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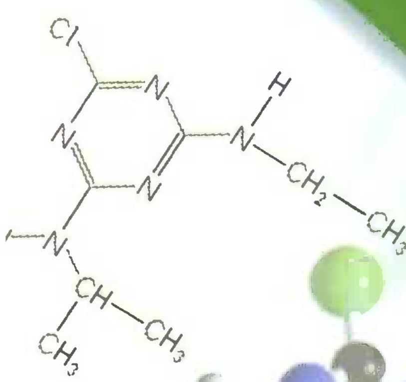

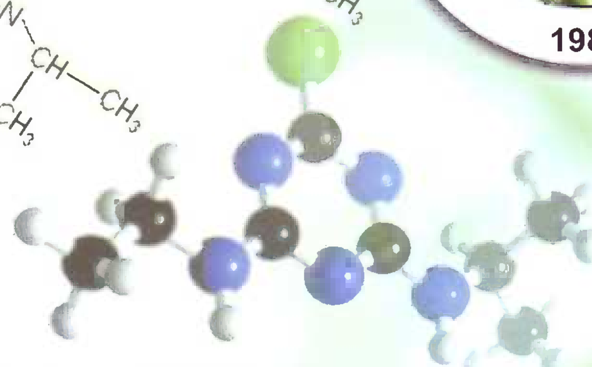

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ETHICS FOR WEED SCIENCE

Robert L. Zimdahl[1]

ABSTRACT

Those engaged in agriculture including the sub-discipline - weed science possess a definite but unexamined moral confidence or certainty about the correctness of what they do. This paper examines the origins of that confidence and questions its continued 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 and weed science is potentially harmful because it is unexamined. This paper advocates analysis of what it is about agriculture's moral confidence and its interactions with the greater society that inhibits or limits agriculture's development and contributions. All engaged in agriculture should strive to nourish and strengthen the aspects of agriculture 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.

Keywords: Weed science, work ethics, agriculture

INTRODUCTION

I begin with a story and a conundrum (a puzzle). In his 1999 book, “The Lexus and the Olive Tree”, