L. is a invasive weed commonly found in upland fields and on paths between fields and pastures in Japan. The phytophagous beetle, *Gastrophysa atrocyanea* Mots, prefers to eat *R. obtusifolius* L. leaves and stems during the adult and larval stages in the spring. During the adult stage, beetles become dormant in the soil from summer until the next spring. We performed experiments to elucidate the ecological characteristics during the growth and dormancy stages of the beetle. Phenological traits of the beetle, such as egg-laying, hatching, larval stage, emergence, and underground movement, were recorded through field observation in 2015 and 2016. Effects of temperature on beetle growth were also investigated under controlled conditions during these two years. We found that beetle growth was accelerated under high temperature conditions; for example, hatching occurred at temperatures above 7.5 °C and emergence occurred at temperatures above 17.5 °C. These results indicate that beetle phenology is closely related to field temperature. Survival rates of dormant adults were investigated under different soil types in the two years of this study. Survival rates differed between both soil types and experiment years. We also measured the depth of the soil where the adults spent their dormancy. Dormant adults were observed at a depth of approximately 15 cm beneath the soil surface. These results indicate that soil water content may be one of the environmental factors that can affect survival rates. Dormant beetles seemed to be sensitive to dry soil conditions. Increased knowledge about *G. atrocyanea* Mots would be useful for devising techniques to control *R. obtusifolius* L. by using this beetle.

P-057

Evaluation of Fungi, *Paradendryphiella salina* as potential biocontrol agent of aquatic weed, waterhyacinth

Writuparna Dutta, Puja Ray

Multitrophic Interactions and Biocontrol Research Laboratory, Department of Life Sciences, Presidency University, 86/1 College Street, Kolkata-700073, India
email: d.writuparna@gmail.com

Tropical and sub-tropical parts of the world are more prone to weed infestation associated problems, as absence of natural enemies and the climatic conditions favour their invasiveness. In search of a potential mycoherbicide against the macrophyte waterhyacinth, *Eichhornia crassipes* , one of the worst aquatic weeds, an indigenous fungi was isolated from diseased waterhyacinth collected from the outskirts of Kolkata, India. The fungi caused severe chlorosis, under laboratory and field conditions. Though slow initiator, it caused 72% disease by the 5th day and complete mortality of the plants by 15th day of application under green house conditions. Hence, as potential biocontrol agent, the fungus was subjected to morphological identification and then molecular characterization by amplification of 18S RNA gene fragment from genomic DNA using 18S gene universal primers. Subsequently with sequencing, GenBank database comparisons and phylogenetic analysis, the fungus was determined as *Paradendryphiella salina*. This is the first report of the fungus from waterhyacinth. Culture filtrate and spore suspension of the fungus was evaluated for host-range against 71 plants species belonging to 25 families. Waterhyacinth was the only susceptible plant, diseased by the spore suspension (5×10^5 conidia/ml) of *P. salina* among the 12 plant species tested from aquatic habitat. Among terrestrial plant species tested, damage symptoms were observed on *Spinacia oleracea* when applied with the fungal culture filtrate, while *Amaranthus viridis* showed damage symptoms on application of both fungal spore suspension and culture filtrate, but as these species belong to different ecological niches from the target weed, the fungus may be further studied as a potential biocontrol agent against waterhacinth. In order to fully exploit its potential, further studies on the physiochemical properties, mycoherbicidal formulation and application methods of *P. salina* along with field experiments are required to establish it as effective biocontrol agent against waterhyacinth.

P-058

Variability and phenotypic plasticity of *Ulex europaeus* seeds in the Hawaiian Archipelago and California, U.S.A: How do they support its invasiveness?

Mika Hozawa[1], James Boyd Friday[2], Eiji Nawata[1], Kanehiro Kitayama[3]

[1] Laboratory of Tropical Agriculture, Division of Environmental Science and Technology, Graduate School of Agriculture, Kyoto University, Kirshirakawa Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan
[2] College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, Komohana Research and Extension Center, 875 Komohana St. Hilo, HI 96720 USA
[3] Laboratory of Forest Ecology, Division of Environmental Science and Technology, Graduate School of Agriculture, Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan

Ulex europaeus or gorse is native to Western Europe, is listed among the world's top 100 invasive species by the IUCN because of its vigorous propagation, among other negative qualities. The plant produces large quantities of long-lived seeds. Germination tests of seeds collected in Pescadero (California), Maui, and Hawaii from March 2016 to July 2016 were done in Hawaii under natural sunlight. Seed dry mass and length were measured and the relationships with germination rate were analyzed. All the analyses were done by software R, ver. 3.3.2. The results showed that the germination rate of the seeds from California was significantly higher than those from the Hawaiian archipelago. Seeds from California were significantly longer than seeds from Maui and Hawaii, but the seeds from the two Hawaii sites did not differ in length. Dry mass did not differ among seeds collected in the three sites. Seed length was positively correlated with dry mass for Maui seeds ($r=0.74$) but not for Hawaii seeds or California seeds. Seed dry mass was positively correlated with germination rate for Maui seeds ($r^2=0.49$, $p<0.05$) but negatively correlated with germination rate for Hawaii seeds ($r^2=0.54$, $p<0.05$) and not correlated for California seeds. Length was positively correlated with germination rate for Maui seeds ($r^2=0.56$, $p<0.05$) but not for California seeds or Hawaii seeds.

In general, light-effect is larger in smaller seeds; smaller seeds tend to germinate even in the deep soil (Koutsovoulou et al. 2014). Seeds produced on Hawaii were inferred to be more suitable for seed banks compared to those produced on Maui.

P-059

Weed flora of Timor Leste

John Westaway[1], Sancha de Jesus Marcal[2], Andrew Mitchell and Ian Cowie[3]

1 Northern Australia Quarantine Strategy, Australian Department of Agriculture and Water Resources;

2 National Directorate of Quarantine & Biosecurity, Timor-Leste Ministry of Agriculture & Fisheries.

3 Northern Territory Herbarium (DNA), Darwin.

Abstract

Timor Leste occupies the eastern half of the island of Timor and experiences a monsoonal climate with pronounced dry season. Timor is characterized by mountainous hill-country of relatively recent, mainly sedimentary geology with principal vegetation comprising tropical evergreen forests, monsoon forests, eucalypt forests and grassy woodlands.
Timor Leste is one of the world's newest nations but also one of the oldest known locations in Southeast Asia of human activity, dating back 42,000 years. This long human history of habitation and land use has played a significant role in shaping present vegetation and flora.
Timor's natural forests have been depleted by slash-and-burn agriculture with intact native vegetation now mostly restricted to steep or infertile landforms. The landscape is now dominated by modified vegetation communities of introduced plants, including species tolerant of human activities and livestock pressures.

Surveys conducted by Timorese and Australian biosecurity agencies between 2000 and 2017 have compiled an inventory of introduced and pest plant species. Records from herbarium databases and the literature have supplemented this inventory. More than 400 introduced plants from 85 families have been recorded as naturalised in Timor Leste. A further 80 presumed indigenous species are also recorded as weeds. Fabaceae and Poaceae are the best represented families with Asteraceae and Malvaceae also prevalent. Herbaceous plants account for 42% of the weeds, and shrubs and grasses are represented by 22 & 17% respectively. Analysis of the origin of Timor-Leste's introduced flora reveals that more species originated from the Americas than from Asia; with considerably fewer species derived from Africa or Europe. Assessment of the mode of introduction indicates that the majority of species either arrived inadvertently or were introduced as ornamentals. Many species were also introduced for agricultural purposes such as fodder or pasture improvement. Only a small subset of cultivated food plants have established naturalized populations. A relatively small proportion of the total introduced flora has become invasive, exerting a detrimental impact on Timorese livelihoods and environment.

P-060

Response of *Parthenium hysterophorus* in terms of phenological, morphological and functional traits upon exposure to variable temperature conditions

Amarpreet Kaur[1], Daizy R. Batish[1], Shalinder Kaur[1], Harminder Pal Singh[2]

[1]Department of Botany, Panjab University, Chandigarh-160014, India
[2]Department of Environment Studies, Panjab University, Chandigarh-160014, India

Parthenium hysterophorus L. (Asteraceae), a native of tropical and subtropical Americas has invaded several Asian, Australian and African countries over a past few decades. It is highly obnoxious weed posing a threat to biodiversity, agriculture, human health *etc*. Invasive traits such as enormous reproductive potential, ecological adaptability and allelopathic properties are responsible for its widespread growth. Recent revelation regarding the enhancement of its invasion potential under climate change scenario and possibility of its further spread in non-invaded areas presents a warning to the researchers worldwide. Understanding the invasive behavior of *P. hysterophorus* in response to climatic variations may help in estimating its probable response towards the potential seasonal drifts. A study was therefore, planned with an objective of documenting the phenological, morphological and functional traits of *P. hysterophorus* in response to different climatic conditions. The weed was grown in summer (37.5/19.6°C) and winter (13.1/7.6°C) temperature conditions and various phenological, morphological and functional traits that can influence its invasive behavior were evaluated. The life cycle of the weed varied in terms of phenophases and duration under different temperature regimes. The plants were morphologically distinct in terms of quantitative growth variables and biomass allocation. Further, relative growth rate and net assimilation rate were significantly higher in case of the plants sown under low temperature conditions whereas reproductive traits were more pronounced in the summer-sown plants. The results support the theory of phenotypic plasticity in imparting ecological adaptability to the plant, thereby contributing to its invasive success. This study provides an insight into the fundamental behavior and scope of acclimatization of weed in response to climatic variations.

P-061

Yield losses caused by parthenium weed (*Parthenium hysterophorus*) in maize crop at different competition durations

Ali A Bajwa[1,2], Tamado Tana[3], Lisanework Nigatu[3], Bhagirath S Chauhan[2], Steve Adkins[1,2]

[1]School of Agriculture and Food Sciences, The University of Queensland, Gatton, QLD 4343, Australia.
[2]The Centre for Plant Science, Queensland Alliance for Agriculture and Food Innovation, The University of Queensland, Gatton, QLD 4343, Australia.
[3]Haramaya University, Dire Dawa, Ethiopia.

Parthenium weed is a problematic invasive weed species in more than 40 countries. It infests several major crops and cause substantial yield losses. It is important to figure out its critical competition duration in different crops to devise a suitable management strategy. A field study was conducted to evaluate the effect of parthenium weed on maize at different weed-crop competition durations in Ethiopia. Six treatments applied included, weedy check, weed free, and parthenium weed competition for 2, 4, 6 and 8 weeks after crop emergence. Parthenium weed biomass increased with increasing competition duration. Parthenium weed caused significant reductions in thousand grain weight and grain yield of maize. The 2-week competition treatment did not affect the thousand grain weight. Weed free treatment provided the highest grain yield (9.4 t/ha) whereas, the yield was least in the weedy check (7.9 t/ha). Parthenium weed competition for 2, 4, 6 and 8 weeks after crop emergence caused 3, 6, 8 and 15% yield losses, respectively as compared with the weed free treatment. It is important to note that the yield reductions with 8 weeks of competition and weedy check treatments were almost the same. So, management strategies should be devised to control parthenium weed in maize during the critical competition period of 4 to 8 weeks after crop emergence.

P-062

Restricting the species distribution models to regional settings may lead to wrong projections

Shahid Farooq, Huseyin Onen

Department of Plant Protection, Gaziosmnapaşa University, Tokat, 60250, Turkey

Species distribution models (SDM) are increasingly being used at regional and global scales to predict the invasive species' distribution under prevailing and future climatic conditions. These models are mostly restricted to regional settings while predicting species distribution for a particular region. However, restricting SDMs to regional scales could not project the actual suitable ecological niche. We used an Ensemble modelling approach to predict the current and future distribution of invasive common ragweed (*Ambrosia artemisiifolia* L.) in Turkey. We developed two different models; one calibrtaed on global scale with distribution data from GBIF and literature and projected on local scale (i.e., Turkey), while the second model was calibrated and projected on regional scale with distribution data available from IBIL project (www.i-bil.org). The global calibrated model projected higher suitable area for the species compared to local calibrated model, both for current and future climate. The local model only projected the species' suitable ecological niche closer to the presences in Turkey, whereas the rest of the country was predicted as unsuitable. Hence we argue that SDMs should be calibrated on global scales and projected on local scales to predict the actual ecological niche of the species. Alternatively, suitable approaches need to be developed to combine the outputs of local and global models to further strengthen the outputs of SDMs.

Keywords: Common ragweed, Distribution modelling, Model calibration,

P-063

Title

Distribution of Invasive Alien Species in Korean Croplands

Jin-Won Kim, In-Yong Lee, Jeongran Lee

National Institute of Agricultural Sciences, Rural Development Administration, 166 Wanju-gun, Jeollabuk-do, 55365, Republic of Korea

Invasive Alien Species (IAS) can affect ecosystem negatively and critically. The geographical distributions of nine IAS plants in Korean orchards and uplands were investigated. *Ambrosia artemisiifolia* distributed widely in Korean peninsula and *Ambrosia trifida* distributed intensively in Gyeonggi-do. *Aster pilosus* distributed in Gyeonggi-Gangwon region and *Lactuca scariola* distributed linear region from the north-western to south-eastern part of Korea. *Hypochaeris radicata* distributed mainly in Jeju-do, and *Solanum carolinense* distributed in eastern Gyeonggi-do. *Rumex acetosella* and *Sicyos angulatus* sporadically occurred in Korean croplands and *Eupatorium rugosum* was found in one region only. The distribution of IAS plants in croplands was very similar to that in non-croplands suggesting that ecological position of arable lands is not different from that of non-arable lands. Therefore, IAS plants in the croplands should be managed for not only prevention of yield reduction, but also protection or maintenance of original ecosystem. Development of management methods apposite to current Korean status are required to control IAS plants in croplands.

P-064

Floating time and longevity for achenes of potentially water dispersed invasive *Parthenium hysterophorus* L.

Runping Mao[1], Steve Adkins[1]

[1] The University of Queensland, Brisbane QLD 4072 Australia

The rapid spread of the highly invasive parthenium weed (*Parthenium hysterophorus* L.) has caused serious problems in many countries of the Asian-Pacific region. Multiple identified spread routes have facilitated its population expansion on the local and regional scale. This study focuses on the mechanisms of dispersal by water, and explores buoyancy, viability and germinability of achenes and their rate of spread in water. Block designed experiments studying floating and sinking rates were conducted under simulated field conditions. Achenes and isolated seed were studied in still, slow moving and turbulent solutions of both distilled water (control) and river water. High germination (over 80%) was possible at the end of most experiments indicating such treatments did not reduce viability. One experiment showed that achenes could float on the water surface much longer than the dense seed with about 15% still floating after 20 days of treatment. Over 50% of these achenes germinated after only 3 days in the distilled water treatments, while in slow moving and turbulent water achene germination was delayed, though the final germination percent was similar. A negative correlation was observed between achenes sinking and their germination rate, indicating that lack of water movement or lack of air contact before sinking may result in a delayed germination. Removal from water has less acceleration effect when achenes stay more than 5 days in water. In another experiment where achenes were pressed underwater, delay of germination after achenes removal from water was observed, with lower germination percentage in longer sinking (over 15 days) treatment. This test also determined dark can inhibit achene germination while floating, but has no significant influence on germination behavior after removal. The overall finding indicates good germination and persistence of parthenium weed achenes in natural river environment and suggests water dispersal potential.

P-065

Adaptability of malignant invasion plants *Parthenium hysterophorus* L. in different types of soil

Gao Xing-xiang[1], Sun Zuo-wen[2], Li Mei[1*], Fang Feng[1], Li Jian[1], Zhao Mi-ruo[3], Zhu Hong[3]

[1] Institute of Plant Protection, Shandong Academy of Agricultural Sciences, Ji'nan 250100, China
[2] Shandong Plant Protection Station, Ji'nan 250100, China
[3] Southwest University, Chongqing 400715, China

Parthenium hysterophorus is an alien weed with strong invasiveness in China. The original habitat is in the north of Mexico to the southeastern of the United States, and now widely distributed in the tropical regions of global. It was found in Yunnan, Guangxi, Guangdong, Hainan, Hong Kong, Fujian, Guizhou and Shandong Province. In order to better understand the potential spread region of *P. hysterophorus*, pot experiment was conducted to study the adaptability of *P. hysterophorus* in 31 different types of soil in Shandong Province. Results showed that *P. hysterophorus* has a strong adaptability to different types of soil. There are 23 types of soil are suitable for its growth which accounted for 74.19%. And 8 types of soil are not suitable which accounted for 25.81%. Moreover results demonstrated that the growth of *P. hysterophorus* was not affected by nitrogen, phosphorus, potassium, organic matter content and soil type but affected by pH, soil texture and salt content of soil, especially the strong acidic, clay loam or sandy soil and high salty soil. It is means that the soil of mountain regions of Shandong middle and plain regions of Shandong northwest was the most suitable for *P. hysterophorus* growth, and hill regions of Shandong east, plain regions of Shandong middle and mountainous regions of Shandong south were appropriate to its growth. However, the coastal regions of Shandong north and plain regions of Shandong southwest depression area are not suitable for *P. hysterophorus* growth.

P-066

Comparative Study on the Competitive Ability of Different Cytotypes of Solidago canadensis L. in a common garden

Jiliang Cheng, Beibei Yao, Xianghong Yang, Jun Li, Sheng Qiang*

Weed Research Laboratory, Nanjing Agricultural University, Nanjing 210095, Jiangsu, P. R. China.
*Corresponding author, wrl@njau.edu.cn

Solidago canadensis L., a perennial herb (Asteraceaea) native to North America, becomes a worldwide invasive species including East Asia, Europe, Oceania and South America. Multiple cytotypes, including diploids, tetraploids and hexaploids, have been found in native populations, but only tetraploid and hexaploid populations have been found wildly in China (introduced range) despite the diploids have been cultured widely as cut flowers. There is little empirical evidence that the invasion of *S. canadensis* was associated with polyploidization. In order to elucidate the effect of polyploidization on plant invasiveness, 17 populations of six geo-cytotypes which include the three diploid, three tetraploid and three hexaploid populations from North America (called as native populations) and the two cultured diploid populations, three tetraploid and three hexaploid populations from China (called as introduced populations) were grown respectively in the different four-repeated plots with the same plant density and competed freely with local weed species in a common garden. We continuously observed dynamics of the communities in the plots with different geo-cytotype *S. canadensis* and associated weeds for five years. The results showed that the introduced polyploid populations increased continuously and succeeded into dominant populations and even pure *S. canadensis* populations in the plots after five years. The native hexaploid populations standed with an increase at the forst two years but decreased continuously from the third year. The native and introduced diploids and native tetraploids decreased continuously and were almost taken over by other local associated weeds after five years. We could conclude that *S. canadensis* leads the successful invasion in China through polyploidization enhancing the competition ability and facilitating the invasion. This provides an evidence for evolutionary increased competitive ability (EICA) in the invasive plant *S. canadensis*.

Foundation item: The National Natural Science Foundation of China (31070482).
Profession Scientific Research Special Item of Environmental Public Welfare (201409061).

P-067

The effects of *Acacia* invasion on leaf litter and soils of coastal tropical heath forests in Brunei Darussalam.

Aiman Yusoff[1], Kushan Tennakoon[1,2], Faizah Metali[1], Rahayu Sukmaria Sukri[1*]

[1] Environmental and Life Sciences Programme, Faculty of Science, Universiti Brunei Darussalam, JalanTungku Link, BE 1410, Brunei Darussalam
[2] Institute for Biodiversity and Environmental Research (IBER), Universiti Brunei Darussalam, Jalan Tungku Link, Gadong, BE1410, Brunei Darussalam
*Corresponding Author: Tel:+6732460923, E-mail Address: rahayu.sukri @ubd.edu.bn (R.S. Sukri)

Acacias are fast-growing exotic trees that were introduced to Brunei Darussalam in the 1990s for plantation forestry and rehabilitation of degraded land. However, due to anthropogenic activities and superior adaptive capabilities, Acacias are now becoming invasive, threatening the native tropical heath (Kerangas) ecosystems. Despite numerous reports on the spread of *Acacia* species worldwide, reports on the invasiveness of Acacias in Brunei Darussalam are currently scarce. Here we report the impact of *Acacia* invasion on litter nutrient composition and soil physicochemical properties of Brunei's coastal Kerangas forests (KF) by comparing the physicochemical properties between the *Acacia*-invaded (IKF) and uninvaded Kerangas forest (UKF). Our findings highlight the importance of nitrogen fixing abilities of *Acacia* species as shown by increase in leaf litter production in invaded Kerangas forests (IKF), along with increasing N and P input. However despite this higher N input in the leaf litter, there was no significant increase in soil N concentration in IKF. This can be attributed to the short invasion time scale of Acacias in Brunei (<25 years). Additionally, no significant changes were detected in IKF soil physicochemical properties except for available P and exchangeable Ca concentrations. Our results also revealed a positive correlation between litter N and topsoil N in IKF which highlight the role of nitrogen-fixing *Acacia* in influencing soil nutrient availabilities in IKF after a relatively long invasion time scale. Therefore, long term monitoring of IKF is needed to get insights to the exact reasons of soil physicochemical properties responsible for enhanced *Acacia* invasion to these sites.

P-068

Host invasive plant species and parasitoids of European corn borer (*Ostrinia nubilalis* (Hubner, 1796) (Lepidoptera: Crambidae) in Black Sea and Marmara Regions of Turkey

Cumali Özaslan[1], Huseyin Önen[2], Kenan Kara[2], Shahid Farooq[2], Ahmet Bayram[1], Halil Bolu[1]

[1] Department of Plant Protection, Dicle University, Diyarbakır, 21280, Turkey
[2] Department of Plant Protection, Gaziosmanpaşa University, Tokat 60250, Turkey

Maize (*Zea mays* L.) is widely cultivated in Black Sea and Marmara regions of Turkey. European Corn Borer (ECB) damages the maize crop in both regions. Recently, numerous invasive plant species have been observed in agricultural areas, abandoned lands and along roadsides of both regions. The objective of the current study was to determine whether ECB uses these plant species as alternative hosts for 2nd generation or not. The second aim of the study was to search the parasitoids, which could be used as biological ontrol agents against ECB. Several invasive plant species such as, *Ambrosia artemisiifolia* L., *Persicaria perfoliata* (L.) H. Gross, *Commelina communis* L., *Bidens frondosa* L., *Polygonum thunbergii* Sieb. & Zucc., *Phytolacca americana* L. and *Xanthium strumarium* L. were observed through June to September 2015. The plant samples showing the sypmtoms of ECB damage were collected and brought to labortary for rearing the adults and parasitoids. The ECB adults were successfully reared from the collected plant species from both regions. Similarly, three parasitoids; *Eriborus terebrans* Gravenhorst (Hymenoptera: Ichneumonidae), *Lydella thompsoni* Herting (Dipt., Tachinidae) and *Microgaster fulvicrus* Thomson (Hymenoptera, Braconidae) were also successfully reared from the collected samples. Our results indicate that the ECB, being polyphagous uses invasive plant species as alternative hosts for the 2nd generation. Similarly, the parasitoids reared could be used as potential biological control agents against ECB after thorough investigations.

Key words: Invasive plant species, European corn borer, Parasitoids, Alternative hosts, Turkey

The current study was supported by The Scientific and Technological Research Council of Turkey (TUBITAK) with a project number 113O790.

P-069

The relationship between the composition of weed seed contaminants of imported grain and the vegetation of international trading ports.

Takeshi Nishi, Yoshiko Shimono, Tohru Tominaga

Graduate School of Agriculture, Kyoto University, Kitashirakawa-oiwakecho, Kyoto 606-8502, Japan

Contamination of grain commodities by weed seeds is considered a major pathway for alien plants to enter a new region. International trading ports, where grain spillage occurs, are known as major entering spots for nonnative weeds. However, there are few researches that have quantitatively evaluated the degree of invasion occurring at international trading ports. Here, we conducted a country-wide vegetation survey at ten international trading ports to investigate the influence of grain spillage on local vegetation. The survey was conducted twice in a single year, first in spring and second in autumn. Five of these ten ports are 'grain importing ports (GIP),' where large amount of grain is imported, whereas the other five are 'non-grain importing ports (NGIP),' where no grain is imported. In total, 277 and 232 plant species were recorded in spring and autumn, respectively. Diversity of nonnative species was much higher for GIP, possibly because of grain spillage. At GIP, crop species such as wheat and barley were growing along roadside, also indicating that grain spillage was actually occurring. In the spring survey, plants belonging to the family Brassicaceae were recorded remarkably more at GIP than at NGIP, and in the autumn survey, Amaranthaceae and Convolvulaceae showed similar tendencies. These three families are thus considered indicators of vegetation of GIP. We also investigated the species composition of weed seeds contaminated in different kinds of grains and forages, and compared the results to species occurrence data in the vegetation survey. Three previous studies on weed seed contaminants were also used for the comparison. The results showed that species with high grain contamination rates tended to show higher occurrence at GIP than at NGIP. TTC tests showed that weed seeds contaminated in most grains are still alive, but that feed processing at high temperature can completely kill the seeds.

P-070

Palmer amaranth (*Amaranthus palmeri* S. Watson): A new addition to the alien flora of Turkey

Cumali Özaslan[1], Shahid Farooq[2], Hüseyin Önen[2]

[1] Department of Plant Protection, Dicle University, Diyarbakır, 21280, Turkey
[2] Department of Plant Protection, Gaziosmanpaşa University, Tokat 60250, Turkey

Turkey has a long history of floristic research and hosts some 12000 plant species. However, there have been much less works concentrated on tracking the alien plant species in the country. A recent study has identified 340 alien taxa in the country, which is comparatively much less than rest of the Europe. New species are being identified for the flora of Turkey. This study reports a new addition to the alien flora of Turkey. An unusual species was identified during the surveys aimed at tracking alien species in the country. The species was identified as palmer amaranth "Palmer pigweed" (*Amaranthus palmeri* S. Watson). The species has never been reported from Turkey in earlier or current studies. The species was found on 25.08.2016, in a corn and cotton field in Mardin province (Derik district/Atlı town), close to the roadside from Kızıltepe to Viranşehir, 37.121735^{0}N, 40.083941^{0}E. The species was at flowering stage in the both crops, widely cultivated in Southeastern Anatolia Region of the country. The species is native to southwestern United States and northern Mexico. It has widely expanded its range, becoming invasive in agricultural fields in North and South America, Africa, Asia, Australia, Europe and in many other parts of the world. Palmer amaranth occurs in cultivated land, especially in cotton, corn, soybean and other row crops. It is the most competitive and aggressive pigweed species. It is considered as one of the worst invasive alien plant species worldwide. It is therefore recommended that early warning should be issued to limit the further spread of the species in the country.

Key words: Palmer amaranth, *Amaranthus palmeri*, new record, alien flora, Turkey

P-071

A survey of alien invasive weed species in Hubei Province, China

Ruhai Li, Shihai Chu

Key Laboratory of Integrated Pest Management on Crops in Central China, Ministry of Agriculture / Hubei Key Laboratory of Crop Diseases, Insect Pests and Weeds Control / Institute of Plant Protection and Soil Science, Hubei Academy of Agricultural Sciences, Wuhan 430064, China

In this paper, field surveys and literature review were adopted to systematically assess the occurrence overview of alien invasive weed species in Hubei province, China. Invasion pathways of invasive weed species and the relationship between invasion and human activity were analyzed. There were 104 alien invasive weed species recorded in Hubei province, including aquatic weeds (3) and terraneous weeds (101). Among these, weeds belonging to Asteraceae (32) ranked the first, accounting for 30.8% of the total; weeds belonging to Poaceae (11) and Leguminosae (10) ranked the second and third, respectively. There were two types of mode of invasion of invasive weeds into Hubei province, one is the voluntary introduction of invasive species accounting for 46.2%; the other is inadvertent species introduction, accounting for 53.8%. The number of alien invasive weed species rose year by year after 1980s. The number of alien invasive weed species was positively correlated with the GDP, number of incoming passengers, total import and export, and density of traffic in Hubei province. With vigorously developing the economy, it is necessary to further strengthen the species introduction regulatory and strict implementation of quarantine measures to prevent further and new invasions of invasive species. At the same time, it is necessary to carry out prevention and control technology research of invasive species, in order to curb the spread and hazards of invasive species.

P-072

Alternate of vascular bundles lignification plays a central role in the invasiveness of *Solidago canadensis* L.

Yu Zhang[1], Sheng Qiang[1]

[1] Weed Research Laboratory, Nanjing Agricultural University, Nanjing, China.

Many studies have shown that individuals from invasive populations of many different plant species increase in plant growth and vigor. Some evidence suggests that invasive species may allocate a higher fraction of resources to increased growth or fecundity, which is thought to be due to reduce resource allocation in defense. However, no study has focused on the shifts in growth-defense capacity of invasive plant and the mechanism involved in such tradeoffs. Given the importance of vascular bundles in higher plants, as well as it's provided support for both plant growth and defenses. In present study, we investigated the development pattern of vascular bundles and defense traits of 10 invasive populations in comparison with 10 native populations. At earlier stage, compared to the native populations, invasive populations seem to grow faster and lager in vegetative growth, histochemical analysis revealed that stems of invasive populations present more developed vascular structure and accumulated high levels of lignin in xylem, but less developed fibers in phloem. These differences during development were associated with different expression level of lignin synthesis-related genes but only present in phloem region. Comparative studies between native and invasive populations also revealed differences in sensibility during pathogen infection, while the invasive populations were more susceptible by pathogen infection. Both native and invasive populations showed an increased level of expression of lignin synthesis-related genes in phloem region after inoculated with the fungus *S. rofsii*, but the invasive populations had the lower and slower increase. These results provide empirical evidence that alternative resource allocation of vascular bundle lignification leads to invasive populations more ability to grow but less to defense in the development of stem.

P-073

Broomrape infestation in lentil crop and farmer knowledge on the management of parasitic weed species in Diyarbakır province, Turkey

Cumali Özaslan[1], Shahid Farooq[2], Hüseyin Önen[2]

[1] Department of Plant Protection, Dicle University, Diyarbakır 21280, Turkey
[2] Department of Plant Protection, Gaziosmanpaşa University, Tokat 60250, Turkey

Lentil (*Lens culinaris* Medik.) is among the oldest domesticated crops in the world and has an important role in human and animal nutrition. Lentil is widely grown in Southeastern Anatolia Region, Turkey. Broomrapes are the family of parasitic plants, which threaten the production of grain legumes globally. Several members of broomrapes infest the roots of numerous crops, including lentil. This survey study was conducted to determine the broomrape species infesting lentil crop in Diyarbakır province in the Southeastern Anatolia Region, during lentil growing season of 2015-2016. Moreover, 124 farmers were interviewed to identify their knowledge of parasitic weeds and their management. A total of 74 fields were surveyed and broomrapes were observed to infest the lentil roots in all surveyed districts. The most abundant broomrape species infesting lentil plants were; *Orobanche crenata* Forsk., and *Phelipanche aegyptiaca* (Pers.) Pomel (syn. *Orobanche aegyptiaca* Pers.). The frequency of occurrence of broomrape species ranged between 12-41%, whereas the average number of broomrape branches on a lentil plant were recorded between 0.6 and 1.6. Similarly, the average density was 1.8-3 plants m^{-2}. It is concluded that broomrape species have been established in Diyarbakır province and could lead to massive losses in the future. The results of the interview study indicated that the farmers did not have sufficient knowledge of biology, ecology and management of parasitic weed species. Therefore, management studies and farmer awareness programs are urgently needed in the region to prevent the future losses in the region.

Key words: Lentil, broomrape, Farmer knowledge, Diyarbakır, Survey, Turkey

P-074

Herbicidal management of parasaitic *Dendrophthoe* in semi- temperate and temperate fruit crops of Jammu-Kashmir Himalayas

Anil Kumar[1], R. Puniya[2], B. R. Bazaya[2], Amit Mahajan[3], Lobzang Stanzen[4] and [1]Sunny Raina

[1]Advanced Centre for Rainfed Agriculture, SKUAST-Jammu
[2] AICRP-Weed Management, SKUAST-Jammu
[3]KVK Rajouri, SKUAST-Jammu
[4]AICRP-Agrometeorology, SKUAST-Jammu

Dendrophthoe is a partial stem parasite. It has leaves, flowers and fruits. Birds eat the fruits of the parasite and the seeds are excreted through droppings which fall on limbs and branches of the tree. The seed germinates under favourable conditions and gives out clusters of shoots. The seeds while sprouting produce bulged haustoria which penetrate into the bark and absorb water and minerals from the host and grow as plant. The haustoria of the parasite serve as roots. Due to absorption of nutrients by the parasite from the host the tree gradually weakens. It poses serious losses to economically valuable fruit trees, whether growing in forests or orchards. The problem of stem parasite was found to be severe in plants like Fig, Walnut, Peach, Timbru, Apricot, Pomegranate, *Grewia* and Citrus in Udhampur district of Jammu and Kashmir, India. For management of stem parasite a field experiment was conducted during 2015 and 2016 in Udhampur district in the domain area with three treatments viz. cotton padding of 4 g copper sulphate + 0.5 g 2, 4-D sodium salt, directed spray of 0.5% paraquat on parasite and directed spray of 1% glyphosate on parasite where the parasitic weed was identified as *Dendrophthoe spp.*, family Lorenthaceae. Observations after one month of imposition of treatments revealed that directed spray of paraquat 0.5% and glyphosate 1% gave satisfactory control of *Dendrophthoe spp.* in Walnut, Timbru, Apricot, Pomegranate, Fig, Grewia and Citrus with slight phytotoxicity to host plant. However, cotton padding of copper sulphate + 2, 4-D sodium salt gave satisfactory control of *Dendrophthoe spp.* in all the host-parasite situations except for that a relatively lesser response was observed in case of Walnut, Fig and Citrus host plants.

P-075

Integration of Provisia® Rice into Existing Rice Culture

Sunny Bottoms[1]

[1]Horizon Ag, LLC, P.O. Box 266, Dumas, Arkansas 71639, USA

Provisia® rice is tolerant to quizalofop-P-ethyl, a selective grass herbicide that inhibits acetyl-coenzyme A carboxylase (ACCase). There are other ACCase inhibitors used currently in rice production, but do not have activity on weedy rice. This new technology is a useful tool for extending the life of the Clearfield rice system. Provisia rice technology can be integrated into the existing Clearfield rice-soybean-conventional rice rotation system to manage herbicide-resistant weedy rice outcrosses. The weed control strategies being tested in commercial fields include: clomazone and/or saflufenacil applied preemerge followed by two consecutive postemergence applications of Provisia® herbicide with various tank mixes as well as other combinations. The yearly in-crop dose is no more than 2.26 liters hectare^{-1}. There are some challenges for which to prepare and overcome with the Provisia® system, such as plant back intervals after using imazethapyr in monoculture, mixing quizalofop-P-butyl with appropriate herbicides and adjuvants, and proper sprayer cleaning after herbicide application.

P-076

Silencing Seed Dormancy Genes to Mitigate Risk of Escaped Transgenes in Weedy Rice

Xing-You Gu, Alexander Kena, Heng Ye, Luai Muhammad, Ugur Korkmaz, Jiuhuan Feng

Agronomy, Horticulture & Plant Science Department, South Dakota State University, Brookings, SD 57007, U.S.A.

Gene flow from genetically engineered crops into wild relatives may exacerbate weed problems. Seed dormancy (SD) is a key adaptive trait that disseminates germination over time resulting weed persistence in agroecosystems. This research aimed to develop transgene mitigating (TM) strategies to reduce the risk of gene flow by linking to a fitness-enhancing transgene with SD gene-silencing structures. This built-in linkage would have no negative effect on a GE crop, but could reduce SD and promote germination uniformity for transgene-containing weeds, which make the new weed genotypes relatively easy to eliminate by agronomic practices. Several SD loci differentiated between weedy and cultivated rice (*Oryza sativa*) were cloned; their coding sequences were used to design inverted repeat sequences (IRSs) for gene silencing by RNA interference (RNAi), or guide RNAs (gRNAs) for gene knockout by a CRISPR/Cas9 multiplex system. The IRSs or gRNAs ligated with the *Bar* gene for herbicide resistance (HR); the tandem constructs *Bar::IRSs* or *Bar::gRNAs* were used to transform the cultivar Nipponbare. Selected transgenic T_0 plants were crossed with weedy rice to evaluate the fitness of hybrid F_1s, or the linkage between HR and SD in the higher generations. For the RNAi system targeting two SD genes simultaneously, silencing effects and HR-SD linkage were detected in the F_1 to F_3 generations. For the CRISPR/Cas9 system targeting six SD genes simultaneously, the mutation frequency was higher in the T_0 than in the hybrid F_1 generation, and the F_2 population is used to test for the HR-SD linkage. The available results proved that SD genes common across weed ecotypes are ideal targets to design TM strategies using RNAi or genome-editing techniques.

Key Words: transgene mitigation, seed dormancy, gene flow, genetically engineered crop, weed

P-077

Evaluation of weed control efficacy and safety of glyphosate in herbicide tolerant transgenic maize

Huilin Yu[1], Hailan Cui[1] and Xiangju Li[1]

[1]Key Laboratory of Weed and Rodent Biology and Management, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing 100193, China

Herbicide-tolerant (Ht) maize has been planted widely and provided an effective tool for weed control. However, so far no Ht maize varieties were commercially planted in China. Prior to the commercialization of any Ht crop, weed control efficacy and the safety of herbicide on Ht crops are two important aspects to assess. Transgenic *G10evo-EPSPS* maize expressing EPSPS protein conferring herbicide tolerance trait, was used in our study. The efficacy of weed control and the impact on transgenic maize growth were investigated under field conditions after application of glyphosate 41% aqueous solution. When maize plants was at 40 day after sowing (DAS), glyphosate was applied at the dosage of 615, 1230 (recommended dose), 2460 and 4920 g ai/hm^2. These treatments were compared with hand weeding on 40 DAS and unweeded control. Our results showed that weed flora of experimental field plots predominantly consisted of four species of grasses and fourteen species of broadleaved weeds. Considerable reduction in the density of grasses and broadleaved weeds were observed under glyphosate at 1230, 2460 and 4920 g ai/hm^2 at 28 days after treatment (DAT) compared with hand weeding. Glyphosate at 1230, 2460 and 4920 g ai/hm^2 at 28 DAT provided > 85% and > 90% control for grass and broadleaved weeds compared with hand weeding treatment that separately provided 50.10% and 40.90% control. Lower dosage of gylphosate at 615 g ai/hm^2 did not prove effective in controlling grass weeds. No differences of the leaf number and plant height in maize among different treatments at any time of investigation indicated that no impact of glyphosate applied on maize growth.

P-078

Ethylene and ABA mediated rapid grain filling of weedy rice to promote early maturity

Can Zhao[1], Lingchao Meng[1], Xi Chen[1], Wenrong Xu[1], Xiaoling Song[1], Sheng Qiang[1*]

[1] Weed Research Laboratory, Nanjing Agricultural University, Nanjing 210095, Jiangsu, P.R. China
[*]Corresponding author. E-mail: wrl@njau.edu.cn

The early maturity causes weedy rice to persist by escaping artificial harvesting in the paddy fields. The quick rate and short stage of grain filling is mainly responsible to early maturity of weedy rice. However, the physiological and molecular mechanisms of grain filling rate in weedy rice are largely unexplored. Here, we selected four biotypes of weedy rice and cultivated rice at different latitudes to conduct a common garden experiment. We observed and measured the grain filling rate, ethylene evolution rate, ABA content, the activities of key enzymes and expressions of genes involved in sucrose-to-starch conversion of both weedy and cultivated rice. Comprehensive analysis was made on the correlation of the grain filling rate with physiological indexes of the biotypes. We found that the grain filling rate of weedy rice was significantly higher than that of cultivated rice. In the early and middle stages of grain filling, the ethylene evolution rate, ABA content, the activities of key enzymes and expressions of genes involved in sucrose-to-starch conversion of weedy rice were significantly higher than those of cultivated rice, but in the late grain filling period, those indexes of weedy rice decreased more rapidly. There was no correlation between ethylene and grain filling rate, while ABA was significantly positively correlated with grain filling rate. Exogenous supply of ABA significantly increased grain filling rate of both weedy and cultivated rice, while exogenously supplied ethephon suppressed the activities of key enzymes and expressions of genes involved in sucrose-to-starch conversion. It is concluded that high concentrations of ABA at the early stage of grain filling in spikelets improved the grain filling rate of weedy rice, while higher ethylene evolution rate inhibited the weedy rice grain development and reduced starch accumulation. The interaction between ethylene and ABA promoted early maturity of weedy rice.

Foundation item: This research was financially supported by the China Transgenic Organism Research and Commercialization Project (2016ZX08011-001), the National Key Research and Development Program (2016YFD0200805), the Agrotechnical Innovation Projects of Jiangsu Province (SXGC(2016)S321600-17), the Specialized Research Fund for the Doctoral Program of Higher Education (20130097130006), the Recruitment Program of Foreign Experts of Jiangsu Province and the 111 project.

P-079

Unique effect of paraquat product on weedy rice seed by direct contact of the spray droplet

Shunji Wen, Yoshihiro Arisawa, Toshio Enoyoshi and Minoru Sugiyama

Syngenta Japan K.K., Office X21 Tower 1-8-10 Harumi, Chuo-ku, Tokyo 104-6021, Japan

Weedy rice problem is increasing in Japan, and exhausting hand weeding is essential in the area where weedy rice emerges. It was reported that direct application of paraquat to the seeds of volunteer rice or grass weed seeds significantly suppresses the initial growth and causes mortality (Koide 1988, Saitoh 2004, Uchino 2006, Arisawa 2015), and possibility of the products for suppression of weedy rice has been suggested.

When paraquat/diquat (5% /7% SL) solution at registered dilution for foliar spray (x100 dilution) was directly applied to mature weedy rice seed in a petri dish, most (95%) of the seeds stopped the growth immediately after the germination. In another germination test using rice seed as an index plant, the same effect was observed when the paraquat was applied to unhulled seed or hulled seed though the effect significantly reduced when hull was removed right after application onto unhulled seed. The results indicate developmental effects; 1) spray droplets of paraquat solution were trapped by the seed, 2) the active ingredient was retained on hull or grain surface until germination and 3) acted on shoots to suppress the growth. In the test using the entire weedy rice plant, while the foliar spray with the registered dosage (10 L/ha at the spray volume 1000 L/ha) applied at different seed maturing stages significantly reduced the viability of the seeds regardless of the application timing, the other non-selective herbicide tested did not show the same effect when they were applied at late ripening stage.

Suppression of weedy rice density before the paddy cultivation season is important to reduce the burden of the weeding in paddy fields, and it was suggested that the application of the paraquat product in combination with paddy herbicides would be one good measure to control weedy rice.

P-080

Title: Rice cultivars response to weed interference period in dry seeded rice system

Authors: Manpreet Singh[1] and Makhan Singh Bhullar[2]

Affiliation: *[1]Punjab Agricultural University, Abohar, India- 152 116, [2]Punjab Agricultural University, Ludhiana, India- 141 004*

Abstract: The dry-seeded rice (DSR) is more sensitive to weeds compared to puddle transplanted rice, and depending upon the weed species, duration of infestation and weed growth the grain yield losses in DSR may go upto 100 % . The information on the crop-weed interactions would provide an insight to the breeders for development and selection of weed-competitive rice cultivars for such systems. Two rice cultivars - PR114 (145d) and PR115 (125d) were subjected to the different weed interference periods (weedy and weed free for 0, 14, 28, 42, 56, and 70 days after sowing) in a two-year field experiment conducted at Punjab Agricultural University Ludhiana, India. Logistic and Gompertz models were observed to be the best fit for decreasing and increasing growth rate of the fitted curves, respectively. Our study during the two successive years indicated that weed interference periods explained 69-72% and 85-93% of variation in plant height, and 91-92% and 93-94% variation in tiller density. Tiller density was observed to be more sensitive to the increasing weed infestation period as compared to plant height. In most of the weed interference treatments, the plant height and tiller density of PR114 was found to be lesser than PR115, although the weed biomass didn't show any differences between the two cultivars. Moreover, the fitted models show that growth rate of plant height and tiller density with successive increase in weed-free period and reduction rate of these parameters with successive increase in weedy duration was more in PR115 as compared to PR114. Shorter crop duration of PR115 could be one of the reasons for such response curves. From the model, it is predicted that PR115 may be kept weedy for 10 days more than PR114, without reducing the tiller density by more than 10%; for the same permissible reduction in tiller density, PR115 required 32-46 days of initial weed-free period in contrast to 45-49 days required for PR114. This study suggests the weed tolerance ability of PR115 over PR114 and establishes the markers for adoption of rice cultivars in DSR system without losing out to weeds.

P-081

Weeds: Still the Fundamental Problem in Rice

KeeFui Kon[1] and Ben Wu[1]
[1]Syngenta Asia-Pacific Pte. Ltd., No. 1 HarbourFront Avenue, #03-03 Keppel Bay Tower, Singapore 098632

Small-holders are the predominant farmers in rice. With constrained cash flow, they tend to invest more in the early than later crop cycle. Such progressive investment on the crop may impact on the final yield. A DOE was initiated to compare crop protection inputs in seedling and vegetative only, in seedling, vegetative and reproductive only, in seedling, vegetative and ripening only, in reproductive and ripening only, and in full crop cycle. The control is a primitive check with only niclosamide which protected seedlings from golden apple snails. The standard is the local farmer practice. This protocol is repeated in four trials with two Indica varieties (TS10 and Ciherang in two locations) in transplanted and direct-seeded wet-sown rice production systems during the wet and warm season.

Both varieties and production systems produced similar results across all treatments. Modelling of all responses selected the below five variables that were statistically significant with $R^2 = 0.88$ on yield ($P<0.0001$):

Yield (kg/ha)
= 97 * plant height (cm)
- 15 * weed control (%)
- 88 * total insect damage (%)
+ 67 * grains (no/panicle)
+ 460 * thousand-grain weight (g)
+ 19,272 (intercept)

Treatments against weeds, yellow stem borer and leaf folder protected the crop from reduction of height growth and from loss of the number and weight of grains on panicles. All treatments with a pre-emergence herbicide reduced weed cover to 3-8% as compared to 71-100% without a pre-emergence herbicide. In the absence of an herbicide, both varieties competed to some extent with weeds but yield loss remained significant. The farmer practice indicated that early investment in an herbicide and insecticide was foundational for later yield.

P-082

Identification of Cassava Witches Broom Phytoplasma in Some Weed Species.

Yurawan Anantanamanee, Chanya Maneechote, Pruchaya Ekkatin, Theerawut Wongwarat,
Wanlee Amonpon, Supattra Choakongjak and Nimit Wongsuwan
Ministry of Agriculture and Co-operatives, Bangkok, Thailand

Abstract

Cassava (*Manihot esculenta Cruntz*) is an economic crop in Thailand being grown on 1.3 million ha. In 2015, Cassava witches' broom disease (CWBD) symptoms of leaf yellowing, chlorosis, shortening of internodes, and slight stunting caused by phytoplasma were observed in cassava fields in eastern part of Thailand. Likewise, similar symptoms were also appeared in some plants of nine weed species i.e. *Praxelis clematidea*, *Tridax procumbens* L., *Vernonia cinerea* (L.) Less. *Cleome viscosa* L., *Melochia corchorofolia* L., *Paederia foetida* L., *Scoparia dulcis* L., *Berreria latifolia* (Aubl.) K.Sch.), *Ageratum conyzoides* (L.) found in cassava fields. To identify whether those weeds may be host plants of Cassava witches' broom disease phytoplasma, 3-5 samples of leaves with symptoms were collected from each species and total DNA extracted and used as template in a nested PCR technic with universal 16SRII primers P1/P7A and M1/M2. The results confirmed that at least three types of phytoplasma (CWBD, Alfafa Witches' Broom and *Candidatus aurantifolia*) infected on three weed species *P. clematidea*, *T. procumbens* and *V. cinerea*. Hence, good control of those three weed species did not prevent only cassava yield loss but also prevent an outbreak of CWBD in cassava plantations.

Keywords: cassava witches broom disease, CWBD, phytoplasma, weed species.

P-083

Modelling rice and multiple weed competition under elevated temperatures

Yeon-Ho Park, Jong-Seok Song, Ji-Hoon Im, Do-Soon Kim

Department of Plant Science, College of Agriculture and Life Sciences, Seoul National University, Seoul 08826, Korea (E-mail: dosoonkim@snu.ac.kr)

Global warming is a challenge to future agriculture. Plants, including both crops and weeds, respond sensitively to temperature rise, so temperature rise may affect both crops and weeds, resulting in change in crop-weed interaction. In comparison to crops, weeds are more diverse ecologically and genetically, assuming that weeds may get advantage from temperature rise over corps. Therefore, it is expected that temperature rise may result in greater weed competition against crops and consequentially greater yield loss. However, few studies have been conducted to investigate the effects of temperature rise on crop-weed competition. Therefore, this study was conducted to investigate the effects of elevated temperature (ambient, +1.5℃, +3.0℃, +5.0℃) on rice-weed competition under multiple weed interferences conditions consisting of *Echinochloa oryzicola*, *Eleocharis kuroguwai*, *Scirpus juncoides* and *Scripus maritimus* and to model them. Rice was cultivated in competition with multiple weed species with various species and density combinations. Rice biomass and yield components were assessed at harvest. Rice yield decreased with elevated temperature, which was due to significant decrease in grain maturity under elevated temperature. Rice yield resulted from weed competition under elevated temperature was regressed to a combined rectangular hyperbolic model. The combined rectangular hyperbolic model well described rice yield due to rice-multiple weed competition under elevated temperatures. This work was carried out with the support of “Cooperative Research Program for Agriculture Science & Technology Development (Project No. PJ01052602)”, Rural Development Administration, Republic of Korea.

P-084

Weeds as Reservoirs of Some Important Pests in Cassava Fields

Supattra Choakongjak[1]

[1]Ministry of Agriculture, Thailand

Weeds provide shelter and food for insect and mite pests and act as a host for diseases. To date, some important pests i.e. mealy bugs, red spider mites and root knot nematode cause severe damage in some area of cassava plantations. The surveys were conducted during 2014-2015 in 668 cassava fields in 33 provinces of Thailand in order to identify weed species as reservoirs for those insect pests. The results revealed that four species of mealy bugs (*Ferrisia virgata*, *Paracoccus marginatus*, *Phenacoccus manihoti* and *Psedococcus jackbeardleyi*) were frequently observed on broadleaved weeds such as *Borreria laevis*, *Commelina benghalensis*, *Praxelis clematidea*, *Ricardia brasiliensis* and *Trianthema portulacastrum*. Red spider mite (*Tetranychus truncatus*) was prevalent on both broadleaved (*Alysicarpus vaginalis, B. laevis, C.benghalensis* and *P. clematidae*) and grass weeds (*Digitaria adcendens and Eleucine indica*). In addition, root knot nematode (*Meloidogyne incognita*) was mostly found in *P. clematidea*. The management of those weed species would be significant to prevent pest outbreaks in cassava production.

Keywords: host weeds, mealybugs, red spider mite, root knot nematode, cassava

P-085

Non chemical weed management in organically grown bhendi + leaf coriander - maize + cowpea cropping system

Murali Arthanari Palanisamy[1] Chinnusamy Chinnagounder[2] and Somasundaram Eagan[3]
[1,2,]AICRP-Weed Management, Department of Agronomy,
[3]Department of Sustainable Organic Agriculture,
Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India
e-mail: agronmurali@gmail.com and agronmurali@tnau.ac.in

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore, India during *Kharif* and *rabi* 2016 to study the weed population dynamics and crop productivity in organically grown bhendi + leaf coriander - maize + cowpea cropping system as influenced by non chemical weed management methods. The experiments were laid out in randomised block design with three replications. Treatments consisted of hand weeding, twin wheel hoe weeder weeding and crop residue application @5 tonne/ha. These were tested with individually and combinations. This was compared with chemical weed management with recommended herbicide viz., pendimethalin @ 1 kg/ha. Weed flora of the experimental field predominantly consisted of thirteen species of broad leaved weeds, eight species of grasses and a sedge weed. The predominant among broad leaved weeds were Trianthema portulacastrum, Digera muricata Amaranthus viridis, Amaranthus polygamus, Portulaca oleracea, Desmodium triflorum, Parthenium hysterophorus and Boerhaavia erecta. Among the grass weeds, Cynodon dactylon, Chloris barbata, Dactylactenium aegyptium, Echnicoloa colonum, Setaria verticilliata and Dinebra retroflexa were the dominant ones. Cyperus rotundus was the only sedge weed present in the experimental field of Bhendi. Among different non chemical methods in bhendi, significantly lower total weed density and dry weight (3.3/m^2 and 1.2 g/ m^2) higher weed control efficiency of 91.2% were recorded in crop residue mulching @ 5t/ha. Among different non chemical weed management methods in bhendi, crop residue mulching @ 5t/ha recorded significantly higher plant height (93.0 cm) and DMP (857 kg/ha) at 60 DAS and fruit yield of 298 q/ha and net return and B: C ratio of 5.8 was recorded in crop residue mulching @ 5t/ha. The soil physico – chemical and biological properties were changed significantly due to application of crop residues.

P-086

Organic weed management in rice

[1]Eagan Somasundaram, [2]P. Gnanasoundari and [1]D. Udhaya Nandhini

[1]Department of Sustainable Organic Agriculture, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India
[2]Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India

Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore, India during Rabi 2012-13 (October-February) to identify the suitable weed management technique in organic rice production in randomized block design with three replications. The weed management techniques evaluated are paired row planting of rice with daincha as intercrop and incorporation on 35 days after transplanting (DAT), Azolla as dual crop and rotary weeder incorporation on 20 and 40 DAT. Azolla as dual crop and cono weeder incorporation on 20 & 40 DAT. Rotary weeder four times on 10, 20, 30 and 40 DAT and cono weeder four time on 10, 20, 30 and 40 DAT, rice hill solution (50%) spray on 3 DAT + hand weeding (Hw) on 35 DAT, Rice hill solution (50%) spray on 15 DAT + Hw on 35 DAT. Sunflower dried stalk solution (1:10 w/v) spray on 3 DAT & 5 Hw on 35 DAT, sunflower dried stalk solution (1:10 W/v) spray on 15 DAT + Hw on 35 DAT, Rice straw @ 3t ha^{-1} on 3 DAT + Hw on 35 DAT; Rice bran @ 2 t ha^{-1} on 3 DAT & Hw on 35 DAT, Hw on 15 & 35 DAT and unweeded control. Medium duration (135 days) rice variety Co (R) 48 was used as test cultivar sown at 30 x 10 cm. Weed flora, density and dry was taken at 20, 30 and 50 DAT. Rice growth, yield parameters and yield of rice was calculated and statistically analyzed. Results revealed that application of rice bran @ 2 t ha^{-1} on 3 DAT followed by hand weeding on 35 DAT kept the weed density (15 no/m^2) and dry weight (3.38 g m^{-2}) below the economic threshold level which increased the grain yield of organic rice (4816 kg ha^{-1}) besides increased the nutrient reserve.

P-087

Development of flaming machine for land cleaning on leafy vegetable fields

Li Feng, Xing-shan Tian, Chun Zhang, Ye Cui, Mao-feng Yue

Institute of Plant Protection, Guangdong Academy of Agricultural Sciences, Guangdong Provincial Key Laboratory of High Technology for Plant Protection, Guangzhou 510640, China

In southern China, due to the hot and humid weather, leafy vegetable could be cultivated six to eight times a year. After vegetable harvested, farmers usually apply herbicides to kill stubble and weeds, followed by shallow plowing to prepare next cultivation in a short time. The insect and pathogen pests in field are not controlled and thus accumulate continuously. New techniques are urgently needed for land cleaning in leafy vegetable cultivation. Flaming represents a concrete alternation for contact controlling stubble and different kinds of pests instantaneously and synchronously. We designed and built the flame machines fed with liquefied petroleum gas (LPG). The working pressure of the burner is 0.25 Mpa in maximum, under which the flame temperature is up to 1040 °C. On June to November in 2014 and 2015, we conducted four times experiments in *Brassica parachinensis* fields infested by grasses, pests and stubble in Guangzhou, China. Two days after flaming treatment with a LPG dose of 101 kg hm^{-1} , the control efficiency on aboveground fresh weight of total weeds was 95.4%, higher than 90.8% treated with 900g hm^{-1} paraquat; 68.6% of *Phyllotreta striolata* and 87.5 % of *Plutella xylostella* larva that perching on plants' above ground parts were killed. While, 14 days after treatment, *Eleusine indica*, *Echinochloa colonum*, *Alternanthera philoxeroides* and *Eclipta prostrata* regrew quickly, and there was no significant difference in the effect of flaming and paraquat treatment. Conclusion: Flaming is able to kill weeds and insect pests instantaneously and synchronously, and thus could be used as a new technology for field cleaning on leafy vegetable fields.

Acknowledgement: This work was supported by the Agricultural Science Programs from Guangdong Province, China (2014A020208048).

P-088

The Effect of Essential Oil of *Rosmarinus officinalis* L. on Several Weed and Crop Species

İlhan Üremiş[1], Soner Soylu[1], Ahmet Uludağ[2,3], Mehmet Arslan[4]

[1]Faculty of Agriculture, Mustafa Kemal University, Turkey
[2]Faculty of Agriculture and Nature Sciences, Düzce University, Turkey
[3]Faculty of Agriculture, Çanakkale Onsekiz Mart University, Turkey
[34]Faculty of Agriculture, Erciyes University, Turkey

Alternative weed control techniques and systems are gaining importance due to problems created by current techniques such as chemical weed control, new system approaches such as integrated weed management, new demands such as organic products and new understandings such as sustainable agriculture. Natural plant based products are among the most promising once. Essential oils of different plant species have been studied so far. *Rosmarinus officinalis* L. is well known medicinal and aromatic plant. A laboratory study was conducted to see the effect of essential oil of *R. officinalis* (EORO) on weeds and crops which are both common in Turkey. The weed species were *Amaranthus retroflexus* L., *Amaranthus hybridus* L., *Echinochloa colonum* (L.) P. Beauv., *Hirchfeldia incana* (L.) Lag.Foss., *Physalis angulata* L., *Portulaca oleracea* L., *Sinapis arvensis* L., *Solanum nigrum* L., and *Urtica urens* L.. The crops were wheat (*Triticum aestivum* L. and *Triticum durum* Dest.), pepper (*Capsicum annuum* L.), and tomatoes (*Lycopersicon esculentum* Mill.). The essential oil was applied at rates 0, 2, 4, 8, 16 µl per plate. The estimated lethal concentrations (LD_{50}) values (µl/petri) of essential oil for each plant species were estimated by using Probit analysis. *S. arvensis*, *H. incana*, and *P. angulata* were the most effected species with a LD_{50} value less than 1, which were followed by *S. nigrum* and *U. urens* with a LD_{50} value less than 2. *P. oleracea* was the least affected weeds with LD_{50} 5.43. The other three weeds had LD_{50} about 4. LD_{50} for crops were 7.35 *T. aestivum*, 7.20 tomates, 5.23 *T. durum*, and 1.71 pepper. These results suggest that except pepper the EORO can be used in the other three crops. Most of the weeds were susceptible to the EORO; especialy *P. oleracea* was tolerant. EORO has a potential to use weed control in some winter and summer crops against some common weeds, but there are need further experiments.

P-089

Allelopathic effect of *Piper betle* Linn on the germination and seedling growth of barnyard grass and slender amaranth

Thanatchasanha Poonpaiboonpipattana[1]

[1]Department of Agricultural Science, Faculty of Agriculture, Natural Resources and Environment, Naresuan University, Phitsanulok, Thailand, 65000

The allelopathic potential of extracts of *Piper betle* L., which is a medicinal plant in Thailand, was investigated under laboratory condition. The aqueous extract of leaves at different concentrations was evaluated by petri-dish test on germination and seedling growth of barnyard grass (*Echinochloa crus-galli* (L.) Beauv) and slender amaranth (*Amaranthus viridis* L.). The result showed that germination, root growth and hypocotyl growth of *E. crus-galli* and *A. viridis* decreased with increasing concentrations of *P. betle* leaf aqueous extract. The extract exhibited a completely inhibiting germination of both species at the concentration of 50 g/L and 100 g/L. Another pot experiment was conducted to effect of soil mulching with *P. betle* dried powder. The phytotoxic effects were tested on the germination, establishment and growth of rice and some representative accompanying paddy weeds. Dried powder soil mulching at 0.5 and 1 and 2 ton/ha reduced the emergence of total weed by 37.54, 65.47 and 83.48%, respectively. Although the aerial biomass of rice was reduced by 24.58, 35.91 and 34.25%, respectively. Our results constitute evidence that *P. betle* residues to soil could be a feasible practice to reduce the reliance on synthetic herbicides in paddy rice-based cropping systems.

P-090

Isolation and characterization of *Streptomyces* sp. KRA16-334 producing herbicidal metabolite from soil

Ko Young Kwan[1], Jung Sub Choi[1], Young Sook Kim[1], Jae Deok Kim[1], and Surk Sik Moon[2]

[1]Eco-friendly and New Materials Research Center, Korea Research Institute of Chemical Technology, 141, Gajeong-ro, Yuseong-gu, Daejeon 34114, Republic of Korea

[2]Department of Chemistry, Kongju National University, 182 Shinkwangdong, Kongju 32588, Republic of Korea

Approaches to the biological weed control in arable crops and integration of biological weed control with other weed management methods have been broadly made. Metabolites produced by *Streptomyces* sp. are being studied as possible herbicides or herbicidal adjuvants to develop biological agents that are easily degradable and environment friendly. Therefore, many isolations and screening attempts have been done on *Streptomyces* to find microbial metabolites with bioherbicidal potentials. In the course of our screening of bioherbicidal agent, the isolate KRA16-334 showed significant herbicidal activity against a grass weed, *Digitaria sanguinalis*. According to the result from 16S rDNA sequence comparison with the close strains, the isolate was identified as *Streptomyces* sp. KRA16-334. The foliar application of the culture broth of KRA16-334 showed strong herbicidal activity for grass species, *D. sanguiinalis*, *Panicum dichotomiflorum*, *Sorghum bicolor*, *Echinochlia crus-galli*, *Agropyron smithii* and broad leaf species such as *Solanum nigrum*, *Aeschynomene indica*, *Xanthium strumarium*, *Calystegia japonica*. The culture broth of KRA16-334 by foliar application showed phytotoxic symptoms of wilting or burn-down of leaves and stunting and finally plant death. Herbicidal metabolites extracted from the culture filtrate of the isolate were purified by HP20, C_{18}, Sephadex LH20 column chromatography and high performance liquid chromatography (HPLC). The structure of active metabolites, HP100-M and HP50-W4, were identified by electrospray ionization mass spectra (ESI-MS) and ^{1}H-, ^{13}C- NMR and 2D- NMR spectral data analyses. Herbicidal activities of each individual metabolite will be investigated for the potential as a biocontrol agent and their structures may be used as a lead compound for development of a natural herbicide.

P-091

Microwave: A Novel Non-Chemical Weed Management Approach in Different Cropping Systems

Muhammad Jamal Khan, Graham Brodie, Dorin Gupta, Jim He

Faculty of Veterinary and Agriculture Sciences, The University of Melbourne, Australia

Herbicides resistance has prompted the development of a chemical-free weed management technique in sustainable crop production systems. In this study, we examined the effect of pre-sowing microwave soil treatment for weed management in temperate rice (*Oryza Sativa* L) and no-till wheat (*Triticum aestivaum* L) production systems of Australia, under field conditions. Once-off microwave soil treatment (2.45 GHz, 600 W, 120 s,) was applied to corresponding plots, which were arranged in a randomized complete block design with five replicates. The applied microwave energy density in the treated plot, which was calculated by Simpson's numerical surface integral approximation, was approximately 560 J cm^{-2}. Therefore, the projection of 560 J cm^{-2} of microwave energy through a horn antenna (5.5 × 110 cm) into the top soil (0 to 6 cm) horizon gave a concurrent increase in the soil temperature of about 75^{o}C to 80^{o}C for both crops. This temperature induced a 65% to 80% reduction in weed establishment through thermal devitalisation of the seedbanks, compared to the untreated control soil. However, a substantial increase of 34% in rice grain yield and 39.2% in wheat grain yield was achieved through microwave energy application compared to non-microwave treated conditions. Therefore, this broad spectrum weed management strategy can be implemented in different cropping regimes. In summary, investment in this non-chemical weed management strategy promises to effectively control herbicide-resistant weeds and sustain crop yield.

P-092

Administration effect of rutin on canine alopecia

Taiki Iida[1], Hiromi Shimasaki[1], Yoshiharu Fuji[1]

[1] International Environmental and Agricultural Sciences, Tokyo University of Agriculture and Technology, 3-5-8, Saiwai-cho, Fuchu-shi, Tokyo, 183-0057, Japan

Rutin has been found to be a causative agent of allelopathic activity which strongly inhibits the growth of surrounding weeds. Buckwheat have a high rutin content. This time, we administered Tartary Buckwheat (*Fagopyrum tataricum*) to dogs for unknown reasons (That were not a bacterial, infections property, hormonal imbalance, allergy) and intractable alopecia. Because that are rich in rutin 100 times than ordinary one. Having good results, I will now report. On veterinary treatment about dogs and cats, rutin has been administered for management of chylothorax. There has been no study that tried to administered rutin for canine alopecia. Four of cases, they came to animal hospital, are not experiment dogs.

Case A, mix-breed, B.W. 13.7 kg. In addition to alopecia, hyperemia in eyes was seen. The administration started at 10 mg/kg/day, and the hair loss site disappeared on the 71th day. Improvement in redness of eyes has also been observed.

Case B, Golden retriever, B.W. 37 kg. In addition to alopecia, constipation and skin redness was seen. The administration started at 2 mg/kg/day, and shrinking of hair loss sites were observed on day 64, loss of hair loss sites and improvement in roughness of coat were observed on day 155. (Pigmentation of the skin also disappeared)

Case C, Labrador retriever, B.W. 25 kg. alopecia and itching was seen . The administration started at 6 mg/kg/day, and the depilation range was reduced on the 22th day.

Case D, shih tzu, B.W. 6.6 kg. Besides hair loss, itching, dandruff was seen. Administration started at 15 mg/kg/day, and hair regrowth was observed on day 49.

[result]

Although there were differences in susceptibility, improvement of hair growth and hair gloss was observed in all four heads.

P-093

Assessment of inhibitory effects, LC50 values and herbicidal activity of Eucalyptus leaf oil on wheat and associated weeds

Sumit Chaturvedi[1], Ankita Arya[1], Vipin C Dhyani[1]

[1]Department of Agronomy, GBPUAT, Pantnagar

Eucalyptus has succeeded as a preferred species for agroforestry and farm forestry interventions throughout India (Sachan, 2006). *Eucalyptus* species released volatile compounds which inhibited growth of crops and weeds growing near it (Sasikumar *et al*., 2001). Seed germination, seedling growth, chlorophyll content and respiratory ability of some weed plants was drastically affected by allelochemical extracted from *Eucalyptus citriodora* (Chaturvedi *et al.,* 2012). However effect on wheat and associated weed species and their LC_{25} values are unknown. Elucidating underlying physiological and biochemical processes will broaden our understanding of mechanism of action of *E. citriodora* leaf oil. Laboratory experiment was laid out in completely randomized design with eight concentrations (0, 0.05, 0.1, 0.2, 0.4, 0.8, 1.6 and 3.2 ppm volatile oil of *Eucalyptus citriodora*) and three replications to assess the inhibitory effect against some plant species *viz.*, *Triticum aestivum*, *Parthenium hysterophorus*, *Melilotus indica*, *Phalaris minor* and *Avena leudoviciana.* Another green house experiment was conducted in randomized block design with six treatments (0, 0.05, 1.0, 2.5, 5.0, and 7.5 % spray of *E. citriodora*) and three replications to establish the herbicidal activity of *E.citriodora* against 4 week old wheat crop and above weed species and to explore their possible mechanism of action. Increase in concentration of leaf oil from 0.05 to 3.2 ppm concentration resulted in successive decrease in germination per cent. Complete inhibition of *M. indica* was observed beyond 0.8 per cent oil. At highest concentration (3.2 ppm) there was 100, 64, 60, 56 and 7 per cent reduction in germination per cent as compared to control in *M. indica*, *P minor*, *P*. *hysterophorous*, *A. ludoviciana* and wheat respectively. LC_{25} and LC_{50} values were found to be highest for *Parthenium* and lowest for *Melilotus*. However, none of the concentrations inhibited wheat germination by 25 per cent. Spray treatment of volatile oil on the 4 week old mature plants of weed species adversely affected the growth in term of plant height, chlorophyll content and fluorescence, thereby indicating the adverse effect of Eucalyptus oil on photosynthetic machinery. The increased H_2O_2 content in oil treated plants was indicative of oxidative stress causing cellular damage and electrolytic leakage.

P-094

Evaluation of allelopathic potentials in plant species in Mekong Delta Vietnam by sandwich method and dish pack method

Nguyen Thi Hanh Hien[1], Nguyen Thi Hong Nhan[2], Yoshiharu Fujii[3]

[1] United Graduate School of Agricultural Science, Tokyo University of Agriculture and Technology, Tokyo 183-8509, Japan
[2] College of Agriculture and Applied Biology, Can Tho University, Vietnam
[3] Department of International Environmental and Agricultural Science, Tokyo University of Agriculture and Technology, Tokyo 183-8509, Japan

Mekong Delta is the southernmost region of Vietnam where the economy is mainly based on agriculture. The main agricultural products of Mekong Delta are rice, fruits and other annual crops, however paddy rice is still the major crop. In recent years, development of agricultural technologies has significantly increased the amount of crop products; yet agrochemicals, including herbicides, have been overused to maintain high levels of crop yields despite of environmental hazards, unsafe agricultural products, and human health problems. Biological management by utilization of plant allelopathy might help to reduce this dependence on synthetic herbicides. With the high floristic diversity in Mekong Delta, many plants with strong allelopathic potential can be a source for biological weed suppression and soil fertility improvement. Therefore, the main objective of this paper was to screen for the allelopathic activity of Mekong Delta plant species in order to select the strongest allelopathic species for future studies. Sandwich method and dish pack method were respectively used to screen plant leaf leachates and volatile materials with lettuce as receptor plant. Among the species that showed inhibitory effect on lettuce radicle elongation, *Camellia sinensis* (L.) Kuntze, *Paramignya trimera* (Oliv.) Guillaum, *Rhinacanthus nasutus* (L.) Kurz, *Vernonia amygdalina* Delile were presented as allelopathic candidate species.

Keywords: allelopathy, Mekong Delta, crop production, biological management

P-095

Ethnobotanical survey as a benchmark for screening for allelopathic species among medicinal plants in Ghana

Kwame Sarpong Appiah[1], Hossein Mardani[1], Sylvia Kpabitey[2], Christiana Adukwei Amoatey[3], Yosei Oikawa[1] and Yoshiharu Fujii[1]

[1]Tokyo University of Agriculture and Technology, 3-5-8, Saiwai-cho, Fuchu, Tokyo 183-8509 Japan.

[2]University of Ghana, Department of Agricultural Economics & Agribusiness, P. O. Box LG 64. Legon.

[3]University of Ghana, Department of Crop Science, P. O. Box LG 44. Legon-Accra.

Recently, medicinal plants have been targeted for isolation and identification of allelochemicals for sustainable weed control. While ethnobotanical surveys could increase the likelihood of finding bioactive substances of pharmacological and allelopathic leads, there is no clear relationship between medicinal plants and their corresponding potential allelopathy. The aims of this study were to document medicinal plants uses in Ghana and evaluate their allelopathic potentials to establish any possible relationship between medicinal plants and their allelopathic potential.

Ethnobotanical data was collected in 2016 by using semi-structured questionnaire, field tour, and personal interviews with 140 local informants in 20 communities in the Ejisu-Juaben Municipality, Ghana. Statistical tool and ethnobotanical indices; fidelity levels (FL), relative frequency of citation (RFC), and use value (UV) were used to analyse the relevance of the ethnobotanical data. The sandwich (bioassay for leaf leachate allelopathy) and dish-pack methods (bioassay for volatile allelopathy) were used to screen allelopathic potential of the species mentioned.

A total of 95 species with *Cleistopholis patens* (UV=0.54; FL=90.7%; RFC=0.37), followed by *Ocimum gratissimum* (UV=0.37; FL=38.4%; RFC=0.35), and *Alstonia boonei* (UV=0.36; FL=70%; RFC=0.22) being rated as highly used medicinal species. Also, *Alstonia boonei*, *Cleistopholis patens*, and *Ocimum gratissimum* were among the top inhibiting species in the sandwich bioassay (71.5, 67.6, and 62.3% respectively). The reported species in this study showed inhibition on lettuce radicle in both sandwich (3.6-86.2%) and dish-pack methods (-6–84%). There was a significant positive correlation (Pearson) between the UV and RFC of medicinal plants and their corresponding allelopathic activity based on sandwich bioassay for leaf leachates (r=0.639; p=0.01 and r=0.653; p=0.01 respectively). It is evident from our report that highly rated medicinal species (based on UV and RFC) could have potential allelopathic properties. Thus, ethnobotanical survey can form the basis for screening medicinal plants to increase the odd of finding bioactive compounds.

P-096

Determination of allelopathic potentiality of *Rosmarinus officinalis*

Kwame Sarpong Appiah[1], Christiana Adukwei Amoatey[2], Yosei Oikawa[1], Yoshiharu Fujii[1]

[1]Tokyo University of Agriculture and Technology, 3-5-8, Saiwai-cho, Fuchu, Tokyo 183-8509 Japan.
[2]University of Ghana, Department of Crop Science, P. O. Box LG 44. Legon-Accra.

Management of weeds is important since weeds can cause significant crop loss. However, the excessive use of synthetic herbicides has led to the rise in herbicide-resistant/tolerant weeds (Heap, 2016) and this can be reduced by exploiting allelochemicals from plants. In this study, the contribution of some phenolic acids to rosemary allelopathic activity was evaluated.

Leaves and stems of rosemary (30 g dry weight) were separately extracted twice with methanol (80% and cold methanol successively). The two filtrates were combined and the biological activity was determined on test-plants. Soils incorporated with rosemary dried leaves were also tested on test plants in the greenhouse. The leaves of rosemary were evaluated for their phenolic acid content (caffeic, ferulic, gallic, rosmarinic, and chlorogenic acids) to test their contribution to rosemary allelopathic activity. The specific activity and total activity of crude extract and individual phenolic acids were tested using Lactuca sativa as test plant.

Seed emergence and dried matter of lettuce were inhibited by rosemary leaf debris incorporated into the soil at 1%. The growth inhibitory effects of the aqueous methanol extracts of the rosemary leaves were higher than that of the stems on all test plants. The inhibitory activity increased in a concentration-dose dependent manner and the roots were inhibited more than the shoot growth. At concentration 30 mg D.W. equivalent extract mL-1, root and shoot growth of lettuce were completely inhibited. Ferulic acid had the highest specific activity and chlorogenic acid had the lowest. The specific activity of rosmarinic acid was medium level compared to other compounds but the total activity was high due to its high concentration in rosemary. Based on specific and total activity, as calculated by concentration and growth inhibitory effect, it could imply that rosmarinic acid, among other tested compounds, is the major allelochemicals in rosemary.

P-097

Isolation of the growth inhibitory substance from *Heliotropium indicum* (L.) aqueous methanol extracts

Sirinapa Chaipon[1], Arihiro Iwasaki[2], Kiyotake Suenaga[2] and Hisashi Kato-Noguchi[1]

[1]Kagawa University, 2393 Ikenobe, Miki 761-0795, Japan
[2]Keio University, 3-14-1 Hiyoshi, Yokohama 223-8522, Japan

Heliotropium indicum (L.) belongs to the family Boraginaceae. This is a common weed distributed widely in crop fields, roadsides and wastelands in tropical and subtropical areas in the world. It has also been used as a folk medicine in some countries for wound healing, insect bite-, fever- and malaria-treatments since it possesses anti-inflammatory, antimicrobial and antitumor activities. Some plants contain a large variety of secondary compounds, and some of those compounds were reported to possess allelopathic property. Therefore, this study was conducted with the purpose to evaluate the allelopathic activity and to isolate the growth inhibitory substances in *H. indicum.* An aqueous methanol extract of whole plants of *H. indicum* inhibited shoot and root growth of barnyard grass (*Echinochloa crus-galli* P. Beauv.), foxtail fescue (*Vulpia myuros* (L.) C.C.Gmel.), cress (*Lepidium sativum* L.) and lettuce (*Lactuca sativa* L.) at concentrations greater than 10 mg dry weight equivalent extract/mL. The inhibitory effects on seedling growth depended on the extract concentration. The concentrations required for 50% inhibition (I_{50}) of shoot and root of test plants ranged from 5.1-280 mg dry weight equivalent extract/mL. The results suggest that the extract of *H. indicum* may contain growth inhibitory substances. The extract was partitioned with an equal volume of ethyl acetate. After the separation of the ethyl acetate fraction by chromatographic fractionations, a growth inhibitory substance was isolated and characterized by spectral analysis as methyl caffeate. Methyl caffeate inhibited lettuce shoots and roots at concentrations greater than 1 mM. I_{50} values were 0.7 and 1.0 mM on shoot and root growth of lettuce, respectively. The results suggest that methyl caffeate may be a contributor to the growth inhibitory effect of *H. indicum*.

P-098

Allelopathic Volatile Compounds from *Callistemon viminalis*: Role in weed management

Daizy Rani Batish[1] and Aditi Shreeya Bali[1]

[1]Department of Botany, Panjab University, Chandigarh 160014, India

Callistemon viminalis, commonly known as bottlebrush, is an aromatic tree of family Myrtaceae and is widely grown in the gardens, parks and along roadsides for its aesthetic value. However, the tree harbours sparse vegetation under and around its canopy. We explored the possible role of volatile monoterpenes released from the trees in exhibiting such a pattern of vegetation under the tree. The volatile monoterpenes from the foliage of the tree were analyzed through headspace-gas chromatography. These monoterpenes (prominently, 1, 8-cineole and α-pinene) were found to have profound inhibitory effects on the associated vegetation. Further, the essential oil extracted from the foliage was found to contain these two monoterpenes as the major constituents. The oil exhibited considerable toxicity towards the test weed species – *Bidens pilosa, Phalaris minor*, *Avena fatua* and *Cassia occidentalis* under laboratory as well as pot conditions. The emergence and growth (root length and shoot length) of the weed was significantly reduced in a dose dependent manner in a laboratory bioassay. Pre-emergent application of the essential oil severely affected the emergence of test weeds and the emerged seedlings were weaker and exhibited poor growth. Post-emergent application of the oil to one-month old weed plants reduced the chlorophyll content, cellular respiration and photosynthetic activity. The oil induced severe visible injuries in the form of necrosis and chlorosis, and wilting of the plants particularly at higher doses of application. The study indicates the volatile compounds and essential oils of *C. viminalis* possess phytotoxicity towards the weeds, and thus can be exploited as an eco-friendly option for the weed management under organic farming.

P-099

The effect of soil types on allelopathic activity of caffeine from Vietnamese tea (*Camellia sinensis*)

°Van Thi Thanh PHAM, Maryia MISHYNA and Yoshiharu FUJII

Graduate School of Agriculture, Tokyo University of Agriculture and Technology (TUAT)

Caffeine (1,3,7-trimethylxanthine) has been known as a putative allelochemical in tea, that mainly contribute to inhibitory activity of crude tea extract under the laboratory conditions with total activity obtained at 500 ppm. However, caffeine in soil can be affected by soil physical and chemical property or decomposition of microorganism. Therefore, to utilize caffeine for producing bio-herbicide, the studies in soil conditions are required. In this study, we aimed to evaluate the caffeine content from tea screened in three different soil types (Fluvisol, Andosol, Sand), and its inhibitory effect on the growth of lettuce seedlings.

Four tea samples (green, oolong, fresh, black) were obtained from Vietnam, and the Andosol, Fluvisol, Sand soil was collected from the TUAT experimental farm, Field Museum Fuchu Honmachi, and Laboratory-available soil, respectively. Tea leaves (50 and 100 mg) and 1000 ppm of pure caffeine was mixed with 10g of each autoclaved soil sample. After 5 days of incubation (22ºC), 5g of each type of soil were analysis by high performance liquid chromatography (HPLC) and the same amount of soil was used to test the allelopathic activity. The recovery of pure caffeine at concentration of 663 ppm determined in Andosol soil was significantly higher than that of Fluvisol and Sand soils. Fluvisol soil contains a high amount of clay particles and the nature of colloidal particles of clay soils that are able to absorb most allelochemicals**.** By these characteristics, the lowest caffeine content was found in Fluvisol soil sample. Consequently, the effect of green tea caused 50% inhibition of radicle growth of lettuce seedlings was observed in Andosol at 10 mg tea/g soil. In our findings, caffeine concentrations in Andosol and Sand soils had a positive correlation with growth inhibition on lettuce seedlings.

P-100

Safranal, the volatile allelochemical of Saffron (*Crocus sativus*) and its effect on biological responses of lettuce (*lactuca sativa*) and some common weeds

Hossein Mardani Korrani[1], Asma Osivand[1], Yoshiharu Fujii[2]

1 Department of Biological Production Sciences, Tokyo University of Agriculture and Technology.

2 Department of International Environmental and Agricultural Sciences Tokyo University of Agriculture and Technology.

The allelopathy principles have always been applied as an alternative pest management strategy. In our recent screening attempt of natural organic chemicals in order to find alternatives to synthetic herbicides, stigma of saffron (*Crocus sativus*) showed strong plant inhibitory activity. In this study safranal bioactive compounds of saffron was identified as the main allelochemical and showed strange inhibitory activity against plant growth (EC_{50} value of 1.2 µg/cm^3). The effect of safranal on physiological and growth parameters of lettuce and some common weeds were investigated. Results showed foliar application safranal caused strong inhibitory activity on dicots and monocots (*Lotus scoparius, Trifolum pratense, Dactylis glomerata, Phleum pratense, Lolium multiflorum*). However, the effect of safranal was more significant on physiological parameters of dicots (*L. scoparius, T. pratense*) in compression to the monocots (*D. glomerata, Ph. pratense*, *L. multiflorum)*. Safranal significantly decreased the chlorophyll content and fresh weight of the test monocot species (*L. scoparius, T. pratense*). Moreover, safranal inhibited the activity of catalase enzyme (CAT) of lettuce while it did not inhibit the peroxidase (POX) activity indicating the possible suppressive effect of safranal on CAT enzyme. Dose-response of safranal on lettuce plant growth and CAT was obtained. Application of an aliquot of 2.41 ng/cm^3 of safranal resulted in approximately 50% decline in CAT and resulted in 50% weight loss. The result of this experiment specifies that the inhibition of CAT by might be the main mechanism of action for safranal.

Key words: Allelopathy, dose-response, catalase enzyme, saffron, safranal

P-101

Weed control using herbal medicine extraction residue as natural mulch

○Kouki Oyama[1], Masanori Morimoto[1], Sakae Horimoto[2], and Kazuhiko Matsuda[1]

1: Kindai University, School of Agriculture, 3327-204, Nakamachi, Nara, Nara city, 631-8505, Japan
2: Kyoto Institute of Technology, Saga Ippongichou, Ukyo-ku, Kyoto city, Kyoto, 616-8354, Japan.

Although herbal medicine extraction residues are waste, some are used to make compost for agricultural use. Here, we have evaluated the effects of waste from the cinnamon bark on weed growth in the field as well as identified components responsible for the weed control activity.

A field test on weed growth of the residue resulting from extraction of the cinnamon (*Cinnamomum cassia*) bark with 70% EtOH extract (RCB) was performed on June 8th, 2016 in Kyoto Institute of Technology, Kyoto, Japan. The material was provided by Nippon Funmatsu Yakuhin, Co., Ltd. Mulch was prepared with thicknesses of 0, 1, 2, and 3 cm on the soil surface. Weed species and their masses were measured 46 days after the treatment.

The volatiles from the residue were also measured using SPME-GCMS. The MeOH extract was also prepared from RCB by MeOH extraction. Phytotoxic compounds were isolated using bioassay-guided silica gel flash column chromatography and identified by spectroscopic data. Phytotoxicity tests were performed using lettuce (*Lactuca sativa* cv great lakes) and Italian ryegrass (*Lolium multiflorum* cv wasefudo) seedlings.

The RCB mulch completely controlled various annual weeds, *Digiraria cillaris*, *Setaria* spp., and *Amaranthus viridis*, while affecting the growth of some perennial weeds such as *Cayratia japonica* and *Cyperus rotundus*. The sesquiterpene hydrocarbons, cinnamaldehyde and coumarin were detected by GCMS as volatiles from RCB. Only *trans*-cinnamic acid was isolated and identified as a phytotoxic substance in the RCB MeOH extract. The results of the plant growth inhibitory test suggested that since the volatiles exerted only weak effects against the plant species tested, *trans*-cinnamic acid eluted from RCB by rainfall plays a centrol role for the weed control action.

P-102

Allelopathic potential of invasive *Acacia mangium* on the germination and radicle growth of selected crops

Nor Amal Nabilah Ismail, Rahayu Sukmaria Sukri, Faizah Metali*

Environmental and Life Sciences Programme, Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, BE1410, Brunei Darussalam

Acacia mangium, which is an invasive tree species in Brunei Darussalam, may release numerous chemical substances that negatively affect the germination and growth of native plants and crops. We investigated the allelopathic potential of aqueous extracts of *A. mangium* phyllodes and soils collected from *A. mangium* plantation on seed germination and radicle growth of selected crops (*Raphanus sativus* L. or radish and *Zea mays* L. or maize) using laboratory bioassays. The air-dried and powdered phyllodes of invasive *A. mangium* and fresh soils close to *A. mangium* trees in an *Acacia* plantation were soaked in distilled water in a ratio of 1:100 (w/v) for 24 h and 36 h in order to prepare a series of aqueous phyllode extract (0.5, 1, 2.5, 5, 7.5, 10 and 12%) and soil extract (1, 5, 10%) concentrations, respectively. Distilled water was used as the control. The seeds of the target crop species were germinated in petri dishes and final germination percentages and relative elongation rate were recorded at day 20 and day 14, respectively. The *A. mangium* phyllode and plantation soil extracts decreased seed germination and relative radicle elongation rates of *R. sativus* and *Z. mays*. The findings suggest that the inhibitory effects on seed germination and radicle growth might be due to the release of allelochemicals from the phyllodes of *A. mangium* into the surrounding soil.

P-103

Characterization of plant growth-promoting effect of γ-terpinene and β-caryophyllene in lettuce and maize

Shohei Ebina[1], Yukari Sunohara[1], Yuina Takeuchi[1], Satoshi Iwakami[2] and Hiroshi Matsumoto[1]

[1]University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8572, Japan
[2]Kyoto University, Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan

The growth-promoting effects of γ-terpinene and β-caryophyllene on root and shoot of lettuce and maize seedlings were investigated. Root fresh weight increased up to 130% of control at 138 µmol/L and 150% at 518 µmol/L in maize seedlings 3 days after treatment with γ-terpinene and β-caryophyllene, respectively. On the other hand, β-caryophyllene reduced the fresh weight of maize hypocotyl by 70% of control 3 days after treatment, whereas γ-terpinene had no effect on the hypocotyl fresh weight. In lettuce seedlings, 357 µmol/L of γ-terpinene stimulated root length and third leaf area up to 120% and 140% of control 14 days after treatment, respectively. γ-Terpinene (0–357 µmol/L) also increased the number of lateral root in a concentration-dependent manner in lettuce. Similarly, β-caryophyllene stimulated root length of lettuce up to 150% of control 14 days after treatment, but inhibited the third leaf area by 50% of control at 50 µmol/L. Overall, the growth-promoting effects of β-caryophyllene were more significant than that of γ-terpinene. One micromolar of 1-naphthylphthalamic acid (NPA), an auxin polar transport inhibitor, suppressed γ-terpinene-enhanced lateral root growth in lettuce seedlings 14 days after treatment, but had no effect on γ-terpinene-induced growth-promoting effects in both root length and leaf area in lettuce. These results suggest that auxin polar transport might be involved in γ-terpinene-enhanced lateral root growth of lettuce. However, additional studies are required to elucidate the roles of auxin polar transport in γ-terpinene-induced plant growth-promotion.

P-104

Allelopathic potential of mango leaves and an allelopathic substance

Masahiko Suzuki[1,2], Md Sirajul Islam Khan[1,2], Arihiro Iwasaki[3], Kiyotake Suenaga[3], Hisashi Kato-Noguchi[1,2]

[1]Graduate School of Agriculture, Kagawa University, 2393 Ikenobe, Miki, 761-0701, Japan
[2]The United Graduate School of Agricultural Sciences, Ehime University, 3-5-7 Tarumi, Matsuyama, 790-8566, Japan
[3]Faculty of Science and Technology, Keio University, 3-14-1 Hiyoshi, Yokohama, 223-8522, Japan

Mango (*Mangifera indica* L.) is a fruit plant belonging to the Anacardiaceae family, and is widely cultivated in tropical and subtropical regions. Mango leaves have been reported to have growth inhibitory activity against several plants, suggesting that mango leaves may contain allelopathic substances. However, there was limited information on the substances in mango leaves. Therefore, we investigated allelopathic potential and substances of mango leaves. Mango leaves were extracted with aqueous methanol and the extracts were subjected to bioassay. The extracts inhibited the root and shoot growth of cress, lettuce, rapeseed, foxtail fescue, and crabgrass, where the inhibition levels increased with increasing concentrations of the extracts. I_{50} values (concentrations required for 50% growth inhibition) of the extracts on the test plants were 0.80–8.0 mg dry weight equivalent extract mL^{-1}. Based on the I_{50} values, inhibition was the highest on rapeseed of the five test plants, whereas inhibition was the lowest on radish. The extracts inhibited the root growth of all test plants more than their shoot growth. The extract was then purified by several chromatographic runs while the inhibitory activities of all fractions were tested to find out growth inhibitory substances. A growth inhibitory substance was finally isolated and identified as methyl gallate. Methyl gallate significantly inhibited the root and shoot growth of cress and foxtail fescue at concentrations ≥ 1–3 mM. I_{50} values of methyl gallate on cress roots and shoots were 3.9 and 3.3 mM, respectively, and those on foxtail fescue were 1.5 and 9.5 mM, respectively. The present results suggest that mango leaves may have allelopathic potential and methyl gallate may contribute to the allelopathic potential of this plant.

P-105

Allelopathic Potential of a Mushroom, *Cantharellus cinnabarinus*

Asma Osivand[1], Hiroshi Araya[2], Hossein Mardani[1], Yoshiharu Fujii[1]

[1] Tokyo University of Agriculture and Technology, 3-5-8 Saiwaicho, Fuchu, Tokyo, 183-8509, Japan
[2] Meiji University, 1-1-1 Higashi-Mita, Tama-ku, Kawasaki, Kanagawa 214-8571, Japan

To date, not much research on mushroom has been done in allelopathy study area, despite the fact that mushrooms are sources for unique bioactive compounds. For filling a part of this scientific gap, we selected a wild edible mushroom, *Cantharellus cinnabarinus*, and started the study to clarify their allelochemicals by using bioassay-guided fractionation. The fruiting body of the mushroom (500 g, F.W.) was extracted with solvents by using a common procedure. The summation of resulting hexane (5.44 g), ethyl acetate (5.39 g), butanol (3.66 g) and water extracts (45.13 g) were considered as the total dry weight. Aliquots of 500, 100, 50, 10, 5 and 1 mg equivalent of dried weight of original sample material were used for lettuce (*Lactuca sativa* var. Great Lake 366) inhibitory bioassay and the result was defined based on percentage of plant growth inhibition. Effective concentrations of half maximal inhibition (EC_{50}) of all water, butanol, ethyl acetate and hexane extracts on lettuce radicle were 7.48, 46.76, 243.17 and 292.66 g respectively. At first, the ethyl acetate extract was fractionated by silica gel column chromatograph due to easy handling in purification stages. As a result, nine fractions were obtained. Fraction F5, F6 and F7 showed considerable inhibition effect on lettuce hypocotyl at the ten times concentrations of EC_{50} by 100%, 96.5% and 98.8% respectively; and for radicle all three fractions showed 91.6% inhibition, in spite of their different chromatographic patterns. In summary, the results revealed that there might be at least one bioactive compound in obtained extracts of the *C. cinnabarinus*.

P-106

Screening of allelopathic ground cover plants for weed control and analysis of allelochemicals

Hiroko Maeda, Kou Okumura, Riri Nakamura, Takashi Nomura, Yoshiharu Fujii

Graduate School of Agriculture, Tokyo University of Agriculture and Technology (TUAT)

One of functions of ground cover plants is weed control. Major factors of suppression of weed by ground cover plants are competition for light, nutrients and water, but allelopathy play important role in combination with them. For the selection of effective weed control, seven ground cover plants, Creeping thyme (*Thymus serphyllum*), Moss phlox (*Phlox subulata*), Carpetweed (*Phyla canescens*), Trailing ice plant (*Mesembryanthemum spectabile*), Mondo grass (*Ophiopogon japonicus*), Pennyroyal (*Mentha pulegium*), Big blue lilyturf (*Liriope platyphylla*) were compared by field experiment for three years, and allelopathic activity of each plant was examined.

In field experiment, dry weight of weed, cover degree, MDR, weed inhibitory rate and species of weeds were examined. Dry weights of weed at Creeping thyme, Carpetweed, Mondo grass and Big blue lilyturf were lower. Weed inhibitory rate and cover degree of Carpetweed, Creeping thyme, Mondo grass, Big blue lilyturf were more than 90 %. MDR of Big blue lilyturf was highest. Number of species of weed of Big blue lilyturf was minimum.

Allelopathic activity through leaching by rain from leaves was evaluated by sandwich method, and exudation from roots was evaluated by plant box method. Mondo grass and Big blue lilyturf inhibited the growth of lettuce more than 90 % by sandwich method and plant box method. Trailing ice plant inhibited growth of lettuce about 90 % by sandwich method.

Big blue lilyturf is Japanese traditional perennial ground cover plants, and showed best results both in field experiment and allelopathic activity examined. Them the allelochemicals of Big blue lilyturf was investigated by high performance liquid chromatography and evaluation of allelochemical based on total activity. It was found that azetidine 2-carboxylic acid (AZC) is considered to be a main allelochemical of Big blue lilyturf.

P-107

Allelopathic activity of *Coccinia grandis*

Krishna Rany Das[1] and Hisashi Kato-Noguchi[1]

[1] Kagawa University, 2393 Ikenobe, Miki 761-0795, Japan

Coccinia grandis is a tropical vine belonging to the family Cucurbitaceae grown in dense vegetation, deprives neighboring plants from sunlight and nutrients, and ultimately suppresses its beneath vegetation. The leaves of the plants are used as fresh vegetable and its fruits have been used as traditional medicine for a long time. The pharmacological property of *C. grandis* is notable but as far we know there is no report on its allelopathic activity. Medicinal plants have drawn attention of the researcher to explore allelopathy to control weeds, as weeds are the detrimental factor for successful crop production. Considering allelopathy as ecologically sound weed management approach, the aqueous methanol extracts of *C. grandis* were examined on the seedling growth of cress, alfalfa, lettuce, rapeseed, barnyard grass, timothy and foxtail fescue at six concentrations. The inhibitory activity of the extracts was concentration dependent. The root growth of all test plants was more sensitive than the shoot growth. The concentration required for 50% growth inhibition of the test plants were ranged from 4.8–220 mg dry weight equivalent extract/mL. The lettuce seedling was most sensitive to the extracts, whereas barnyard grass seedling was least sensitive. The extracts were then adjusted to pH 7, partitioned three times against an equal volume of ethyl acetate. The ethyl acetate fraction was separated by columns of silica gel, Sephadex LH-20 and C_{18} cartridges. Finally, two active fractions were identified by reverse-phase HPLC at the retention time of 81-85 and 90-102 min. These results suggest that *C. grandis* has allelopathic potential, might help to suppress weeds in an ecofriendly management system. Experiments are continuing for isolation and identification of allelochemicals in *C. grandis.*

P-108

Autotoxicity may play an important role in "asparagus decline"

Hisashi Kato-Noguchi[1], Keisuke Nakamura[1], Osamu Ohno[2], Kiyotake Suenaga[2] and Nobuyuki Okuda[1]

[1]Department of Applied Biological Science, Faculty of Agriculture, Kagawa University, Miki, Kagawa 761-0795, Japan
[2]Department of Chemistry, Faculty of Science and Technology, Keio University, 3-14-1 Hiyoshi, Kohoku, Yokohama 223-8522, Japan

Asparagus (*Asparagus officinalis* L.) is a perennial vegetable that is harvested over several years. One major problem of the asparagus cultivation is the "asparagus decline". Crop production and quality of asparagus decrease gradually year by year. One of the possible reasons for "asparagus decline" is thought to be the infection by soil-borne pathogenic fungi, mainly *Fusarium* spp. When asparagus residues are incorporated into the soils of asparagus cultivations, the growth of asparagus seedlings is retarded, which indicates that some compounds were released into the soils during their decomposition processes and then caused the autotoxic effects on asparagus. This finding suggests that asparagus may contain some autotoxic compounds and the autotoxicity of asparagus can also be a reason for "asparagus decline". However, the autotoxic property of asparagus rhizomes remains unknown. The objective of this study was to determine the potential role of rhizomes in the autotoxicity of asparagus. An aqueous methanol extract of asparagus rhizomes inhibited the growth of asparagus seedlings. These results suggest that asparagus rhizomes contain autotoxic compounds. The extract was purified through several chromatographic steps with monitoring the autotoxic activity, and *p*-coumaric acid and iso-agatharesinol were isolated. These compounds inhibited the shoot and root growth of asparagus at concentrations higher than 0.1 mM. The inhibitory activity of the compounds increased with increasing concentrations of the compounds. The concentrations required for 50% inhibition of the root and shoot growth of asparagus ranged from 0.36 to 0.53 mM and 0.62 to 0.72 mM for *p*-coumaric acid and iso-agatharesinol, respectively. Plants secrete many kinds of compounds from their roots such as by proton-pumping and endoplasmic-derived exudation. *p*-Coumaric acid and iso-agatharesinol may also be released into asparagus soils by the secretion function via roots from the rhizomes and accumulate in the soils year by year. Those accumulated compounds may inhibit the growth of asparagus itself and reduce asparagus productivity year by year, which causes "asparagus decline".

P-109

Allelopathic weed suppression through the use of *Rottboellia cochinchinensis* (Lour.) W.D. Clayton

Apirat Bundit[1], Kosumi Yamada[2], Tosapon Pornprom[3]

[1] Department of Plant and Soil Sciences, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand
[2] Faculty of Life and Environmental Sciences, University of Tsukuba, Ibaraki 305-8572, Japan
[3] Department of Agronomy, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140, Thailand

Itchgrass (*Rottboellia cochinchinensis* (Lour.) W.D. Clayton) has a strong competitive ability and possible allelopathic activity on other plant species. Farmers in the Chaehom-Lampang (CH-LP) area, northern Thailand, have been cultivating itchgrass to use it as a mulching material for weed control in vegetable fields. The objectives of this study were conducted to explore the allelochemical and its phytotoxic effects. This study showed that the density of weed species in the itchgrass-infested soil was lower than that in the itchgrass-uninfested soils under natural field conditions. Allelopathic activity of itchgrass under field condition was observed from phytotoxic effects on test plants seedling growth in soil. Results showed that the itchgrass-infested soil of CH-LP soil and Kamphaeng Saen-Nakhon Pathom (KPS-NP) soil incorporated with itchgrass powder also highly inhibited the shoot and root lengths of *Bidens pilosa* L. and *Echinochloa crus-galli* (L.) Beauv., when compared to itchgrass-uninfested soil. In addition, the structure elucidation of allelochemical from itchgrass was investigated. In this study, *trans*-*p*-coumaric acid (*trans*-4-Hydroxycinnamic acid) was identified as an allelochemical from itchgrass powder, based on its electrospray mass spectrometric (ESI-MS) data and ^{1}H and ^{13}C nuclear magnetic resonance (NMR) spectra. Considering the endogenous level and the inhibitory effect, *trans*-*p*-coumaric acid may play an important role as allelochemical in itchgrass through the growth inhibition of weeds. These results suggested that itchgrass may have allelochemicals and possess allelopathic activity. Therefore, the utilization of itchgrass in practice as a mulching material might be useful for biological weed control and for the reduction of the amount of herbicides that are commonly used in vegetable fields.

P-110

Allelopathic activity and a growth inhibitory substance in shoots of *Echinochloa crus-galli* (L.) P. Beauv.

Kana Tanaka and Hisashi Kato-Noguchi

Kagawa University, 2393 Ikenobe, Miki, Kagawa, 761-0795, Japan

Barnyard grass (*Echinochloa crus-galli* (L.) P. Beauv.) is an annual weed belonging to the poaceae family. The weed is highly competitive to crops and one of the worst weeds. Allelopathy of barnyard grass has been suggested as a potential factor to cause the harmful effect to crop plants. Extracts of barnyard grass roots have been reported to have allelopathic activity and to contain some growth inhibitory substances. However, information on allelopathic activity and substances in barnyard grass shoots is limited. Therefore, this study aimed the evaluation of the allelopathic activity of extracts of barnyard grass shoots and the isolation of growth inhibitory substances from the extracts. The aqueous methanol extracts of barnyard grass shoots inhibited the shoot and root growth of dicotyledonous plants (cress, lettuce, and alfalfa) and monocotyledonous plants (barnyard grass, rice, and Italian ryegrass), where the inhibition was extract concentration dependent. I_{50} values (concentrations required for 50% growth inhibition) of the extracts were 0.575-34.3 and 34.3-134 mg dry weight equivalent extract mL^{-1} for dicotyledonous plants and monocotyledonous plants, respectively. On the basis of I_{50} values, lettuce was the most sensitive to the extract, while barnyard grass was less sensitive than most of other plants. The growth of dicotyledonous plants was inhibited more than that of monocotyledonous plants. The extract was then separated by several chromatographic runs. In those separation steps, growth inhibitory activities of all fractions were determined by bioassay and the active fractions were further purified. A growth inhibitory substance was finally isolated by HPLC. These results suggest that barnyard grass shoots may have allelopathic activity and the growth inhibitory substance may be involved in the allelopathic activity.

P-111

Study on competitive ability of hybrid and inbred rice varieties (*Oryza sativa* L.) against weeds

Thang Lam Lun[1], Mar Mar Kyu[1], Hisashi Kato-Noguchi[2]

[1]Department of Agronomy, Yezin Agricultural University, Nay Pyi Taw, Myanmar
[2]Department of Applied Biological Science, Faculty of Agriculture, Kagawa University, Miki, Kagawa 761-0795, Japan

The experiments were conducted at the Department of Agronomy, Yezin Agricultural University, Myanmar during wet and dry seasons in 2013. Factorial arrangement in Randomized Complete Block Design (RCBD) with three replications was used in both experiments. Three hybrid rice and three inbred rice varieties were tested to compare their competitive ability against weeds and to investigate the yield losses due to weeds. The tested varieties in both seasons were Palethwe 1 (hybrid), Palethwe 3 (hybrid), Palethwe Basmati (hybrid), Manaw Thu Kha (inbred), Shwe Thwe Yin (inbred) and Sin Thwe Latt (inbred). In both seasons, yield loss percent due to weeds was greater in inbred rice varieties than in hybrid rice varieties except the inbred Sin Thwe Latt. The highest yield loss percent was observed in Manaw Thu Kha (72.64%) in dry season and 47.95% in wet season respectively. It indicated that Manaw Thu Kha can be assumed as weak competitor against weeds than other tested varieties. The lowest yield loss per cent was found to be in Sin Thwe Latt (39.21%) in dry season and Palethwe Basmati (17.47%) in wet season. The results of dry season showed that the highest grain yields were obtained from Manaw Thu Kha in weeded plot and Sin Thwe Latt in unweeded plot. In wet season the highest grain yields were obtained from Palethwe 1 in weeded plot and Sin Thwe Latt in unweeded plot. The results of both seasons revealed that the inbred rice variety Sin Thwe Latt was found to be the strong competitor against weeds as shown by higher grain yield than other tested varieties when it was unweeded.

P-112

Effect of nitrogen fertilizer application method and dosage on weed and weed competition in rice

D.D. Witharana[1], A.S.K. Abeysekera[2], H.M.S.D. Kulatunga[2] and W.M.U.B. Wikrama[2]

[1]Postgraduate Institute of Agriculture, Peradeniya, Sri Lanka.

[2]Rice Research and Development Institute, Batalagoda, Sri Lanka.

The greatest competition among plants is usually for nitrogen and it is the major nutrient input that farmers utilized to increase crop yield. Prevailing farmer adaptation facilitate higher lose in fertilizer without utilize by the crop. Major portion of unutilized fertilizer were used by the opportunistic weeds due to their higher competition. The study was conducted to study the suitable fertilizer application method to minimize the weed competition. Field experiment was conducted at the Rice Research and Development Institute, Sri Lanka. The soil was red yellow podzolic soil, with a p^H 5.95, 115μS/cm of CEC. 90 days old rice variety Bg-300 was used in Randomized Complete Block Design with three replicates during 2012/13 major and minor seasons. The nitrogen fertilizer dosages, Department of agriculture (DOA) recommendation (225 Kg/ha), without nitrogen in basal application (225 Kg/ha- basal nitrogen splits in top-dressings), zero Nitrogen (0 Kg/ha), Leaf Colour Chart (LCC) application rates (Plant specific) were used with respective with weeded and un-weeded treatments. Result showed that all un-weeded treatments had significantly higher weed dry weight over weeded treatment for grasses, sedges and broad leaves. Un-weeded LCC treatment had the significantly lowest grass weed dry weight over un-weeded DOA treatment in both seasons. Result reveals that all the other treatments had no significant effect on grass weed dry weight. Nitrogen fertilizer effect was not significant in all the un-weeded treatments for sedge and broad leaves weed dry weight. Treatment effect showed no significant effect over total grain yield in un-weeded treatments. No basal nitrogen treatment had showed comparative lower grass and broad leave weed dry weight and comparable yield advantage over the DOA treatment. Result indicated that LCC practice and without nitrogen in basal application significantly minimized grass weed competition in rice without no significant yield change over common DOA practice.

P-113

A *Zoysia* Grass Net-Planting Technique for Rural Levees

Akihide Fushimi[1], Kazuo Naganuma[2]

[1]Western Region Agricultural Research Center, NARO, 6-12-1 Nishifukatsu-cho, Fukuyama-shi, Hiroshima 721-8514, Japan
[2]Zoysian Japan Co., Ltd., 275 Tikada, Jinsekikougen -cho, Jinseki-gun, Hiroshima 720-1622, Japan

Problems related to the control and maintenance of rural levees on farmland and other open areas have become increasingly important in Japan, particularly in mountainous areas where maintaining levees is costly due to the difficulties associated with weeding steep slopes. The development of weeding machines for slopes greater than 30° is lacking and farmers do not typically apply herbicides on levees for weed control. We decided to use *Zoysia japonica* as a ground cover to prevent weed growth on levees in rural areas in 2005, but there was no established planting method for *Zoysia* grass on 30 to 45° slopes at that time. However, in spring 2006, we found a company that marketed a *Zoysia* grass NET-planting technique and we decided to repurpose the ZNET for application in sports amenities (e.g. golf) and agriculture in rural areas. In collaboration with Zoysian Japan Co., Ltd., we adapted the technique for use on levees in rural areas in 2014. Compared with traditional propagation methods, such as block sodding and using cell trays, the ZNET method is more efficient for establishing *Zoysia* on 30 to 45° levee slopes. By establishing levees with *Z. japonica*, 'Asagake', the cutting frequency can be reduced from four to three times a year, which is equivalent to a 25% reduction in labor costs.

P-114

Productivity low land Rice on Different Land Preparation and Weed Control

Dedi Widayat [1)], Yayan Sumekar[1)], Uum Umiyati[1)], Denny Kurniadie [1)]
[1] Faculty of Agriculture, Padjadjaran University, Bandung Indonesia

Email：widayatdedi@yahoo.com

ABSTRACT

Low land rice rice cultivation requires relatively high labor especially for land preparation and weed control, making it relatively expensive, therefore there should be an effort to reduce production costs, but high production. One way is to weed management, and efficient tillage. This study aims to investigate the response of growth and yield of low land rice on different on tillage and weeds control. So that can know the response of lowland rice growth and yield best to weed control and different tillage. The usefulness of this research is expected to complement previous research and may be the basis for further research, in addition to the expected results of this study can be the basis for policy in increasing rice production. This research uses experimental methods (experimental) and design used was a randomized block design (RBD) Spit pattern plot done in SPLPP Ciparay for 5 months starting January, 2016. The results showed that there is no interaction between tillage and weed control on growth and yield of rice paddy fields. Perfect processing and without tillage did not leave a different effect on the growth and yield of rice paddy fields, while the use of herbicides methilmetsulforon can replace the control of weeds manually 2 times per season.

Keyword : Low land rice productivity, Land preparation, Weed Control Management,.

P-115

The Influence of Different Amounts of Nitrogen and Weed Interference on Yield and Yield Components of Corn in Two Irrigation Systems

Rouzbeh Zangoueinejad[1], Seyed Abdolreza Kazemeini[2], Mohammad Taghi Alebrahim[3]

[1] PhD Student in Weed Science, Department of Agronomy and Plant Breeding, University of Mohaghegh Ardabili, Ardabil, Iran.
[2] Associate Professor of Crop Production, Department of Agronomy and Plant Breeding, Shiraz University, Shiraz, Iran.
[3] Associate Professor of Weed Science, Department of Agronomy and Plant Breeding, University of Mohaghegh Ardabili, Ardabil, Iran.

A study was conducted to evaluate the effect of nitrogen on yield and yield components of corn and weed interference in the flood and drip irrigation systems. The results of this study showed that under weedy condition, grain yield (51.0%) and its components (number of rows and kernels per ear, ear length and diameter and seed weight) decreased significantly. In the former studies weed competition had been a major limitation for corn production. Also we observed that nitrogen application caused a different response in each irrigation systems, so that the application of 75 and 150 kg ha^{-1}nitrogen under drip irrigation systems reduced weed biomass 62.6 % and 64.4 % compared to flooding system respectively. The using of drip irrigation system reduced weed density (56.8%) and biomass (54.3%) and increased corn grain yield compared to flooding irrigation system. Under weed free condition and using of drip irrigation system increased number of grain per ear 50.1% significantly. In drip and flooding irrigation systems under weed free condition compared to weedy plots number of grain per ear increased 17.0 and 7.9 % respectively whilst drip irrigation system compared to flooding irrigation system increased ear diameter 50.5 % significantly. However, hundred grain weights were affected by all treatments, under weed free condition compared to weedy condition, in drip irrigation system increased hundred grain weights 18.2 %, but in flooding irrigation system no significant differences was observed. The results showed that the effectiveness of nitrogen was much higher in drip irrigation compared to flooding irrigation. It can be because of that drip irrigation system directly provide water for plants and prevent from availability of water for weeds. Therefore appropriate irrigation system as an agronomical of practice, affects the growth and weed competition ability and crop production.

Key words: Weed density, Competition, Weed biomass.

P-116

Efficacy of the canopy height-to-row spacing ratio as an onsite index to determine the termination time of *Ipomoea coccinea* control using the soybean mini-core collection

Shunji Kurokawa[1], Akito Kaga[2], Mai Tsuda[3], Daisuke Sekine[2], Tomoko Shibuya[1]

[1]Central Region Agricultural Research Center, NARO
[2]Institute of Crop Science, NARO
[3]GRC, T-PIRC, University of Tsukuba

The canopy height-to-row spacing ratio (CHRSR) could be a simple and practical onsite index for relative photosynthetic photon flux densities (PPFD). A CHRSR of 1.0 should indicate a PPFD of approximately 50% under the soybean canopy. At this point, growers could terminate *Ipomoea coccinea* control in soybean fields. Growers would simply need to measure plant height and terminate weed control when the canopy height reaches a value equal to the row-spacing value (Kurokawa et al. 2015). However, the CHRSR has only been studied in a single cultivar, Hatayutaka, and it might not be applicable to soybean cultivars with different canopy architectures.

In this study, the general applicability of a CHRSR of 1.0 corresponding to a relative PPFD of 50% was determined using accessions of the NIAS soybean mini-core collection. The number of days after sowing when the relative PPFD reaches 50% was defined as PPFD50.

Of the 190 accessions used in this study, 104 had a relative PPFD that reached <10%. The PPFD50 values of the 104 accessions were estimated using the formula developed for the soybean cultivar Hatayutaka, and estimated PPFD50 values were compared with measured values. Using an acceptable error range between estimated and measured values of 7 days, the estimated values of 59 accessions were acceptable. The measured values of PPFD50 in 39 accessions occurred over 7 days earlier than the estimated values. In these cases, there would be negligible risk of failure if growers used CHRSR to determine the termination time for *I. coccinea* control. The measured values were rarely over 7 days later than the estimates (6 accessions); however, the estimation of PPFD50 using the CHRSR could result in early termination of the control.

In conclusion, the CHRSR has broad applicability as an onsite index for a relative PPFD of 50% under soybean canopies.

P-117

Weed infestation, yield losses and control methods in maize crop

Khawar Jabran[1], Ahmet Uludag[1,2], Bhagirath Singh Chauhan[3]

[1]Department of Plant Protection, Faculty of Agriculture and Nature Sciences, Duzce University, Duzce, Turkey
[2]Faculty of Agriculture, Canakkale Onsekiz Mart University, Turkey
[3]The Centre for Plant Science, Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, Gatton, Queensland 4343, Australia

Weeds are among the main biotic stresses that impact the maize growth negatively and decrease its global productivity. *Amaranthus retroflexus*, *Chenopodium album*, *Convolvulus arvensis*, *Digitaria sanguinalis*, *Echinochloa crus-galli*, *Echinochloa colona*, *Polygonum* spp., *Setaria* spp., and *Sorghum halepense* (L.) are the most common weed species of maize. Parasitic weeds such as *Striga* spp. are important in the maize fields of Africa and Asia. Yield losses in maize caused by weeds may range from 20 to 98%. Chemical control is the most important method to control weeds in maize. However, innovative weed control techniques are required in the wake of several problems such as evolution of herbicide resistance in weeds and environmental pollution. Important of these are allelopathic weed control, use of remote-sensing for site-specific weed control, sowing of competitive cultivars, use of robots for mechanical weed control, sowing of herbicide-resistant cultivars and classical cultural weed control. An integrated use of such innovative methods alongside the herbicide application will help to achieve sustainable weed control in maize.

P-118

Influence of weed management measure on glyphosate resistance and endophyte infection in naturalized Italian ryegrass (*Lolium multiflorum*)

Valentina Dwi Suci Handayani[1], Yuki Tanno[1], Masayuki Yamashita[1], Hiroyuki Tobina[1], Minoru Ichihara[2], Yoshiki Ishida[2], and Hitosi Sawada[1].

[1]Shizuoka University, 836 Ohya, Suruga-ku, Shizuoka 422-8529, Japan
[2]Shizuoka Prefectural Research Institute of Agriculture and Forest, 678-1 Tomigaoka, Iwata, Shizuoka 438-0803, Japan

Italian ryegrass (*Lolium multiflorum*) has become a problem weed in rice paddy field margins (levees) and wheat fields in Japan. Recently, glyphosate-resistant Italian ryegrass was found on rice paddy levees in a western region of Shizuoka Prefecture. Naturalized populations of Italian ryegrass are frequently infected with fungal *Epichloë* endophytes. Endophytes often confer benefits to their host grasses. This study investigated the influence of five weed management treatments on glyphosate resistance and endophyte infection in Italian ryegrass that was growing on paddy levees where glyphosate-resistant individuals were dominant. The weed management treatments were: (i) mowing once before the grass flowered; (ii) mowing once during flowering; (iii) mowing twice during flowering; (iv) glyphosate application before flowering; and (v) no treatment. The seeds were collected from the treatment plots in 2013 and 2014. The seeds were examined for endophyte infection and the seedlings that had been grown from the seeds were tested for the frequency of glyphosate resistance. The seedlings that had been derived from the glyphosate treatment showed higher frequencies of glyphosate resistance than those seedlings that had been derived from all the other treatments. Endophytes were found in all populations of the seeds from the paddy levees, with higher infection rates in the seeds that had been derived from the glyphosate treatment and the twice-mowed treatment. There was a significant relationship between the endophyte infection frequency in the seeds and glyphosate resistance in the seedlings that had been grown from the same populations. The results indicate that where glyphosate herbicides are frequently used, selection for glyphosate-resistant Italian ryegrass occurs, and along with this, the frequency of endophyte infection also increases.

P-119

Efficacy of weeding machine composed of steel tines in terms of growth stage of weeds in soybean

Hiroyuki Kobayashi[1], Nozomi Ihara[1], Hiroyuki Kondo[2]

[1] Central Region Agricultural Research Center, NARO, 2-1-18 Kannondai, Tsukuba 305-8666, Japan
[2]QFO Inc., 5-71-1 Asahimachi, Ashoro 089-3721, Japan

One of the authors, QFO Inc. developed weeding machines composed of steel tines mainly for vegetable fields in Hokkaido, northern Japan. However, the weeding machines require fine-tuning for each field by well-trained technicians to maximize the effectiveness. Consequently, we set a goal to generalize the weeding machine to various kind of crops based on scientifically verifiable evidences so that farmers can get maximum weeding efficacy in any crops anywhere without advice from the technicians of QFO Inc. As part of the study, we firstly tried to clarify the applicable period of the weeding machine paying special attention to growth stage of weeds in soybean employing two fields whose soil types were well-pulverized andosol (FieldⅠ) and poor-pulverized alluvial (FieldⅡ) in Tsukuba, central Japan in 2016. The dominant weed species in FieldⅠand FieldⅡwere respectively *Persicaria maculosa* and *Ipomoea hederacea*. Soybeans were sowed at a row spacing of 60cm in 24 June in fieldⅠand in 5 July in FieldⅡ. In FieldⅠ, *Persicaria* plants of 4-leaf stage or younger were successfully controlled by a weeding practice using the machine at 2 or 4-leaf stage of soybean (12 or 20 July). However, Some *Persicaria* plants of 6-leaf stage or older survived just one weeding practice at 5-leaf stage of soybean without weeding at 2-leaf stage. Thus, we concluded that the weeding machine could control *P. maculosa* of 4-leaf stage or younger under the experimental conditions described above. In FieldⅡ, Only 4/5 or less of *Ipomoea* plants were controlled by the weeding machine irrespective of the growth stage of *Ipomoea*. We consider the poor control efficacy in FieldⅡ was caused by the soil characteristics rather than kind of weed species.

P-120

Morphological variations, genetics and geographic background of *Echinochloa crus-galli* in China

Yongliang Lu[1]; Manyu Zou[2]; Liping Yin[3]; Shuiliang Guo[2]

[1]China National Rice Research Institute, Hangzhou 311400;
[2] College of Life and Environmental Sciences, Shanghai Normal University, Shanghai 200234;
[3]Shanghai Entry-Exit Inspection and Quarantine Bureau, Shanghai 200234

Thirty-three seed samples of *Echinochloa crus-galli* (L.) P. Beauv. were collected from paddy regions of nine provinces (Autonomous Region) in China, and sown in the same environment to obtain their offspring. Sixteen morphological traits of their offspring were measured. Nine ISSR primers with good repeatability were selected and 109 ISSR loci were amplified from these thirty-three *E.crus-galli* samples. Based on morphological traits and locus information, cluster analysis and principal component analysis on these thirty-three populations were conducted. The main results are as follows: (1) Four morphological groups were identified from these populations, among them are *E.crus-galli* var. *zelayensis* (Kunth) Farw., *E.crus-galli* var. *mitis* (Pursh) Peterm. and *E.crus-galli* var. *praticola* Ohwi; (2) Six groups were also identified from these samples by using cluster analysis based on ISSR locus data, which corresponds well with the morphological groups, especially for *E.crus-galli* var. *praticola*; (3) Obvious genetic differentiation existed among these thirty-three populations, which is obviously influenced by the geographical locations (r=0.684, n=33, P<0.001). Their morphological variation, however, is weakly affected by the geographical locations (r=0.425, n=33, P<0.02); When plants grow in the same environment for long time, the convergent adaptation may appear in their morphological characters, which make it hard to distinguish the different species of *Echinochloa crus-galli* by morphology; (4) Both the morphological data and the ISSR data separated the populations of *E.crus-galli* var. *praticola* from the other populations. Therefore, the variety was suggested to elevate to species level: *Echinochloa praticola* (Ohwi) Guo S L, Lu Y L, Yin L P & Zou M Y.

P-121

Seed Germination, Seedling Emergence and Response to Herbicides of Triquetrous Murdannia (*Murdannia triquetra*) in Rice

Wei Tang, Jie Chen, Jing Yuan, Jianping Zhang, and Yongliang Lu*

First and fourth authors: Associate Professor, and fifth author, Professor, State Key Laboratory of Rice Biology, China National Rice Research Institute, Hangzhou 311400, China; Second and third authors, Associate Professor and Professor, School of Forestry and Bio-technology, Zhejiang A&F University, Hangzhou 311300.
Corresponding author's E-mail: luyongliang@caas.cn

Triquetrous murdannia is an annual weed commonly found in rice fields in China. Laboratory and screenhouse experiments were carried out to determine the effect of light, temperature, osmotic and salt stress, seed burial depth, amount of rice residue, and depth of flooding on seed germination and seedling emergence of triquetrous murdannia and to evaluate the response of this weed to commonly available POST herbicides in China. Germination was greater than 93% under a wide day/night temperature range of 20/10 to 30/20 C in the light/dark regime. The onset of germination was shortened as temperature increased. Germination was slightly stimulated when seeds were placed in light/dark conditions compared to seeds placed in the dark. The osmotic potential and NaCl concentration required for 50% inhibition of maximum germination were -0.5 MPa and 122 mM, respectively. The highest germination (68%) was observed from seeds sown on the soil surface, but decreased with increasing burial depth. Only 7% of seedlings emerged from a depth of 4 cm, and no seedlings emerged from seeds buried deeper than 6 cm. Seedling emergence decreased from 93to 35% with increasing quantity of rice residue (1 to 6 t ha^{-1}) applied on the soil surface. Seedling emergence was reduced by 40, 48, 64 and 70% at flooding depths of 1, 2, 4 and 6 cm, respectively, for the seeds sown on the soil surface. Fluroxypyr and MCPA herbicides provided 100% control of triquetrous murdannia at the two- to six-leaf stages, however to achieve 100% control with bispyribac-sodium, MCPA+bentazone or MCPA+fluroxypyr, herbicides had to be applied by the four-leaf stage. The results of this study could help in developing more sustainable and effective integrated weed management strategies for the control of triquetrous murdannia in rice fields of China.

Keywords: Burial depth, flooding, osmotic stress, salt stress, rice residue.

P-122

Identifying early germination characters that leads to the weediness of a plant: Border regulatory perspectives

W. J. Nimanthika[1], S. M. W. Ranwala[2], H. S. Kathriarachchi[2]

[1]National Plant Quarantine Service, Sri Lanka,
[2]Department of Plant Sciences, University of Colombo, Sri Lanka

Invasive alien species (IAS) is one of the important threats to the biodiversity. Recent developments of international trade could be a major contributor that introduces species in to territories which are potentially noxious or invasive. Therefore, the border regulatory activities need to be stringent and precise if controlling of entry and establishment of those species. Present study aimed development of a protocol that identify potential weediness of such plant species. Ten species from each Poaceae and Asteraceae (a combination of invasive, non-invasive and quarantine weeds) were studied. The study was performed in three diverse geographical locations. 100-seed weight, seed imbibition rate, time taken for emergence of radical and cotyledons, seedling-height (7 days), Plant-height (3 months), number of inflorescence and seeds produced by plants within three months, evaporation rate, stomatal density and the anatomical characters were measured. Data were analysed by cluster analysis, Principle Component Analysis and Discriminant Analysis using the SAS version 9.0. Results were compared with outcomes of weed risk analysis performed for each species, and their potential threat was ranked using National IAS Early Warning System, Sri Lanka. The results showed that the species having invasive characters and the species that are not invasive were categorized in to two distinct clusters with an exception for *Carthamus oxycanthus*. The discriminant analysis has resulted a descriminant function and the STEPDISC procedure has resulted the variables (No. of seeds produced within three months, height of seedling after 7 days and time taken for the cotyledon emergence were shown to have the greatest contribution for the invasiveness of selected species. However, further studies inclusive of the species belong to other angiosperm families are required to confirm whether the characters identified in this study could be universally applicable.

P-123

Seed germination of *Xyris complanata*, a monocot pioneer plant in burnt tropical peatlands, can be stimulated by a soil *Penicillium* sp.

Yasuyuki Hashidoko[a], Masataka Hane[a], Ryosuke Tamura[a], Yanetri A. Nyon[b], and Hanny C. Wijaya[c]

[a] Graduate School/Faculty of Agriculture, Hokkaido University; [b] Faculty of Agriculture, University of Palangka Raya; [c] Faculty of Food Science, Bogor Agricultural University

Hawaii yellow-eyed grass (*Xyris complanata*: Xyridaceae) is a monocot pioneer plant in burnt tropical peatlands in Southeast Asia. This acidic soil-adapted plant deposits a large number of dormant seeds to soil seed bank in deforested open areas and waysides. The tiny, football-shaped seeds that are approximately 0.2 × 0.3 mm in size show high dormancy, but some saprophytic *Penicillium* fungi in soil break down this seed dormancy and induce seed germination. We have isolated one of the *Penicillium* fungi from the seed and identified it as *Penicillium rolfsii*.[1)] Based on a hypothesis that the fungus *P. rolfsii* Y-1 strain produces a factor to break the dormancy of the *X. complanata* seeds, we searched for the hypothetical seed dormancy-breaking factors. As such seed dormancy-breaking factors, butenolides (3-methyl-2*H*-furo[2,3-c] pyran-2-one derivatives, also known as karrikins) have been identified as substances present in smoke of bushfire. As karrikins promote the germination of seeds from a wide range of plant species while patulin (4-hydroxy-4*H*-furo[3,2-c] pyran-2(6*H*)-one) is a major mycotoxin produced by several *Penicillium* fungi, we investigated whether karrikin-like low molecular compounds are in secondary metabolites of *P. rolfsii* Y-1 cultured in potato-dextrose broth (pH 7.0) or Winogradsky’s mineral solution with 2% sucrose and 0.2% glutamine (pH 3.0). Culture fluid (100 mL) of *P. rolfsii* Y-1 was extracted with EtOAc, and the resulting extract (46 mg) fractionated by silica gel column chromatography yielded some chemical substances. To surface-sterilized seeds of *X. complanata* on Hoagland’s solution-based 0.5% agar gel bed (10 seeds per a bed in a 12-well dish), we added a substance to Fr-11-22 to the 2 mL-gel as equivalent to a 0.01-0.001 mL-culture fluid per mL bed. In the preliminary experiments (n=3), germination rate increased from 13% (control) to 37% with a statistical significance ($P<0.05$). We are now focusing on this karrikin-like active metabolite.

P-124

Population dynamics of *Ipomoea hederacea* Jacq. var. *integriuscula* A. Gray (morning glory) in paddy field levee – relationship between emergence time and fruiting –

Nozomi Ihara[1], Hiroyuki Kobayashi[1]

[1] Central Region Agricultural Research Center, NARO, 2-1-18, Kannondai, Tsukuba 305-8666, Japan

Ipomoea hederacea Jacq. var. *integriuscula* A. Gray causes serious weed problems in soybean in Japan. *I. hederacea* is considered to invade paddy fields from levees surrounding them. However, the hypothesis is not confirmed because its life cycle and population dynamics in levee have not been studied in detail. The information helps us to make effective technology to control *I. hederacea*. Therefore, we examined seasonal population dynamics of *I. hederacea* in fields and their levees to clarify whether *I. hederacea* invades fields from their levees or not, and to obtain information for development of effective control technology.

Examination was conducted at farmer’s paddy fields and their levees from April through December, 2016. Rice was cultivated in the fields. Weeds in the levees were controlled by non-selective herbicide or mowing three times a year: June, July and October. Quadrats were set up in the paddy fields and their levees. All *I. hederacea* plants emerged in each quadrat were labelled and recorded their growth stages once every 1-2 weeks.

The results showed that *I. hederacea* emerged from April through November. In levee, *I. hederacea* emerged in April and from August through September fruited in the middle June and in the middle September, respectively. *I. hederacea* plants emerged from late August through late September produced the most seeds. Moreover, we observed some plants emerged in August invaded paddy fields from levee by using vines (10.3 vines/m^2).

It was speculated that these results were caused by omission of weeding in levee from August through September. Therefore, these results suggested that weeding before middle September could have prevented *I. hederacea* from invading paddy field.

P-125

Changes of Weed Flora in Wheat Fields in the Southeast Anatolia Region of Turkey

Zübeyde Filiz Arslan[1], Ahmet Uludağ[1,2], Ayşin Bilgili[3], Ayçin Aksu Altun[3]

[1]Faculty of Agriculture and Nature Sciences, Düzce University, Turkey
[2]Faculty of Agriculture, Çanakkale Onsekiz Mart University, Turkey
[3]GAP Agricultural Research Institute, Şanlıurfa, Turkey

Wheat is widely grown in the Southeastern Anatolia Region (SAR) of Turkey in the winter season. Weeds have been problem in wheat areas in the SAR as well as in other crops and the other places. Major changes have occurred in agricultural production, problems and their management in the region since the last century. Weed occurrences and managements also closely related to all these agricultural changes. The changes have been identified in comparison with the almost ten survey studies conducted in the last 50 years (between 1966 and2014) in the SAR region. As a result of this comparison; it has become clear that the flora has been notably changed, some species vanished whereas some are recorded later, the prevalence and density of weed species are much higher past than the present. The most important reason for this situation is thought to be the increased use of herbicides, especially after 1990. Other important reasons for the change in weed flora are; the change of the crop rotation system after 1982, and the increase of the irrigated areas after 1995, It is speculated that weed species resistant to herbicides could be a problem, although the overall weed density in wheat production will be reduced, in the future. Therefore, some measures must be taken to deal with the weed problems threatening the wheat production and biodiversity.

P-126

Barnyardgrass (*Echinochloa crus-galli*) genome analysis provides insight into its adaptation and invasiveness as a weed

Jie Qiu, Chuyu Ye, Longjiang Fan

Institute of Crop Science and Institute of Bioinformatics, Zhejiang University, Hangzhou 310058, China

Barnyardgrass (*Echinochloa crus-galli*) is a pernicious weed in agricultural fields worldwide. The molecular mechanisms underlying its success in the absence of human intervention are presently unknown. We sequenced the *E. crus-galli* genome and generated a 1.27 Gb assembly representing 90.7% of the predicted genome size. An extremely large repertoire of genes encoding cytochrome P450 monooxygenases and glutathione S-transferases associated with detoxification were found. Two gene clusters involved in the biosynthesis of an allelochemical 2,4-dihydroxy-7-methoxy-1,4-benzoxazin-3-one (DIMBOA) and a phytoalexin momilactone A were found in the *E. crus-galli* genome, respectively. The allelochemical DIMBOA gene cluster is activated in response to co-cultivation with rice, while the phytoalexin momilactone A gene cluster specifically to infection by pathogenic *Pyricularia oryzae*. Our results provide a new understanding of the molecular mechanisms underlying the extreme adaptation of the weed.

P-127

Response of Se stress on the accumulation of Se and the absorption of mineral elements in alfalfa

Hui-ping Dai [1], Hua Zhao[2], Shuhe Wei[3,1*]

[1] Shaanxi Province Key Laboratory of Bio-resources, Shaanxi University of Techology, Hanzhong 723001, China;

[2] College of Resources and Environment, Institute of Tropical Agriculture and Forestry, Hainan University, Hainan 570228,China;

[3] College of Biological Science & Engineering, Shaanxi University of Technology, Hanzhong, Shaanxi 723001, P.R. China.

In order to explore the effect of Se stress on the accumulation of Se and the absorption of other mineral elements in alfalfa. In this paper, the effect of selenium stress on the accumulation of Se and the absorption of mineral elements in different alfalfa were investigated by pot experiments, including biomass content, translocation factor, tolerance factor, Se accumulation, Se accumulation and mineral elements content in different tissues of *Medicago sativa* L. The results showed that the content of Se, tolerance factor, Se accumulation and mineral elements (K, P, Fe, Ca, Mg) were gradually increased when the Se stress increased to 100μmol/L Se, compared with control (non-Se).After exposure to 900μmol/L Se, Se stress markedly increased the Se accumulation in the different tissues of three alfalfa. However, Se stress markedly decreased the contents of biomass in the different tissues of *M. sativa* cv, Vitoria alfalfa and the root of *Medicago sativa* ssp., and it was markedly decreased the absorption of Zn content. Under different levels of Se stress, Se accumulation and mineral elements (K, P, Mg), compared with other species. Thus, it was concluded that *M. sativa* ssp. had high selenium resistance.

* Correspondence: Prof. Dr. Shuhe Wei
Telephone: +86 (0) 13109852193

E-mail: shuhewei@iae.ac.cn or daihp72@aliyun.com

Acknowledgements

This work was financially supported by National Natural Science Foundation of China(41571300), Natural Science Foundation of Shannxi Province(2015JM3086) and Supported by Foundation of Gansu Key Laboratory of Biomonitoring and Bioremediation for Environmental Pollution(GBBL2015006, QBXTZ(P)-15-7).

P-128

A novel gene of seed vernalization in *Conyza canadensis*, which regulates life histories of facultative winter annuals

Yoshihiro Kobayashi, Kohei Kiriyama, Nozomi Aoyama, Satoko Takahashi, Katsuhiro Shiono, Toshihito Yoshioka

Faculty of Bioscience and Biotechnology, Fukui Prefectural University, 4-1-1 Kenjojima, Matsuoka, Eiheiji-Cho, Fukui 910-1195, Japan

Soil-buried seeds of facultative winter annuals germinate both in autumn and spring. Autumn-germinating plants overwinter as rosettes, and flower in the next year, whereas spring-germinating ones can quickly flower without having the rosette stage. We found that when non-germinating imbibed-seed of a facultative winter annual, *Conyza canadensis*, has been exposed to low temperature, an early flowering trait of the resultant plant is induced. This flowering trait is called seed vernalization. Contrastively, an obligate winter annual, *C. sumatrensis*, flowers only after overwintering with a rosette form because of lack of the trait. The seed vernalization should be distinguished from plant vernalization, in which plants sense low temperature at the rosette stage. The molecular mechanisms of plant vernalization have been well understood, but genes of seed vernalization are still unknown. Recently, we succeeded to get a candidate gene of seed vernalization, *PRE-GERMINATION SEED VERNALIZATION* (*PSV*), in *C. canadensis*. The full length mRNA of *PSV* consists of 723 bp (241 aa) and has signal peptide, glycine rich and cysteine rich domains. On the other hand, a homolog of *PSV* in *C. sumatrensis* has a base substitution mutation at 133rd position from the translation initiation site, which results in a nonsense codon. These results suggest that *PSV* is a key gene responsible for the life history differentiation between facultative and obligate winter annuals. Generally, habitats of facultative winter annuals are more frequently disturbed than those of obligate winter annuals. Thus, *PSV* would also be a critical factor for habitat segregation among allied winter annual weeds.

P-129

High-throughput sequencing reveals bacterial community composition in the rhizosphere of the invasive plant *Flaveria bidentis*

Zhen Song, Weidong Fu, Guoliang Zhang

Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences, Beijing, China

Bacteria are important soil components as both decomposers and plant symbionts and play a major role in plant-microbe interaction processes. However, little is known about the diversity of bacterial communities in the rhizosphere of the invasive plant *Flaveria bidentis*. In this study, we used high-throughput sequencing to investigate bacterial communities in the rhizosphere of *F. bidentis*, compared with those of native crop maize and control plant *Setaria viridis*. We obtained >70000 analysis reads from the three samples and used bioinformatics and multivariate statistics to analyse the results. An analysis of indicators showed that *F. bidentis* samples had lower richness but higher diversity than maize and *S. viridis* samples. Operational taxonomic unit (OTU)-based bioinformatics and statistical analysis also demonstrated that *F. bidentis* significantly altered the bacterial rhizosphere community. Higher abundance of Actinobacteria and lower abundance of Firmicutes were observed in *F. bidentis* rhizosphere than those of maize and *S. viridis*. Redundancy analysis (RDA) revealed the correlations between soil bacteria communities, soil nutrients and the abundance of bacterial groups. Our results provide a starting point for investigations of the effects of *F. bidentis* on soil bacterial diversity and a theoretical basis for the micro-ecological mechanism of *F. bidentis* invasion.

P-130

Effects of *Solanum rostratum* Invasion on Soil Properties in Different Soil Types

Weidong Fu, Guoliang Zhang, Zhen Song

Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences, Beijing, China

The effects of alien invasive plant on the soil ecosystem have become a hot spot in the research of invasion ecology. To analyze the influences of *Solanum rostratum* Dunal invasion on soil nutrients and enzyme activities in various habitats of different soil types, soil was sampled at two test areas in this study, one is in Xuanhua county of Hebei province and the other is in Baicheng city of Jilin province. In addition, to make a more comprehensive analysis of its impact on soil properties, 4 habitats were selected in each region (including wasteland, roadside, farmland and forestry in Xuanhua; wasteland, roadside, farmland and grassland in Baicheng; the forestry of Xuanhua and the grassland of Baicheng are the endemic habitats in each region, respectively). Soil nutrients and enzyme activities were determined by titration and colorimetry methods. The results indicated that the invasion of *S. rostratum* changed the soil nutrients. In the two areas, the total soil nitrogen was increased in farmland, forestry and grassland ($P<0.05$), in which the total nitrogen content of farmland and forestry in Xuanhua (anthropogenic-alluvial soil) was increased by 102.49% and 79.02% compared with CK, and that on farmland and grassland in Baicheng (light chernozem) was increased by 44.04% and 21.81% compared with CK; soil ammonium nitrogen content was also increased in farmland and forestry($P<0.05$), in which the farmland and forestry in Xuanhua increased by 137.59% and 50.32% compared with CK, and 140.18% in farmland of Baicheng. In the same time, soil nitrate nitrogen content was increased in the roadside, forestry, farmland (Baicheng) and wasteland (Xuanhua) ($P<0.05$), among them, soil nitrate nitrogen content of wasteland, roadside and forestry was increased by 65.52%, 32.96% and 22.68% in Xuanhua, and that in roadside and farmland was increased by 132.59% and 153.96% in Baicheng, respectively. Soil organic matter content was enhanced in Xuanhua area and the wasteland and farmland of Baicheng ($P<0.05$); the total soil phosphorus content of wasteland, farmland and forestry in Xuanhua was decreased by 54.63%, 70.81% and 29.68%, and that in roadside and grassland of Baicheng was also decreased by 17.40% and 14.69% compared with CK ($P<0.05$), respectively. There was no significant effect on the total potassium and available potassium in the two regions. The invasion of *S. rostratum* changed the soil enzyme activity. Soil urease activity was significantly improved in the wasteland, farmland, forestry, grassland and roadside habitats (Xuanhua) ($P<0.05$); soil neutral phosphatase activity was improved in roadside of Xuanhua and wasteland, grassland of Baicheng ($P<0.05$); soil catalase activity was improved in wasteland and forestry of Xuanhua ($P<0.05$), however, there was no significant effect on the activity of catalase in Baicheng. For the soil nutrient and soil enzyme activities of some habitats there was no significant effect, which may be related to the climate, invasive time and other factors, and it need to be further studied. In short, *S. rostratum* may create the benefit soil environment for itself through changing soil nutrients and soil enzyme activities for further spread. Study on effects of *S. rostratum* invasion on soil nutrients and enzyme activities in different areas of different habitats will not only assess the impact of the ecological system, but also provide the basic data for the research and prevention of *S. rostratum*.

P-131

iTRAQ Protein Profile Differential Analysis of Dormant and Germinated Grassbur Twin Seeds Reveals Ribosomal Synthesis and Carbohydrate Metabolism Promote Germination Possibly Through the PI3K Pathway

Guoliang Zhang, Weidong Fu, Zhen Song

Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences, Beijing, China

Grassbur is a destructive and invasive weed in pastures, and its burs can cause gastric damage to animals. The strong adaptability and reproductive potential of grassbur are partly due to a unique germination mechanism whereby twin seeds develop in a single bur: one seed germinates, but the other remains dormant. To investigate the molecular mechanism of seed germination in twin seeds, we used isobaric tags for relative and absolute quantitation (iTRAQ) to perform a dynamic proteomic analysis of germination and dormancy. A total of 1,984 proteins were identified, 161 of which were considered to be differentially accumulated. The differentially accumulated proteins comprised 102 up-regulated and 59 down-regulated proteins. These proteins were grouped into seven functional categories, ribosomal proteins being the predominant group. The authenticity and accuracy of the results were confirmed by enzyme-linked immunosorbent assay (ELISA) and quantitative real-time reverse transcription–PCR (qPCR). A dynamic proteomic analysis revealed that ribosome synthesis and carbohydrate metabolism affect seed germination possibly through the phosphoinositide 3-kinase (PI3K) pathway. As the PI3K pathway is generally activated by insulin, analyses of seeds treated with exogenous insulin by qPCR, ELISA and iTRAQ confirmed that the PI3K pathway can be activated, which suppresses dormancy and promotes germination in twin grassbur seeds. Together, these results show that the PI3K pathway may play roles in stimulating seed germination in grassbur by modulating ribosomal synthesis and carbohydrate metabolism.

P-132

Biology and Distribution of Chickenweed purslane (*Portulaca quadrifida* L.)

J. Pinsupa and S. Zungsontiporn

Weed Science Group, Plant Protection Research and Development Office,
Department of Agriculture, Bangkok 10900, Thailand

Chickenweed purslane (*Portulaca quadrifida* L.) is an important problem weed to vegetable farmers in Kanchanaburi province. The objectives of this study were to know more on the biology and distribution of the weed in Thailand and seek appropriate control measures. Surveys were made in the Central, North and Northeast areas of Thailand. Also germination of seeds and growth under greenhouse conditions were studied during 2014-2015. The weed was found in every vegetable area surveyed. But in the Central area, the weed was found in both field crops and vegetables. In germination trials in the laboratory at room temperature, germination was 6.8-8.2%. Additionally, under controlled lighting, light alternating with darkness, 24/0, 12/12 and under natural lighting, germination did not result in any significant difference. Seeds at 3, 6, 10, 15 and 30 cm below soil surface, for as long as 1 year remain viable. Seeds buried 6-10 cm under the surface had the highest germination rate. Propagation from parts of the plant on soil surface produced 70% survival rate. Plants grown from seeds produced flowers at 5 weeks, taking 2 more weeks for the fruits to mature. Each plant is able to produce on the average 621 fruits, each fruit producing on the average 2-16 seeds or each plant is able to produce 5,000 seeds.

P-133

Population dynamics of black-grass (*Alopecurus myosuroides*) in winter wheat fields and its effect on wheat yield

LI Mei FANG Feng GAO Xing-xiang LI Jian ZHU Ligui

Institute of Plant Protection, Shandong Academy of Agricultural Sciences (SAAS), Jinan, 250100

Germination and growth dynamics of black-grass (*Alopecurus myosuroides*) in winter wheat field were determined in Jinan, Shandong province. Influence of different black-grass density on winter wheat yield and its components were also conducted. The dynamics of emergence of black-grass were surveyed by fixed quadrat sampling once a week. That of tillering, plant height and fresh weight were surveyed by random sampling once a week. The results showed that the peak of black-grass seedling emergence appeared after wheat seeding 20-40d. The rate was 97.1% of the total annual emergence to late November. Tillers appeared in early November and ended in early April next year. Black-grass formed average 6.3 effective tillers per plant, 3.1 more than wheat. In late March, black-grass seedling entered jointing stage.Height of black-grass was higher than wheat after mid-April, and reached 75.6 cm in late May, 2.5 cm higher than wheat. The fresh weight of black-grass and wheat were 1.7, 12.6 g in early May, respectively. The dynamics of emergence, tillering, height and fresh weight of black-grass were closely related with phenology. Black-grass could seriously reduce winter wheat yield. The yields loss were 0, 4.6%, 11.6%, 21.3%, 31.3%, 52.3% and 65.8% according to different black-grass density 0, 10, 20, 40, 120, 240 and 420 plants·m^{-2}, respectively. Spikes and grain number per ear of wheat were effected seriously by black-grass, while thousand-grain weight had nearly no effect. Spikes and grain number per ear of wheat were reduced 55.2% and 26.1% when the black-grass number risen from 0 to 420 plants·m^{-2}.

P-134

Evidence of adaptation of *Setaria viridis* to intensive salt splash from typhoon in sandy seashore

Matsuo Itoh[1*], Yoshitaka Nakashima[2], Yoko Oki[2]

[1] Faculty of Sociology, Shikoku Gakuin University, 3-2-1 Bunkyo, Zentsuji 765-8505, Japan
[2] Graduate School of Environmental and Life Science, Okayama University, 3-1-1, Tsushima-naka, Okayama 700-8530, Japan

A coastal population of *Setaria viridis* inhabiting seashore of a small island in the Seto Inland Sea of Japan was studied from 2014 to 2016 to evaluate the effect of typhoon on the population structure. Research on the damage from typhoon to coastal plants and their responses is important for planning of conservational measures of coastal environments in agro-ecosystems. Since the previous study exhibited that plants from the sandy seashore consisted of two plant groups varying in salt spray tolerance, they were examined in morphology in common garden experiments. As a result, plants showing higher salt spray tolerance produced narrower 2nd leaves (narrow-leaved plants), than the average (normal-leaved individuals). As the difference in the 2nd leaf width between the two plant groups was hereditarily stable, it was used for a marker to distinguish them in the field. When Typhoon Goni hit the island on August 26 2015, it was observed that the normal-leaved plants were deadly damaged, whereas the adjacent narrow-leaved ones survived. Consequently, plants of *S. viridis* on the sandy shore were collected to measure their 2nd leaf widths just before and right after the hit of typhoon. Based on the observations of proportion of the narrow-leaved and normal-leaved plants affected by the typhoon, the normal-leaved plants injured seriously were eliminated from the sandy shore by the typhoon, whereas the narrow-leaved individuals survived surely because of their higher salt spray tolerance. The normal-leaved plants may invade the habitat again from outside of the sandy seashore in a few years. This is prominent evidence showing the potentiality that plants subjected to natural selection of salt splash from typhoon are able to evolve into the plants with high salt spray tolerance. The intensive selection pressure at intervals allows these two plant groups to coexist in a single population.

P-135

Heavy metal tolerance of Japanese knotweed (*Reynoutria japonica* Houtt.) growing on mine site and effects of the endophytic fungi

Yuki Hojo, Keiko Yamaji

Graduate School of Life and Environmental Sciences, University of Tsukuba, 1-1-1 Tennoudai, Tsukuba, 305-8571, Japan

In general, although high concentrations of heavy metals have toxity to plants, some plant species have the tolerance and can grow in mine sites. *R. japonica*, endemic species in Japan, is known to grow in heavy metal polluted area such as old mine sites. At our study site, the Hitachi mine site in Ibaraki prefecture, Japan, *R. japonica* is fully growing and seems to be tolerant to high concentrations of heavy metals. Recently, endophytes, which grow asymptomatically in plant tissues, are reported to impart and/or intensify heavy metal tolerance and detoxification ability on plants growing in heavy metal polluted area. In this study, by considering interaction between *R. japonica* and endophytes, we aim to clarify how *R. japonica* acquire heavy metal tolerance.

We collected five individuals of *R. japonica* and the root-zone soil (500 × 500 × 500 mm) in June to September 2016 at the study site. Collected plants and soils were analysed by ICP-OES to quantify mineral elements concentrations. To isolate endophytes, 100 pieces rootlet per individual collected in September, 2015, were surface-sterilized, and put on 1 % malt extract agar medium and incubated at 23 °C in the dark for 14 days.

Consequently, relatively high concentrations of Cu, Pb, Mn, and Zn were found in the root-zone soils, however, *R. japonica* did not contain high concentrations heavy metals. Main endophytes isolated from *R. japonica* were *Colletotrichum* and *Cryptosporiopsis*. These two genus fungi accounted for over fifty percent of all isolated strains.

Our results seem to show that *R. japonica* has a heavy metal tolerance by the exclusion mechanism. Currently, we are conducting further experiments, such as siderophore production test and plant growth promoting activity test in order to clarify endophytes ability.

P-136

Germination and seedling growth of *Sagittaria pygmaea*

Yumiko Hori, Yoshiko Shimono, Tohru Tominaga

Graduate School of Agriculture, Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan

Sagittaria pygmaea Miq. is a monoecious clonal herb growing in rice paddy fields. Sulfonylurea herbicide-resistant biotypes of this weed have emerged in Japan. Long distance dispersal of herbicide resistant biotypes occurs by seeds and pollen. Nonetheless, there is little information on sexual reproduction of this weed.

Our research aimed to reveal whether 1) *S. pygmaea* seeds have the ability to germinate immediately after shattering, 2) seedlings germinated in summer or autumn grow until winter and produce tubers, and 3) longevity of buried seeds is short or not in paddy soil. The results of this study will provide valuable information in terms of controlling herbicide-resistant biotypes of *S. pygmaea*.

S. pygmaea produces seeds from early summer to late autumn in Japan. Seeds collected right before shattering were used for germination tests in incubators. About 40% of the seeds germinated at 35℃(light)/25℃(dark). The temperature is almost the same as the surface of Japanese paddy fields in summer. After the germination tests the seedlings were transplanted into a cell tray and were grown until the end of the year. They produced neither flowers nor seeds, but 2-8 tubers individually. Seedlings germinated in summer or autumn grow until winter, reproduced asexually.

Collected seeds were buried into the fields every one month from July to September 2016 and picked out in January and April 2017. In January, 75-92% of the seeds died and increased to 80-95% until April. About 80% of survived seeds germinated at 35/25℃ and the percentage were much higher than fresh seeds. The dormancy seemed to be broken down in soil during winter.

Seeds can easily move with irrigation water and facilitate the spread of herbicide resistant biotypes. For effective control of *S. pygmaea* in paddy rice fields, plants should be removed before flowering and seed shattering.

P-137

Dramatic shift of flowering phenology of intraspecific hybrids in *Imperata cylindrica* makes an F1-dominated hybrid zone

Yasuyuki Nomura[1], Yoshiko Shimono[1], Nobuyuki Mizuno[1], Kazuhiro Sato[2], Tohru Tominaga[1]

[1] Graduate School of Agriculture, Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan

[2] Institute of Plant Science and Resources, Okayama University, Chuo 2-20-1, Kurashiki, Okayama 710-0046, Japan

Imperata cylindrica Raeusch. is a perennial grass weed and has two ecotypes. The common ecotype has hairy nodes on culm and flowers in May in western parts of Japan, while the early flowering ecotype has glabrous nodes and flowers in April. The two ecotypes are isolated reproductively in western part of Japan, however, GOT allozyme analysis suggested that hybrids are formed between the two ecotypes in Tohoku region, northern part of Japan (Tominaga *et al*., 2007). In this study, we clarified polymorphisms in chloroplast DNA (cpDNA) and nuclear DNA (nDNA) to evaluate distribution of the hybrids, presence of backcross and maternal or paternal parent of *I. cylindrica* in Japan.

In cpDNA, the common ecotype did not share haplotypes with the early flowering ecotype. In nDNA, *I. cylindrica* were divided into two clusters which correspond to the common and the early flowering ecotypes by STRUCTURE analysis. Admixed individuals, i.e. hybrids between the ecotypes, distributed from Tohoku to Chubu region. We found that 64 of 220 clones were hybrids, 10 of 64 had cpDNA haplotypes of the common type, 54 had the early flowering type. In most cases, maternal parents of the hybrids were the early flowering ecotype.

NEWHYBRIDS analysis revealed that among 64 hybrids, 63 were F1 hybrids. F1 hybrids existed both in 1980's and 2008-2015 collections. It means that backcross rarely occurs and Tohoku to Chubu region is an F1-dominated hybrid zone (F1DZ, Milne *et al*., 2003). The F1DZ has been maintained for at least 30 years in this perennial plant. In Tohoku region, F1 hybrids flowered in fall and two ecotypes did not. The dramatic shift of flowering phenology of F1 hybrids in *I. cylindrica* is a mechanism of the F1DZ.

P-138

Comparisons of morphological and genetic variations between native and alien *Artemisia indica* populations used for revegetation in Japan

Satoshi Wagatsuma[1], Yoshiko Shimono[1], Junichi Imanishi[1], Yoshihisa Suyama[2], Chika Mitsuyuki[2], Yoshihiro Tsunamoto[2], Tohru Tominaga[1],

[1] Graduate School of Agriculture, Kyoto University, Kitashirakawa-oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan
[2] Graduate School of Agricultural Science Forest Ecology, Tohoku University, 232-3, Narukoonsen -yomogida, Osaki, Miyagi 989-6711, Japan

For revegetation, using native plants is recommended because alien species are sometimes harmful to natural ecosystem. However, in Japan, nearly 99% of commercial seeds are imported from other countries, mainly China because there are no regulations about provenance areas of seeds for revegetation. While these approaches have potential adverse impacts on wild populations, little is known about differences of morphology and genetic structure between native and alien populations.

In this study, we compared morphological and genetic variations between native and alien populations of *Artemisia indica*, which is commonly used for revegetation in Japan. We analyzed three categories of commercial seeds; Chinese-origin-seeds, reimported-seeds from China, Japanese-origin-seeds. Reimported-seeds were harvested from plants cultivated Japanese-origin-seeds in China, and reimported into Japan. We also analyzed seeds collected from revegetation sites. We measured number of florets per capitulum and length and width of leaf, seed, and capitulum, and analyzed genetic variation using MIG-seq (Multiplexed ISSR genotyping by sequencing) technique.

We found morphological differences between seed origins; Chinese seeds were significantly smaller than other seeds. Genetic analysis revealed that Chinese populations were clearly separated from other populations, corresponding with seed morphology. Japanese populations were differentiated between eastern and western areas, so local seeds should be used for revegetation. Reimported-seeds are genetically similar to that of eastern Japanese populations, so the original area of reimported-seeds would be eastern Japan.

Individuals growing at sites revegetated recently showed the same genetic cluster with reimported-seeds, whereas, individuals growing at sites revegetated four years ago showed the same cluster with local populations, suggesting that individuals derived from other regions decline with ecological succession. If so, using seeds from other regions for revegetation may have low risk of genetic disturbance, however, further investigation of gene flow between alien and native populations near revegetation sites is needed.

P-139

Echinochloa response to osmotic stress induced by PEG and salt

Hyejin Yu, Min-Jung Yook, Do-Soon Kim

Department of Plant Science, College of Agriculture and Life Sciences, Seoul National University, Seoul 08826, Korea (E-mail: dosoonkim@snu.ac.kr)

Echinochloa species is distributed around the world and regarded as one of the most problematic weeds because of its high competitiveness against crop and ecological adaptability. In Korea, two *Echinochloa* species, *E. oryzicola* (2n=4X) and *E. crus-galli* (2n = 6X), are known to inhabit crop lands. Interestingly, each *Echinochloa* species inhabits a different habitat: *E. oryzicola* inhabit flooded paddy fields, while *E. crus-galli* mainly inhabits upland area, particularly *E. crus-galli* var. *praticola*. It is assumed that the difference in the habitat of the two *Echinochloa* species may be related to its adaptability to osmotic stress. Therefore, this study was conducted to investigate the adaptability of *Echinochloa* species collected from different habitats to osmotic stress induced by PEG and salt, which were used to mimic osmotic stress conditions. Plant response to each osmotic stress was investigated at various growth stages of the *Echinochloa* species including germination (petri-dish assay), seedling emergence (growth pouch assay), and early juvenile plant growth (pot assay). At germination stage, the ability and rate of germination in each *Echinochloa* species decreased with increasing PEG and salt concentration. At seedling emergence, *Echinochloa* species showed stress response in its shoot and root growths with increasing stress level. Interestingly, R/S (root/shoot) ratio was greater in *Echinochloa crus-galli* var. *praticola* than in *E. oryzicola*, suggesting that greater R/S ratio of upland adapting *Echinochloa crus-galli* is related to its adaptation to dry upland condition. At juvenile plant growth stage, *Echinochloa* showed similar response to osmotic stress. In conclusion, our results demonstrate that the different adaptability of *Echinochloa* to osmotic stress enables *Echinochloa* species widely distribute at various crop lands with different water regimes. We are now under molecular investigation to uncover molecular mechanism of ecological adaptive diversity in *Echinochloa* species. This work was carried out with the support of "Cooperative Research Program for Agriculture Science & Technology Development (Project No. 01245702)" Rural Development Administration, Republic of Korea.

P-140

Emergence behavior and seasonal variation in emergence of seedlings in carolina dayflower (*Commelina caroliniana* Walter)

Mitsuhiro Matsuo[1], Taira Sakai[1], Shuji Kurihisa[1], and Yoshiki Kawano[2]

[1] Field Science Center, Faculty of Agriculture, University of Miyazaki, 1-1 Gakuen-kibanadai-nishi, Miyazaki 889-2192, Japan
[2] Paddy Agriculture Group, Agricultural Research Division, Oita Prefectural Agriculture, Forestry and Fisheries Research Center, 65 Kita-usa, Usa, Oita 872-0103, Japan

Carolina dayflower (*Commelina caroliniana* Walter) is native to India and Bangladesh. Recently, this species has invaded the soybean fields on northern Kyushu Island, Japan and seems to be developing into a troublesome weed species. And, it is known that carolina dayflower had seed heteromorphism as it produces two seed types (pericarp and naked seeds) in a fruit. Germination behavior on these seeds had already demonstrated (Matsuo *et al*. 2016), however, it was unknown about emergence behavior and seasonal variation in emergence on their seedlings. The seedlings derived from two seed types could emerged at 0 to 100 mm soil depths until the 1 week after seeding, however, there was no emergence at soil depths of more than 150 mm. When both seeds were sown in Febrary on the soil surface under natural rainfall condition, the seedlings started to emerge from the end of April on the pericarp seeds, whereas those on naked seeds started to emerge from the end of May. The emergence of the seedlings derived from both pericarp and naked seeds peaked in June and August, and continued until the end of September, suggesting that air temperature and rainfall affects the peak of emergence in carolina dayflower. On the seedlings derived from two seed types emerged from April to August, main stem length, plant length, total number of branches, fresh weight of shoot, the number of spathes, pericarp and naked seeds on the plants emerged at July were the highest among them. The plants emerged at May did not produced the spathes from August to September, suggesting that floral differentiation of carolina dayflower plants might inhibited under lowest air temperature of above 20 ^{o}C.

Matsuo *et al*. 2016. Seed heteromorphism in carolina dayflower (*Commelina caroliniana* Walter). Weed Biology and Management 16, 169-176.

P-141

Comparisons of germination characteristics and seedling growth of *Bromus* species between widespread and non-widespread aliens

Emi Kawamata, Yoshiko Shimono, Tohru Tominaga

Graduate School of Agriculture, Kyoto University, Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan

Biological invasion is a threat to native biodiversity and also cause economic losses. Many invasive species were introduced accidentally or intentionally through global trade and transport. However, not all species introduced to a new habitat become invasive and many introduced species fail to spread from the area where they were first introduced. Therefore, comparison between widespread and non-widespread aliens highlights traits that may be responsible for the success or failure of their invasion. In this study, we compared germination characteristics and seedling growth of *Bromus* species, which include native to Japan: *Bromus japonicus*, widespread alien: *B. catharticus*, locally distributed alien: *B. diandrus*, and rarely found aliens: *B. tectorum* and *B. hordeaceus*.

Germination experiments showed that only native species took longer time to release from dormancy than alien species. High temperature more than 30˚C prevented germination of native species but not alien species. These results indicated that alien species had different germination characteristics from native species but there was not a significant difference between widespread and non-widespread aliens.

Comparison of seedling growth under three water conditions; dry, intermediate, and wet, showed that seedlings of native species and widespread alien grew vigorously under the wet condition, whereas, growth of rarely found aliens under the wet condition were inferior as compared with the growth under the intermediate conditions.

Rare aliens, *B. tectorum* and *B. hordeaceus*, are native to the Mediterranean region and have become invasive in North America. Those areas are characterized by dry climate. Therefore, the reason why these species are not able to spread in Japan may be that humid climate in Japan is maladapted for growth of these species.

P-142

Does *Penicillium rolfsii*, a fungus that stimulated germination of *Xyris complanata* seeds, stimulate germination of dormant seeds in a soil seed bank?

Masataka Hane[a], Ryosuke Tamura[a], Yanetri A. Nyon[b], Hanny C. Wijaya[c], and Yasuyuki Hashidoko[a]

[a] Graduate School/Faculty of Agriculture, Hokkaido University; [b] Faculty of Agriculture, University of Palangka Raya; [c] Faculty of Food Science, Bogor Agricultural University

Butenolide derivatives known as karrikins promote seed dormancy-breaking and induce active seed germination of the fire plants and Arabidopsis, and a karrikin (KAR1) also suppresses hypocotyl elongation in Arabidopsis seedlings. KAR1 induces upregulation of several genes, such as *STH7* (B-box zinc-finger protein gene) and *KUF1* (F-box protein gene). High responses of the higher plants to karrikins are likely beneficial for light competition with other plants after forest fire or bushfires, and the suppression of hypocotyl elongation is also beneficial for the seedlings to survive in relative dry lands. We have found that a saprophytic, ubiquitous fungus *Penicillium rolfsii* Y-1 strain induced germination of Hawaii yellow-eyed grass (*Xyris complanata*) seeds. As this fungus hypothetically produced a seed dormancy-breaking factor, we further screened some more *Penicillium* and *Talaromyces* fungi that could break seed dormancy of *X. complanata* and some other plants. Many of such fungi can produce secondary metabolites that possess a butenolide moiety, such as patulin (produced by *Penicillium* spp.), monascorubrin, and purpuride (both produced by *Talaromyces* spp.). Hence, we also assayed extract of the fungal culture fluids active in seed germination induction toward *X. complanata* seeds and a soil seed bank. For the latter case, fungal spores of the active isolates or EtOAc-solubles from their mycelial culture fluids (as 1000 times-diluted solution) were directly applied to herbicide-free, farmland soil bed in a deep Petri dish (60 mm i.d. × 60 mm height). We also examined another fungus, *Penicillium expansum*, obtained from a soil of Hokkaido University campus in Sapporo by the screening of patulin-producible *Penicillium* fungus. We show in this study that butenolide-like effects of these fungal metabolites towards some plant seeds and soil seed bank, and preliminary characterization of the hypothetical active substances using *STH7* and *KUF1* as marker genes for their KAR1-like activities.

P-143

Plant communities around *Spiranthes sinensis* in urban green spaces

Satoru Tanaka[1], Kou Inoue[1]

[1] Department of Landscape Architecture Science, Faculty of Regional Environment Science, Tokyo University of Agriculture, 1-1-1 Sakuragaoka, Setagaya-ku, 156-8502, Japan

Spiranthes sinensis is a perennial Orchidaceae species native to Japan. This flowering plant is particularly useful for improving urban landscapes. However, the habitat characteristics of this species remain relatively unknown. Here, we attempted to determine the types of plant communities within which *S. sinensis* occurs.

METHODOLOGY

The study sites were urban green spaces, such as parks or gardens around the Tokyo metropolitan area. The presence or absence of plant species within a 40-cm radius around individuals of *S. sinensis* at the flowering stage was randomly recorded. Phi coefficients were calculated using the statistical software R (R Core Team 2015).

RESULTS

Eighty-two *S. sinensis* sites were studied. Twenty-two weed species were recorded more than 4 times, the most frequent of which were *Oxalis corniculata*, *Zoysia matrella*, *Digitaria ciliaris* and *Trifolium repens*. The number of pairs of species is ${}_{22}C_2 = 231$.

Figure 1 was generated by connecting species pairs that coexisted at a significant rate ($P < 0.05$), according to Fisher's exact probability test and positive Phi coefficients. In the resulting diagram, certain groups of species formed 'ties' and 'rings' (Agnew 1961), and the species were divided into six groups, based on network theory (Brandes *et al.* 2008). These groups reflect site history, soil fertility, shading intensity of trampling and taxonomic group.

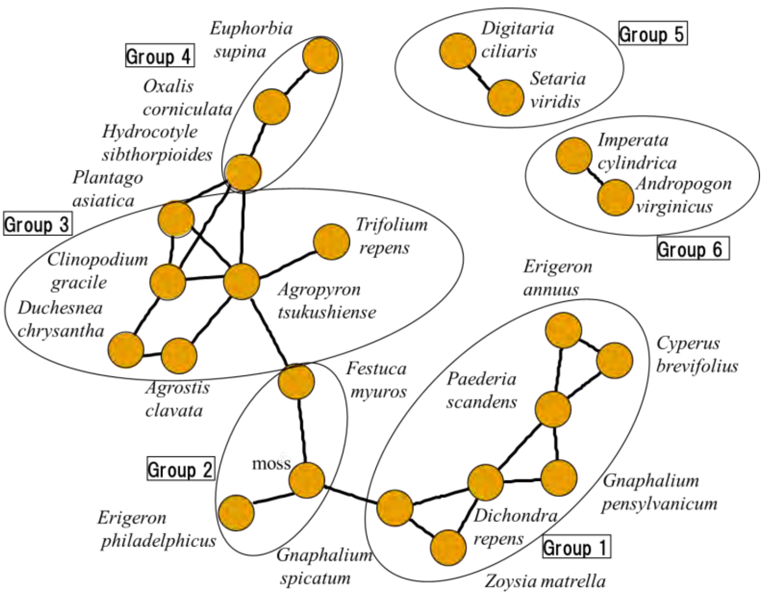
Species included in 'ties' and 'rings' reflect overlap between the realized niches of *S. sinensis* and neighboring weedy species. For example, *Hydrocotyle sibthorpioides* and *Plantago asiatica* may serve as indicators of *S. sinensis* habitat. In addition, the presence of *Clinopodium gracile* or *Agropyron tsukushiense* also increases the probability that the habitat is suitable for *S. sinensis*.

CONCLUSION

Our results indicate that plant species that form 'rings' are highly reliable indicators of the habitat of *S. sinensis*.

REFERENCES

Agnew 1961. *J. Ecol.* **49:** 83-102., Brandes *et al.* 2008. *IEEE Trans. Knowl. Data Eng.* **20:** 172-188.
R Core Team 2015. URL https://www.R-project.org/.



○ Group 1: Planted, but degraded lawn, *Zoysia matrella*, *Cyperus brevifolius*
○ Group 2: Infertile soil, *Festuca myuros*, *Erigeron philadelphicus*
○ Group 3: Semi-shaded, *Trifolium repens*, *Plantago Asiatica*
○ Group 4: Low trampling intensity, *Oxalis corniculata*, *Hydrocotyle sibthorpioides*
○ Group 5: Annual graminoid, *Digitaria ciliaris*, *Setaria viridis*
○ Group 6: Perennial graminoid, *Imperata cylindrica*, *Andropogon virginicus*

Fig. 1 Diagram of species relationships showing the positive correlations between species found at 82 sites of communities in which *S. sinensis* occurred.

P-144

Relationships of leaf age and plant height in *Panicum dichotomiflorum* and in *Eragrostis pilosa* had become the problem weeds at dry-seeded rice in Tohoku, Japan

Maiko Akasaka[1], Soichi Nakayama[1]

[1] Tohoku Agricultural Research Center, NARO, 4 Akahira, Shimo-kuriyagawa, Morioka, Iwate 020-0198, Japan

Recently, activities are promoting in Japan as below, some paddy fields were assembled and used as one large paddy field. Therefore, a rice cultivation in their fields has converted from transplanting to direct-seeding, especially, dry-direct-seeding. As a result, occurrences and infestations of Gramineae weeds, *Panicum dichotomiflorum* and *Eragrostis pilosa,* had not become the problems in paddy fields. Their infestations often cause reductions of rice yield.

It is possible that their weeds will die in conditions of submergence for a long time because they originally live in upland fields. Therefore, our research group aims constructions of integrated weed management combined submerged treatment and herbicidal treatment.

This presentation is going to discuss about potentials of their weed control by submerged treatment based on regular research findings of leaf age and plant height of *Panicum dichotomiflorum* and *Eragrostis pilosa* at infested fields in Tohoku region, Japan.

P-145

Aquatic weed community dynamics of Dal Lake in temperate valley of Kashmir Himalayas

Anil Kumar[1], R. Puniya[2], Ashu Sharma[3], Neetu Sharma[3] and QuaziTassaduqMueen[4]

[1]Advanced Centre for Rainfed Agriculture, SKUAST-Jammu
[2] AICRP-Weed Management, SKUAST-Jammu
[3] Division of Agronomy,SKUAST-Jammu
[4]Department of Horticulture, Rajbagh Srinagar, Kashmir

The Dal lake in Kashmir is a fresh water lake situated in the North-East of Srinagar at 34°7' N latitude and 74° 52' E longitude and at an altitude of 1584 m above MSL. It is probably of fluvial origin having been formed from the ox-bows of the river Jhelum. During the course of time, this lake has shrunk to a great extent due to encroachments and ecological stress from human activities that has also led to deterioration of its water quality with increased nitrate-nitrogen (from 88-642 to 133-2537 µg/l), ammonical nitrogen (from 6-27 to 103-789 µg/l) and total phosphorus (from 75-666 to 390-954 µg/l) over a period of time from 1977 to 2013 which has adversely affected the aquatic life. Further, the discharge of effluents, sewage, sediments and nutrient accumulation has made this lake eutrophic, which has resulted in over growth of aquatic weeds leading to decreased dissolved oxygen supply (from 3.6-10.6 to 1.5-9.6 µg/l in 36 years) to the lake. The predominent weed flora infesting the lake include *Typha angestata* H., *Phragmites mauritianus* K. among emerged macrophytes; *Salvinia molesta* L., *Hydrocharis dubia* L., *Nymphoides peltatum* L., *Nymphaea alba* L., *Nelumbo nucifera* J., *Potamogeton natans* M. & W. among floating macrophytes; *Myriophyllum verticillatum* L., *Ceratophyllum demersum* L., *Potamogeton natans* M. & W. among submerged macrophytes; and *Navicula bicephaloides* V., *Nitzschia accicularis* S., *Fragilaria crotonesis* L., *Scenedesmus obliqus* K., *Pediastrum duplex* M., *Tetraedron minimum* K., *Microcystis aeruginosa* K., *Merismopedia elegans* M. among the phytoplankton were observed in Dal lake in 1987. While large variation in weed floral diversity was also noted in 2008 and these were *Phragmites mauritianus* K., *Sparganium americanum* N., *Typha angestata* H., *Sagittaria subulata* B., *Myriophyllum verticillatum* L., *Carex kobomughi* O., *Alisma wahlenbergii* H., *Marsilea quadrifolia* L., *Polypogon fugax* L.D. among the emergent types; *Chara globularis* L., *Lemna minor* L., *Azolla pinnata* R.B., *Salvinia molesta* L. among the free floating types; *Nymphoides peltatum* L., *Trapa natans* L., *Hydrocharis dubia* L., *Nelumbo nucifera* J., *Nymphaea alba* L., *Potamogeton natans* M. & W. among the rooted floating leaf types and *Ceratophyllum demersum* L., *Hydrilla verticillata* L.F., *Myriophyllum verticillatum* L., *Najas marina* L., *Potamogeton natans* M. & W. among the submerged types. If timely weed management interventions are not done, then the lake may die of its own death. Hence, there is a dire need for large scale interventions that are needed to be done in a consortia mode with public-private participation to mitigate weed menace in the lake.

P-146

Zinc tolerance in four *Medicago sativa*

Hui-ping Dai [1]•Shuhe Wei[2,1*]

[1] Bio-resources Key Laboratory of Shaanxi Province, Shaanxi University of Techology, Hanzhong, Shaanxi 723001, P.R. China;

[2] Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, 110016, China

To evaluate the zinc (Zn) remediation capacity of four alfalfas species, the effects of different concentrations of Zn on plant growth, Zn uptake and translocation as well as uptake of other nutrients were investigated. The results showed that the Zn tolerance index of Aohan was significantly higher than other species. Among four species, Aohan had the highest concentration of Zn in roots, followed by Golden Empress, Sanditi and Longxi. Aohan had the highest bioconcentration factor (BCF) in leaves. Whereas, Sanditi and Longxi had the lowest BCF in stem and roots, respectively. The translocation factor of Golden Empress was significantly lower than other species. The Zn accumulation rate of Aohan was higher than other species regardless of the concentration of Zn. Longxi had the lowest allocation of Zn in leaves and Golden Empress had the lowest allocation of Zn in roots. The concentrations of other elements (Fe and Mg) in leaves were decreased with Zn additions, but the interactions between Zn and other elements in roots varied with species. These results indicated that suitable species of alfalfas could successfully be used for the phytoremediation of Zn contaminated soils.

* Correspondence: Dr. Shuhe Wei

Telephone: +86 (0) 15829863283

E-mail: shuhewei@iae.ac.cn or daihp72@aliyun.com

Acknowledgements

This work was financially supported by National Natural Science Foundation of China(41571300), Natural Science Foundation of Shannxi Province(2015JM3086) and Supported by Foundation of Gansu Key Laboratory of Biomonitoring and Bioremediation for Environmental Pollution(GBBL2015006, QBXTZ(P)-15-7).

P-147

[Title]

The utility evaluation of aerial high resolution images taken from a low latitude with a small drone in the detection of *S. angulatus* community

[Authors]

Osamu Watanabe

[Affiliation]

Faculty of Agriculture Shinshu University, Japan

[Abstract]

Sicyos angulatus is a rapidly growing annual vine, it is an invasive species and can eliminate other plant species, including crops, and can cover an area of land relatively fast. The spread of *S. angulatus* leads to degradation of crop fields, and it invades farmlands from river embankments and agricultural irrigation canals. In Japan, *S. angulatus* and *Pueraria montana* grow together on river embankments and around the agricultural fields at several locations, both species have similar leaf shape and size. In order to prevent the spread of *S. angulatus* distribution, an early detection is essential for the field. Drone technology has great advantages in real time data collected for agricultural land and surrounding environment, high resolution images are effective for identifying weed communities. High resolution aerial photographs can recognize the shape of leaves and enable image processing using several filters to segment the plant targets. This study conducted to investigate the utility evaluation of aerial high resolution images taken from a low latitude with a small drone (DJI Phantom4) in the detection of *S. angulatus* community. This study introduced the Trainable Weka Segmentation, a machine learning tool that leverages a limited number of manual annotations in order to train a classifier and segment the remaining data automatically. Once the classifier is trained, it can be used to classify either the remaining input pixels or completely new image data. In the process of supervised classification, the use of the filter of Gaussian blur, which performs edge detection, was effective for the segmentation of the *S. angulatus* community. Image classification by high resolution images and machine learning has great advantages for highly accurate identification of weed communities.

P-148

A labor saving method for raising *Zoysia japonica* vegetation on paddy field levees using plug shoot, growth retardant and herbicide

Tetsuro Muraoka[1], Jin-ichi Hashimoto[2], Akiu Tsuruya[3], Akihiko Matsuo[4]

[1] Japan Association for Advancement of Phyto-Regulators (JAPR), Head Office, 1-26-6 Taito, Taito-ku, Tokyo 110-0016, Japan
[2] JAPR, Research Institute Chiba-branch, 2894-1 Naruto, Sanmu, Chiba 289-1326, Japan
[3] JAPR, Akita Research Station, 85-1 Nakamachida, Kanezawanishine, Misato, Senboku, Akita 019-1235, Japan
[4] JAPR, Tokai Research Station, 83-3 Okade, Tamashiro, Watarai, Mie 519-0428, Japan

Weed management in levees has been heavy work for rice farmers in Japan. *Zoysia japonica* is a common turf-grass and is useful as a cover plant for paddy field levees, preventing the break of levee slopes with its roots, stolons and rhizomes as well as suppressing weeds, if dense vegetation is established. The methods to establish vegetation for pasture using plug shoots from sprigs of *Z. japonica* and to prevent weed interference to transplanted sods of *Z. japonica* on paddy field levees using growth retardants and herbicides, have been developed by Prefectural Livestock Experiment Stations (1995) and Hashimoto *et al.* (2008). We combined the above methods and made several technical improvements for labor saving of the *Z. japonica* shoot preparing and for the higher efficacy of weed management of levees.

By changing the cuttings for sprigs from rhizomes to stolons and shortening the length of a cutting from 7cm to segment with one node, the time for making sprigs became less than half of the above method. And the duration for nursing shoots from sprigs was reduced from over 60 days to 30-50 days, by using a plug tray for young seedlings (30cm x 60cm with 128 holes). Application of herbicide containing glyphosate before planting the shoots and that of bispyribac-sodium 3% L (0.5mL / m2) + asulam 37% L (1.5mL / m2) with 100mL water / m2 at one month after planting provided adequate efficacy of weed management to encourage the initial growth of *Z. japonica*. In particular, the content of asulam was increased for enough control of southern crabgrass (*Digitaria ciliaris*), most noxious grass weed in levees. Furthermore, repeating the application of bispyribac-sodium + asulam two or three months after planting and the next spring is recommended to obtain enough effect till the establishment of *Z. japonica* vegetation.

If this improved method spreads, the weed management of levees will become easier, and the levees of farm village could be covered with beautiful *Z. japonica*.

P-149

Labor-saving applications of rice herbicide with throw-in type jumbo formulation (granule pack) containing pyraclonil from levees in 1 ha scale paddy rice fields in Japan

Seok Weon Seo[1] , Ryoichi Nishihara [1], Masashi Hamaya[1] , Hitohisa Takahashi[1] ,
Yoshiharu Ikeda[1] and Satoru Andou[1]

[1] Kyoyu Agri Co., Ltd., Yamaman Building, Koami-cho 6-1, Nihonbashi, Chuo-ku, Tokyo,103-0016, Japan

The standard size of paddy fields in Japan is 0.3 ha (100 m × 30 m); however, field sizes have increased in recent years and 1 ha scale paddy fields are becoming more widespread. In Japan, as a labor-saving application method for paddy rice herbicides, the throw-in type jumbo formulation (granule pack) can be applied from the levee by hand, and thus does not require any applicator. Conventionally, in this application, the jumbo formulation is thrown from the levee when the short width of paddy field is less than 30 m. However, when it exceeds 30 m, throwing is conducted from both the levee side and the inside of paddy field to ensure the stability of the herbicidal effect. To further enhance the labor-saving properties of throwing the jumbo formulation, we examined the case of throwing the formulation only from the levees that do not enter the paddy field in 1 ha scale paddy fields. The products used were several commercially-available jumbo formulations containing pyraclonil, which is the most widely spread active ingredient in Japanese paddy fields.

The findings showed that even if the short width of the field is 100 m, the active ingredient spreads approximately uniformly through the paddy field and a high weeding effect is provided without any phytotoxicity to the paddy rice. It was also demonstrated that a higher level of labor saving is achieved than the conventional throwing of jumbo formulation in a 1 ha scale field. The application time of this method is now about 15 min/ha, half of the conventional method. This technology is already spreading in various regions and was authorized in April, 2017 by MAFF as "a rice growing technology to contribute to management innovation of growers".

P-150

A review of the herbarium of Institute of Plant Science and Resources, Okayama University

Jun Yamashita[1]

[1] Institute of Plant Science and Resources, Okayama University, 2-20-1 Chuo, Kurashiki 710-0046, Japan

Our laboratory of the Institute of Plant Science and Resources (IPSR, Okayama University) has been preserving wild plant seeds of 4,041 species, mainly of weed species, at refrigerators. We can supply them to researchers for joint studies. Now the basis of the genetic resources is our herbarium preserving voucher specimens.

IPSR herbarium consists of 70,281 registered voucher specimens of ca. 6,000 species. Among them, 11,014 were collected from foreign countries, and the remains from Japan. Those have been collected by the successive researchers of IPSR (Mantaro Kondo, Chiaki Miyake, Yasuo Kasahara, Takashi Enomoto, etc.) and many botanists (Sanae Nanba, Miyoshi Furuse, etc.). Dr. Kondo was the first president of IPSR, and the pioneer of seed science in Japan. His seed specimens (ca. 4,200 accessions) also have been preserved. In our herbarium, the tentatively oldest specimen was collected by Mr. Miyake in 1901. Dr. Kasahara was the pioneer of weed science in Japan. Recently, many unsorted (unregistered) specimens collected by them were newly found in our laboratory. Dr. Enomoto collected ca. 30,000 specimens. His (and his cooperators') weed collection of ca. 1,000 species is a main feature of our herbarium. He also produced the frozen seed bank of IPSR. Mr. Nanba is one of representatives of botanists who studied plants of Okayama Prefecture. Most of his collection (ca. 11,000 specimens) has been preserved at Okayama Prefectural Nature Conservation Center, and IPSR herbarium also has 1,441 specimens collected from 1932 till 1986. Mr. Furuse is one of the principal plant hunters in Japan. He had collected more than 150 thousands specimens, and our herbarium has the 600 specimens collected from 1952 till 1986. In addition, we have 5,580 specimens of threatened species in Japan. In conclusion, the IPSR herbarium includes the important materials for weed science and also for Japanese flora.

P-151

Soil- and weed-related problems following farmland decontamination post the Fukushima Daiichi nuclear power plant accident

Namiko YOSHINO[1], Motoaki ASAI[1] and Hiroyuki KOBAYASHI[2]

[1] Tohoku Agricultural Research Center, NARO, 50 Harajukuminami, Arai, Fukushima 960-2156, Japan
[2] Central Region Agricultural Research Center, NARO, 2-1-18 Kannondai, Tsukuba 305-8666, Japan

The Great East Japan Earthquake in 2011 caused Tokyo Electric Power Company's Fukushima Daiichi nuclear power plant accident, with radioactive materials (such as radioactive cesium) spreading into the environment, including farmland. Contaminated farmland was decontaminated via several methods depending on the degree of contamination. Farms with high contamination levels and within the evacuation area were decontaminated by removing the topsoil and subsequently dressing with fresh soil. Each decontamination method had some effect on the removal of radioactive materials from farms, reduction of air dose rate, and suppression of radioactive cesium absorption by crops; however, several other problems also occurred in the farms following decontamination. Therefore, through field surveys, we investigated and attempted to clarify these issues.

The nitrogen content of the dressed soil was considerably lower than that of the subsoil that was not stripped during decontamination, as a result of which the amount of dressed soil greatly affected the soil fertility of decontaminated farms. Furthermore, soil fertility was very uneven within each farm because the thickness of the dressed soil was not uniform.

Farms were bare following decontamination owing to the removal of the contaminated topsoil, including the aerial part of weeds and buried weed seeds. New weed seeds, however, immediately invaded from the surroundings, and arable weeds such as barnyard grass (*Echinochloa crus-galli* (L.) P. Beauv. var. *crus-galli*) quickly emerged. In farms where decontamination was late, the rhizome of perennial weeds, such as reed (*Phragmites australis* (Cav.) Trin. ex Steud.) remained in the subsoil and leveed during decontamination; therefore, these weeds flourished in the period just after decontamination, making weed management difficult until farming resumed. We believe that our study provides detailed insights into these issues and lays the foundation for possible countermeasures.

P-152

Effect of orthosulfamuron on sugarcane ripening

Kyosuke Miyamoto[1], Angelo Stasievski[2], Tiago Oliveira[2], Shuji Kumata[1]

[1] Nihon Nohyaku CO., LTD., Research Center, 345 Oyamada-cho, Kawachi-Nagano, Osaka 586-0094, Japan
[2] Nichino do Brasil AGROQUÍMICOS LTDA. Alameda Araguaia, 750 & 751, CJ 101-106 "Araguaia Plaza" 1st Floor Alphaville Industrial, Barueri-SP, 06455-000, Brazil

The chemical ripening is one of the most important crop management components for the sugarcane cultivation to improve and maintain its sugar content high by controlling the crop maturation through the harvest time. For this purpose, certain herbicides and/or plant growth regulators have been widely used as ripeners among farmers and industries, especially in Brazil.

Orthosulfamuron, which belongs to the sulfonylurea group and inhibits acetolactate synthase (ALS), was originally developed worldwide as a paddy-rice herbicide (Kelion®, Strada®) and was launched as a ripener (Sprint™) in Brazil afterward. In this report, we introduce the ripening effect of orthosulfamulon on sugarcane.

To characterize the biological performance of orthosulfamuron, 10 field trials were carried out from 2014 to 2016 in Brazil. The chemical was applied once with or without adjuvant (Assist®) on sugarcane during the ripening and maturation phase by a back pack sprayer or an aerial applicator. After application, some sugar yield components such as TRS (total recoverable sugar yield), AOL (apparent percentage of sucrose in juice) and Brix (total solids content present in the juice) were sequentially evaluated. Orthosulfamuron increased all of the parameters quantified from around 15 days after application (DAA) up to 60DAA at 75-100 g a.i./ha when compared with untreated control. On the other hand, the typical herbicidal injury, such as leaf burn and sugar yield decreasing, was not observed in all the trials. These results suggest that orthosulfamuron is one of the beneficial tools for sugarcane growers and industries to maximize their sugar yield by providing long harvest duration without the degradation of the high sugar content.

P-153

Seed characteristics related to weedy risk of hybrids between GM soybean and wild soybean

Minjung Yook, Hae-Rim Park, Jung Hyo Kim, Do-Soon Kim

Department of Plant Science, College of Agriculture and Life Sciences, Seoul National University, Seoul 08826, Korea

Genetically modified soybean is one of the major biotech crops and accounts for 50% of global area of GM crops. Soybean is believed to have originated from the East Asian region, so wild soybean species which can cross with GM soybeans inhabit wild areas. Despite no GM soybean cultivation in East Asian regions, the concern of unintentional gene flow from GM soybean to wild soybean and the consequential weedy risk has been growing because of increasing GM soybean import. Therefore, we conducted this study to characterize the seed traits related to weedy risk, including germination of hybrids resulting from gene flow from the GM soybean to the wild soybean. For seed phenotypes, pollen-donor GM soybean seeds were much bigger and heavier (about 15.0 g of 100 seed weight) than F2 hybrid (5.7 g), while pollen-recipient wild soybean and F1 hybrid seeds were the smallest and lightest (about 2.5 g). F2 hybrid seeds were brown, an intermediate between the yellow GM soybean seed and black wild soybean seed. These findings indicate that F1 hybrid seeds show similar characteristics to the wild soybean (maternal parent), while F2 hybrid seeds show an intermediate color and size between its two parents. For seed viability, F2 hybrid seed showed the intermediate traits between its parents in germination and dormancy rates, which were 35% and 65%, respectively. GM soybean showed no dormancy, while wild soybean showed greater than 90% dormancy. These results indicate that F2 hybrid show intermediate characteristics in seed germination with high dormancy trait, suggesting a potential weediness of hybrids resulted from gene flow from GM soybean to wild soybean. This research was supported by Rural Development Administration, Republic of Korea (Project code PJ012735; Project of LMO Environmental Risk Assessment Center).

Corresponding author: Do-Soon Kim, dosoonkim@snu.ac.kr

P-154

Bioherbicidal potential of *Typha angustifolia* L. extract

Srisom Suwanwong[1]*, Udomsap Chanthanet[1], Ornusa Khamsuk[1]

[1] Department of Botany, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand
* Corresponding author e-mail: fscisss@ku.ac.th

Narrow-leaf cattail (*Typha angustifolia* L.) is an invasive plant which produces and releases allelochemicals to the environment. In the present study, bioherbicidal effect of aqueous extract of leaves of *T. angustifolia* L. was investigated by using giant mimosa (*Mimosa pigra* L.) and shallot (*Allium ascalonicum* L.) as bioassay materials. Total phenolic contents in crude extract at the concentration of 25, 50 and 75 g/L were 196, 269 and 307 ppm, respectively. The extracts significantly inhibited seed germination and seedling growth of giant mimosa. Seed germinations were 91, 86 and 84 %, shoot lengths were 63, 44 and 30 % and root lengths were 21, 16 and 13 % of control when treated with 25, 50 and 75 g/L of the extract, respectively. Malondialdehyde in both shoot and root were not different from the control. It indicated that the inhibition of seedling growth did not cause by lipid peroxidation. Moreover, the extract also inhibited shallot root cell division by causing an arrest of cells in interphase. This effect was different from dinitroanilines which effect directly on the mitotic apparatus, but it was similar to the effect of alaninyl-analine on root meristem that the inhibition occurred before mitotic entry. Since lipid peroxidation did not affect seedling growth of giant mimosa and total phenolic content in the extract increased by increasing the concentration of the extract, the inhibition of root cell division was not the induction by oxidative stress, but it might be due to the effect of phenolic compounds in the extract.

Keywords: seed germination, seedling growth, cell division, *Mimosa pigra* L., *Allium ascalonicum* L.

P-155

Growth response of Poplar (*Populus deltoides*) entire transplants to weed interference

Navneet Kaur*, H Kaur, RIS Gill and MS Bhullar[1]

***Corresponding author Email:** navik20@pau.edu

Department of Forestry & NR; [1]Department of Agronomy, PAU, Ludhiana-141 004

Abstract

The raising of poplar nurseries is an important commercial activity in India; 25-45 million poplar entire transplants (ETPs) are transplanted in a year in India. Poplar ETPs (15-20 cm long cuttings, 2-3 buds) are first raised in the nurseries at 50 cm square spacing for one year. The longer duration and wider spacing of cuttings make the poplar nursery highly vulnerable to weed competition, especially during early stages of establishment, causing economic losses. The response of Poplar ETPs (clone L 48/89) to weed interference was studied in a field experiment conducted at Punjab Agricultural University Ludhiana, India in 2014 and 2015. Different levels of weed biomass were established in poplar nurseries by using various weed control approaches upto 90 days after planting of cuttings. Linear regression models for height and stem diameter of poplar ETPs, in response to weed biomass, showed negative correlations. Linear regression models indicated that weed biomass at 90 days after planting explained 81-83% and 74-76% variation in height and stem diameter of poplar ETPs during both years. The higher negative slope suggests more weed sensitivity of height compared to stem diameter of poplar ETPs. The slope in the function describing the relation between poplar height and weed biomass was steeper than stem diameter indicating higher reduction in poplar ETPs height (0.44-0.49 cm/g) than its diameter (0.05-0.06 mm/g) in response to increasing weed biomass. The weeds in the unweeded plots reduced poplar plant height by 10-11% compared to hand weeded plots. The higher intercept in height (510-514 m) suggests a better growth of poplar ETPs in nursery under no or low weed pressure. Weed abundance had adverse effect on poplar-morphological traits necessitating the use of appropriate weed control approaches for the production of quality nursery plants.

Key words: Poplar, forest nurseries, weed biomass, plant growth

P-156

Effectiveness of Several Selective Herbicides in Controlling General Weeds in *Cassia cobanensis, Antigonon leptopus, Turnera subulata and Euphorbia heterophylla* Beneficial Plants Establishment in Oil Palm Plantation.

Meor Badli Shah Ahmad Rafie[1] and Samsudin Amit[1]

[1] Sime Darby Research Sdn Bhd, KM10, Jalan Banting-Kelanang, P.O. Box 207, 42700 Banting, Selangor Darul Ehsan, Malaysia.

Beneficial plants like *Cassia cobanensis, Antigonon leptopus, Turnera subulata* and *Euphorbia heterophylla* were commonly established in oil palm plantation estates in Malaysia in order to attract natural predators and parasitoids for the biological control of bagworms and nettle caterpillar pests. A common problem for good establishment of these beneficial pants in oil palm plantations are weed management. Weeds are vigorous, infested and become more dominant than the beneficial plants since most of the beneficial plants were established in open space. Major weeds are broadleaved weeds such as *Asystasia gangetica and Mikania micrantha* and also grasses *like Otthochlo nodosa and Paspalum conjugatum.* In order to control the weeds, a special research on several selective herbicides was conducted to provide solutions to the plantation estates to manage weeds in the beneficial plants. Using selective herbicides that is not harmful or less phytotoxic to beneficial plants could solve the issue. Seven selective herbicides were evaluated in this research which are Clethodim, Fluazifop-p-butyl, Oxyfluorfen, Ametryn, Cyhalofop, MSMA, Sethoxydim and Bentazone. Results from the studies showed that Clethodim and Fluazifop-p-butyl were effective in controlling the grasses weeds that were infesting *C. cobanensis, A. leptopus, T. subulata* and *Euphorbia heterophylla* benefical plants without causing any phytotoxicity effect on the beneficial plants. However, both of the herbicides were not effective on the broadleaved weeds in all the beneficial plants. MSMA was capable to control the grasses and some broadleaved weeds but caused between 10 to 30% injury to *C. cobanensis, A. leptopus, T. subulata* and *Euphorbia heterophylla.* However, with MSMA, *C. cobanensis, A. leptopus* and *T. subulata* recovered after 42 days after treatment. Ametryn, Cyhalofop, Sethoxydim, Oxyfluorfen and Bentazone were not effective in controlling the weeds in all the beneficial plants.

Keyword: Weed Management, Selective Herbicides, Beneficial Plants, *Cassia cobanensis, Antigonon leptopus, Turnera subulata* and *Euphorbia heterophylla*

Remarks: This is not the final abstract, will submit the latest version once approval received.

P-157

Herbicide use and herbicide resistance in *Cyperus difformis* L. in Sri Lanka

HMS HERATH[1], RF HAFEEL[1], RSK KEERTHISENA[2], AP BENTOTA[2], AM BALTAZAR[3], V KUMAR[4] and DE JOHNSON[4]

[1]Rice Research Station, Ambalantota

[2]Rice Research and Development Institute, Batalagoda

[3] University of the Philippines Los Baños, Collage, Laguna, 4031, Philippines

[4] International Rice Research Institute, Los Baños, Laguna, Philippines

Weeds are the most important biological constraint to rice production in Sri Lanka. Herbicides use has increased tremendously in recent decades due to the rising costs of labor. The intensive herbicide use has caused a shift in weed populations, poor weed control and the occurrence of herbicide-resistant biotypes of weeds. This study focuses on herbicide use practices, weeds and possible existence of resistance in the dominant weeds to most popular herbicides in Hambantota district in Sri Lanka. Common herbicides used by farmers were Carfentrazone-ethyl 240g/1EC, bispyribac sodium and their pre-mixed formulation, clomazone 200g + propanil 400g/l, pretilachlor 30% EC, metamifop 10% EC and MCPA. Three main mode of action herbicide group popular among the farmers are protoporphyrinogen oxidase- inhibitors (PPO), ALS-inhibiting herbicides and acetyl CoA carboxylase (ACCase) inhibitors. Sedges are the predominant weed group and the most common species on farmers' fields were *Cyperus difformis* and *Cyperus iria*, while *Ischaemum rugosum* and *Echinochloa crus-galli* were the dominant grass species. Preliminary results of screening for herbicides resistance of *Cyperus difformis* indicate possible resistance to MCPA and bispyribac sodium 40g/l + metamifop100g/lSC. The ED_{50} values from the dose- response experiments indicated that R biotype of *Cyperus difformis* was 1.95 times resistant to MCPA than susceptible ones. The R biotype was 2.4 time resistance to bispyribac sodium 40g/l + metamifop100g/lSC than S biotype while, there was no evidence of resistance in *Cyperus difformis* to carfentrazone-ethyl 240g/1EC and which gave satisfactory control. It is crucial to educate farmers about diversifying weed management strategies to minimize evolution of herbicide-resistant weed populations.

KEY WORDS: *Cyperus difformis*, Herbicides, Resistance, Rice, Weeds

P-158

Weedy Rice: An expanding problem in direct seeded rice production in the Philippines

Leylani M. Juliano[1], Edwin C. Martin[1], Dindo King M. Donayre[1], Jesusa C. Beltran[1] and Roberto Busi[2]
[1]Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines
[2]Australian Herbicide Resistance Initiative, University of Western Australia, Perth, Western Australia

Weedy rice has been increasingly becoming an important weed in direct seed rice (DSR) which is planted to 35% of the 4.56M hectares rice area in the Philippines. Recent surveys indicated the urgent need to increase awareness on weedy rice to allow implementation of location-specific effective weed management strategies. DSR is adopted by >90% of the interviewed farmers especially in Sultan Kudarat and Cotabato in Mindanao and Negros, while >50% of the farmers in Batangas continue to establish rice by manual transplanting. About 70% of farmers in Mindanao and Negros noticed weedy rice presence in their farms between 2013 and 2015, and year 2000 in Batangas. At least 35% of farmers have weedy rice infesting 10-30% of their farms at densities up to 20 plants/m^2 in both rice growing seasons.

Majority of the farmers use saved rice seeds or do seed exchange to source planting materials hence, contamination of weedy rice, off-types, and other weed seeds can be high. Pigmented hulls contaminating 500g sample of saved seeds was high at 5%. An average 85% of the dehulled grains have normal pericarp and 1% pigmented (red) pericarp. A single sample of saved rice seeds can have as many as five weedy rice biotypes present. The morphological variabilty of weedy rice types (eg. awn) can can be used to educate farmers to identify weedy rice features and define potential methods to remove mechanically awned weedy rice from saved rice crop seeds.

Farmers are sufficiently aware of the damaging effects of weedy rice and continuous monitoring is needed as weedy rice and other weeds are a major evolving challenge of DSR systems. Priority should be given to minimize infestations of weedy rice and other co-evolving weed issues to sustain rice production and protect the income of small-holder farmers. Thus, a dedicated endeavor is required to identify and test for control solutions based on improved understanding of weedy rice.

P-159

PERFORMANCE OF UPLAND RICE *(Oryza sativa.* L) AS AFFECTED BY WEED CONTROL TREATMENTS, POULTRY MANURE AND STAND DENSITY

Danmaigoro1, O., Ishaya2, D. B. and Shabayan2, J. A. Y.

1Department of Crop Science, Federal University Dutse, 2Department of Agronomy, Ahmadu Bello University Zaria. 2Department of Agronomy, Ahmadu Bello University, Zaria.
Corresponding author: odanmaigoro@gmail.com 08108673326

ABSTRACT

Field trials were conducted in 2011 and 2012 cropping seasons at the Institute for Agricultural Research, Samaru, Zaria in the Northern Guinea Savanna ecological zone Nigeria to evaluate performance of upland rice as affected by weed control treatments, poultry manure and stand density. The treatments consisted of three rates of five weed control treatments (0.6 +0.4, 1.2 + 0.8, 1.8 + 1.2 kg a.i ha-1 propanil+2,4-D and poultry manure (0, 5 and 10t ha-1) factorially combined in the main plot while there were three stand density (2, 4 and 6 plants per hill) in the sub-plot given a total of 45 treatments. The treatments were laid out in a split-plot design with three replications. The result revealed that application of 1.2 + 0.8 kg.a.i ha-1 of (propanil+ 2-4 D) produced significantly larger leaf area, high leaf area index, higher crop growth rate, relative growth rate, net assimilation rate and grain yield of rice than the other rates but were comparable with the hoe weeded control. The application of 10 t ha-1 of poultry manure gave significantly larger leaf area, high leaf area index, higher crop growth rate, relative growth rate, net assimilation rate and grain yield of rice than the lowest rates and the control (0 and 5 t ha-1). The four plants per hill resulted in significant increase in leaf area, high leaf area index, higher crop growth rate, relative growth rate, net assimilatory rate and grain yield of rice and higher yield of rice in both locations. The study showed that application of 10 t ha-1 of manure, 1.2 + 0.8 kg a.i ha-1 of propanil+2, 4-D and four plants per hill gave the best yield of rice.

Keywords: Rice, poultry manure, herbicide, plant density and grain yield

P-160

Smart Biofumigation as a new and innovative technology for aggressive weed control under Organic and Global GAP Standards.

Mohamed Fathy SALEM
Organic Agriculture Research Unit, Department of Environmental Biotechnology, Genetic Engineering and Biotechnology Research Institute, GEBRI, University of Sadat City, Egypt.
*Corresponding author: salemkairo@gmail.com; Mohamed.salem@gebri.usc.edu.eg
Tel: 00201006639267

Abstract

In many developing countries worldwide, pesticide poisoning causes deaths for farmer's more than infectious diseases. Use of pesticides is poorly regulated and often dangerous in many developing countries. Its easy availability also makes them a popular method of self-harm by illiterate farmers. Weed control is considering the major obstacle for the farmers in the organic and Global GAP agricultural systems. Lower crop productivity in organic mainly related to the poor weed control. It is widely known, that losses caused by weeds exceeded the losses caused by fungal pathogens and agricultural pests. Under water-stress condition, weeds can reduce crop yields more than 50% through moisture competition alone. In the light of the environmental and toxicological problems created by herbicides, it has become necessary to develop the safety methods for controlling aggressive weeds. Smart biofumigation is a sustainable and innovative technology for weed control that was adopted recently by Dr. Salem in 2014 and can be used worldwide to cope with different soil conditions either alkaline, like those in the Middle East, or acidic soils, like those in Europe and Asia. Smart biofumigation not only solve the aggressive weed control but also both root-knot nematode and soil-borne plant pathogens control with eco-friendly technology. Moreover, our modified and innovative technology can be adopted and work efficiently against these aggressive weeds and soil contaminations by those pathogens and pests compared with other chemical pesticides i.e. Methyl Bromide that was banned since 2005 and cannot used in both Global GAP or Organic agriculture systems. We have to emphasize that our innovative technology has a positive role in climate change mitigation compared with other hazard herbicides and banned chemical fumigants by the United Nation. Finally, our innovative, smart biofumigation technology is Eco-friendly and cheap, feasible and can be applied worldwide. We achieved many great success stories for production of completely certified organic crops through this innovative technology without any weed problems. Smart biofumigation can provide a sustainable technology for weed control on the ground and move from

aspiration to fixed descriptive and existing agricultural production systems whether conventional, Global GAP, biodynamic or organic agricultural . We have to work together to protect our planet and to protect the environment for the new generations in a sustainable ways. We have to emphasize that the pesticides including herbicides exposures are increasingly linked to human immune suppression, hormone disruption, diminished intelligence, reproductive abnormalities and cancer.

Key words: Smart Biofumigation, Weed Control, Organic Agriculture, Biological Control, Climate Change Mitigation.

P-161

Evidence for rapid evolution in *Parthenium hysterophorus* L.

Asad Shabbir[1]*, Sadaf Rafiq[1], Sana Amin[1] and Steve Adkins[2]
[1]Ecology and Evolution Lab, Department of Botany, University of the Punjab Pakistan.
[2]School of Agriculture and Food Sciences, The University of Queensland Australia.

Parthenium hysterophorus L., commonly known as parthenium weed is a serious alien invasive weed in Pakistan and in many other parts of the world. In this study, we investigated various vegetative and reproductive traits of 4 native (Mexico, Brazil, Argentina, U.S.A) and 9 exotic (India, Nepal, Taiwan, Vietnam, South Africa, Bangladesh China, Australia, Ethiopia) populations of parthenium weed. Seeds of these populations were collected and imported from its native and introduced ranges and were grown in a glasshouse as common garden experiment. The average plant height (20%), shoot dry biomass (50%), root length (34%) and root dry biomass (57%) were observed to be higher in the introduced populations, while number of leaves (30%), leaf length (10%), leaf width (5%) and number of branches (38%) were found to be greater in the native populations. The native populations produced 65% more numbers of flowers as compared to the introduced populations. Furthermore, the flowering occurred at least 3 weeks earlier in native than non-native populations. These findings reflect that there exists considerable variation between traits of native and introduced populations of parthenium weed and some of traits may have rapidly evolved in the populations of introduced ranges.

P-162

Does phylogenetic similarity among upland weed species influence susceptibility to pre-emergence herbicides, pendimethalin, trifluralin, and flumioxazin?

Naomi Hosaka, Tetsuro Muraoka, Hirokazu Takahashi

[1] Japan Association for Advancement of Phyto-Regulators, 860 Kashiwada, Ushiku, Ibaraki 300-1211, Japan

For the purpose of herbicide registration in Japan, it is required to submit results of the efficacy tests on naturally occurring weeds in crop fields. Japan Association for Advancement of Phyto-Regulators (JAPR) is the institution which provides and accumulates the results of efficacy tests for every herbicide product registered in Japan. Using the results of efficacy tests on broad range of herb and grass species occurred in crop fields throughout Japan, we investigated whether their susceptibilities to herbicides associate with phylogenetic similarity among weed species.

Products of most popular pre-emergence herbicides that consist of either pendimethalin, trifluralin, or flumioxazin as a single active ingredient, respectively, were focused and analyzed with those efficacy datasets obtained from 2003 to 2015. Susceptibility to the herbicides were evaluated for each weed species based on the biomass remaining after application in the efficacy tests (N=2403). Of all evaluated species, we investigated 55 species whose sequence information from chloroplast gene *rbcL* were available from the GenBank database. The phylogenetic tree was constructed based on the Unweighted Pair Group Method with Arithmetic mean (UPGMA) method with the Kimura's 2-parameter model.

The results indicated that species in the cluster including *Amaranthus* are most sensitive to all the tested herbicides, and the susceptibilities of the other weed species were higher as their genetic distances were closer from *Amaranthus hybridus*. On the other hand, there was considerable variability in susceptibility to pendimethalin and trifluralin within the cluster including Asteraceae. Variation in susceptibility to flumioxazin was observed within the cluster including Poaceae. Characteristics of weed species relating the susceptibility to the pre-emergence herbicides was discussed.

P-163

Bispyribac Sodium-Resistant Sedges in Rice Fields of Sri Lanka

R.M.U.S. Bandara[1], B. Marambe[2], A.P. Bentota[1], R.S.K. Keerthisena[1], A.S.K. Abeysekara[1], H.M.S. Herath[1], V.R. Kumar[3], H.M.M.K.K.H. Dissanayaka[1], Y.M.S.H.I.U. De Silva[1], and D.M.C.B. Dissanayake[1]

[1] Rice Research and Development Institute, Batalagoda, Ibbagamuwa, Sri Lanka

[2] Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka

[3] International Rice Research Institute, Los Baños, Philippines

Widespread evolution of herbicide resistance in weed populations in intensive crop production systems is a major threat to the sustainability and profitability of cropping systems. As the rate of introduction of new herbicides has slowed dramatically, there is a strong need to use currently available herbicide resources in a more sustainable manner. Failure of several herbicides to control weeds has been reported in many instances. The objective of this study was to identify development and resistance of weeds in paddy fields to Bispyaribac sodium. Seeds of major weed species in lowland paddy fields namely, *Echinocloa crus-galli, Ischaemum rogosum, Isachne globosa, Cyperus iria, Cyperus difformis, Fimbristylis dichotoma and Aeschynomene indica* were collected during the in 2015 from Batalagoda in Sri Lanka, where poor control of these weed species have been observed (potent-R) against Bispyribac sodium. Seeds of susceptible (S) biotypes of these species were also collected from paddy fields without exposure to herbicide application for more than a decade, located at the Rice Research and Development Institute at Batalagoda. All selected weeds seeds were germinated in pots with three replicates each during September 2015 to February 2016 (major cultivating season). The recommended dosage (300 ml/ha) of a commercial product of Bispyribac sodium 100 g/L SC was sprayed at 14 days after seeding. Water was impounded at three days after spraying. The percentage mortality of each weeds were recorded 10 days after spraying. Weeds, which showed a poor mortality, were selected for the dose response experiments. The response of potent-R and S biotypes was assessed at a at Bispyribac sodium dosages ranging from 25% lower to 25% higher than the recommended dosate. The percentage mortality was recorded and the dose-response curves were plotted for each tested weed species of R and S-biotypes. The ED_{50} for both R and S types were calculated. For *C. iria*, the ED_{50} value for the R-biotype of was 305 ml/ha and S-biotype 230 ml/ha, while that for the R-biotype of *C. difformis* was 305ml/ha and S-biotype was 240 ml/ha. . The ED_{50} value for the R-biotype of *F. dichotoma* was 310 ml/ha and the S-biotype 230 ml/ha. Results revealed that sedge weeds such as *C. iria*, *C. difformis* and *F. dichotoma* have developed resistance to Bispyribac sodium (100g/L SC) while *E. crusgalli, I. rogosum, I. globosa* and *A. indica* have not developed resistance to this herbicide at its recommended dosage. Alternate weed control strategies, including use of herbicides with different modes of action, are recommended to avoid resistance development of major weeds in paddy fields of Sri Lanka.

Key Words: Herbicide-resistant weeds, bispyribac sodium, susceptible biotype, resistant biotype, Mode of action, paddy fields

P-164

Occurrence Characteristics of Weed Flora in Arable Fields of Korea

In-Yong Lee[1], Young-Ju Oh[2], Sun-Hee Hong[2], Su-Jeoung Heo[3], Chae-Young Lee[4], Kee-Woong Park[5], Seng-Hyun Cho[6], Oh-Do Kwon[7], Il-Bin Im[8], Sang-Kuk Kim[9], Deok-Gyeong Seong[10], Young-Jae Chung[11], Chang-Seog Kim[12], Jeongran Lee[1], and Hyun-A Seo[1]

[1]National Institute of Agricultural Sciences, RDA, Wanju 55365, Korea
[2]Institute for Future Environmental Ecology, Jeonju 54844, Korea
[3]Gangwon-do Agricultural Research & Extension Services, Chuncheon 24226, Korea
[4]Chungchengbuk-do Agricultural Research & Extension Services, Chengju 28130, Korea
[5]Chungnam National University, Daejeon 34134, Korea
[6]Jeollabuk-do Agricultural Research & Extension Services, Iksan 54591, Korea
[7]Jeollanam-do Agricultural Research & Extension Services, Naju 58213, Korea
[8]Bio-Plant Environment Research Center, Gwangju 62399, Korea
[9]Gyeongsangbuk-do Agricultural Research & Extension Services, Daegu 41404, Korea
[10]Gyeongsangnam-do Agricultural Research & Extension Services, Jinju 52733, Korea
[11]Shingyeong University, Hwaseong 18274, Korea
[12]National Institute of Crop Science, RDA, Pyeongchang 25342, Korea

The nationwide weed survey was conducted in arable land, paddy field, upland, orchard and pasture, over whole country of Korea during 3 years from 2013 to 2015. Also, these survey were conducted in order to determine a change of weed community and to identify a major dominant weed species, and problem weeds. Weeds of arable land were composed of 619 species belonging to 81 families. Weeds occurred in paddy field were 90 species belonging to 28 families, upland weeds were 375 species of 50 families, orchard weeds were 492 species of 63 families and pasture weeds 275 species of 52 families. Among total 81 families, the Asteraceae (15.5%) was the biggest family, followed by Poaceae (13.1%), Polygonaceae (6.3%), Fabaceae (5.5%), Cyperaceae (5.2%), respectively. And these weed species were composed of summer annual of 209 species (33.8%), winter annual of 102 species (16.4%) and perennial of 308 species (49.8%). Exotic weeds naturalized in Korea were investigated as 166 species. Weed flora in Korean cultivation area have been increased as much as 13 families and 186 species for 10 years compared to 2000~2004 weed survey result of 68 families and 433 species. The increment could be resulted from the change of weed population such as increase of the herbicide-resistant and the difference of investigation method.

P-165

The effect of herbicides on physiological and biochemical responses in oil palm roots correlate with *Ganoderma* disease incidence.

Mohd Hefni Rusli[1], Idris Abu Seman[1]

[1] Malaysian Palm Oil Board. No.6, Persiaran Institusi, Bandar Baru Bangi, 43000Selangor, Malaysia.

Oil palm (*Elaeis guineensis*) is one of the major commodities in Malaysia with export earning amounting to RM64.8 billion. Basal Stem Rot (BSR) caused by *Ganoderma* has been identified as major disease of oil palm in Southeast Asia especially in Malaysia and Indonesia. Since the disease has caused significant losses, the control and management of the BSR disease is crucial. Predisposing factors such as the effect of herbicide applications need to be studied as some herbicides were reported to increase plant susceptibility towards plant pathogens. Therefore, the effect of herbicides on physiological and biochemical reactions of oil palm root seedlings were studied. Eight selected herbicides were used (metsulfron-methyl, triclopyr butoxy ethyl ester, paraquat dichloride, glyphosate isopropylammonium, glyphosate monoammonium, diuron and monosodium methylarsenate and sodium chlorate) and selected based on the phytotoxicity study on oil palm seedlings. Based on the results obtained via Scanning Electron Microscope (SEM) observations, plant roots treated with most of the herbicides showed large numbers of cell ruptures near the meristem of axes particularly plants treated with diuron (92.73% DI) followed by monosodium methylarsenate and metsulfuron-methyl (83.27% DI) and glyphosate isopropylammonium (73.81% DI). The root damages observed also coincided with the reduction and imbalance of targeted phytohormomes (involved in plant growth regulation and plant defense system) in biochemical study whereby in plants treated with Diuron, results showed that the expression of auxin was reduced from 103.3 ng/g to 30.1 ng/g, kinetin (21.81 ng/g to 4 ng/g), zeatin (29.88 ng/g to 11.92 ng/g) and AA (0.14 ng/g to 0.081 ng/g). Therefore, this study shows that oil palm seedlings treated with herbicides such as Diuron could be susceptible to Ganoderma infection due to the physiological injury and reduction in expression of plant defense system caused by the herbicide.

P-166

Herbicidal characteristics of crude extracts from soil bacteria *Streptomyces* sp. G0299

Choi Jung Sub[1*], Young Sook Kim[1], Jae Deok Kim[1], Young Kwan Ko[1] and Kee Woong Park[2]

[1]Eco-friendly and New Materials Research Center, Korea Research Institute of Chemical Technology, 141 Gajeong-ro, Yuseong-gu, Daejeon 34114, Republic of Korea

[2]Department of Crop Science, Chungnam National University, Daejeon 34134, Republic of Korea

Widespread application of chemical herbicides has resulted in negative impacts on human health and environment, and also led to evolution of herbicide resistant weeds. In recent years, there has been a rising interest in the discovery of environment-friendly bio-herbicidal compounds and biocontrol agent. Isolation and structural identification of natural herbicide active compounds from soil *Streptomyces* has been proposed as one of effective approaches for novel lead discovery of bio-herbicides. In this study, a total of 600 different *Streptomyces* isolates were recovered from 12 different locations in Korea. All of the 600 isolates were tested for their herbicidal activity toward a grass weed, *Digitaria sanguinalis*. For the foliar application study, the culture filtrate of the isolate G0299 showed phytotoxic activity to *D. sanguinalis* and herbicidal activity at a concentration of 500, 250, 125 and 62.5 ㎍/㎖ was 100%, 98%, 70% and 40%, respectively. The isolate G0299 showing sequence similarity to *Streptomyces drozdowiczii* strain NRRL B-24297 (99% similarity) was identified as *Streptomyces* sp. G0299 by phylogenetic analysis based on 16S rRNA gene sequence. The herbicidal metabolite, G229M obtained from the broth filtrate was separated by HP20, C_{18}, Sephadex LH20 column chromatography and high performance liquid chromatography (HPLC) and identified by ESI-MS, ^{1}H-, ^{13}C- NMR and 2D- NMR analyses. The active compound, G229M was exhibited only strong herbicidal activity against *D. sanguinalis* in the light condition. Phytotoxic symptoms of the G299M by foliar application were initial water-soaked spot and finally plant death by leaf burn-down. Further studies in herbicidal spectrum and activities are necessary to develop a natural herbicide.

P-167

Effect of rice establishment methods on weed shifts

V. Pratap Singh, Arunima Paliwal, S.P. Singh, Tej Pratap and A. Kumar

Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand 263 145, India

Weed shifts occur when weed management practices do not control entire weed population. Establishment methods had great influence on weed flora distribution in rice. Traditionally, rice is grown by transplanting in puddled situation which weakened natural resource base with hampering the crop yield due to its association with constraints like labour, weeds etc. Weeds alone reduce the crop yield and deteriorate quality. Further, question arises with conventional rice cultivation due to ever increasing energy prices, limited water and labour availability, sequential use of herbicides for weed control etc. So, there is need to switch with an alternative production system, which could conserve natural resources and effectively control weeds. Hence, field experiment was conducted at NEBCRC of G.B.P.U.A.&T, Pantnagar during *kharif* 2012-16, under strip plot design with 15 treatments, comprising 5 tillage methods in vertical and 3 weed control measures in horizontal strips. Weed shift was found with different rice establishment methods during five years study with *kharif* 2012 as base year and *kharif* 2016 as final. The studies demonstrated at 60 DAS, grasses were dominant over BLWs and sedges under TPR with or without *Sesbania* green manure during 2012, which later shared dominance under zero till rice with retention of residues and *Sesbania* brown manure followed by conventional TPR during 2016. However, BLWs showed a negligible shift among different establishment methods, but it was highly reduced under TPR with *Sesbania* green manure during 2016 compared to 2012. While, the sedges density showed huge shift from zero till rice with residues retention and *Sesbania* brown manure to direct sown rice with *Sesbania* incorporation during 2016 compared to 2012.

List of Sponsors and Supporting Societies

APWSS2017 is grateful for the support of the following organizations:

Platinum Sponsor

BAYER Science For A Better Life

Gold Sponsors

BASF We create chemistry

KUMIAI CHEMICAL INDUSTRY CO., LTD.

SDS Biotech K.K.

syngenta

Silver Sponsors

Dow AgroSciences Japan Limited

Kyoyu Agri Co., Ltd.

Bronze Sponsors

HOKKO CHEMICAL INDUSTRY CO., LTD.

ISK Ishihara Sangyo Kaisha, Ltd.

三井化学アグロ株式会社

Nihon Nohyaku 日本農薬株式会社

Nissan Chemical Industries, Ltd.

SUMITOMO CHEMICAL

Exhibition

Japan Association for Advancement of Phyto-Regurators

Advertisement

Japan Agricultural Aviation Association
Japan Analytical Chemistry Consultants Co., Ltd.
Maruwa Biochemical Co., Ltd.
Sumitomo Chemical Garden Products, Inc

Supporters

Kyoto Convention & Visitors Bureau
The Kyoto University Foundation
The Japan World Exposition 1970 Commemorative Fund
The Weed Science Society of Japan

Author Index

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

T

U

V

W

X


地球へのやさしさは人への思いやり
私たちは環境分析、残留農薬分析を通じて社会のお役に立ちたいと願っています。

住友化学園芸

ニッポンの、ファイン。

家庭園芸用殺虫スプレー

販売実績No.1※

ベニカXファイン®スプレー

使いやすくて、効果が続く。
植物の害虫と病気の防除を一本で。

野菜には
（トマト・なす・きゅうり・いちご）

ベニカグリーン®Vスプレー

※ 外部調査会社データベースでの店頭売上金額より家庭園芸用殺虫、殺菌スプレーのカテゴリーを抽出（2013年3月～2016年2月・自社調べ）

⚠ 使用に際しては必ず商品の説明をよく読んで、記載内容に従ってお使いください。

（eグリーンコミュニケーションは住友化学園芸（株）の登録商標）

eグリーンコミュニケーション
e-green communication

www.sc-engei.co.jp 住友化学園芸株式会社 〒103-0016 東京都中央区日本橋小網町1-8

●商品についてのお問い合せ先 TEL03-3663-1128（9:30～12:00／13:00～16:30／土・日・祝日を除く）

自然に学び 自然を守る
クミカ

Create the future

未来を拓く

KUMIAI CHEMICAL INDUSTRY CO., LTD.
4-26, Ikenohata 1-chome,Taito-ku,TOKYO 110-8782 JAPAN
+81-3-3822-5036　HP : http://www.kumiai-chem.co.jp/english/

Bayer's Integrated Weed Management

Bayer's Integrated Weed Management program is a holistic approach to weed control

COUNCIL® prime · COUNCIL® complete · Innova®

Ronstar® · Ricestar® Xtra · Ricestar® · topstar® · sunrice® SUPER · LAUDIS · ADENGO®

BecAno® · ATLANTIS® · sakura® · VELOCITY® · Puma® SUPER · SIGMA® · Capreno®

Alion® · basta® · sencor® · Balance® · Destiny® · Spect(i)cle® · Tribute®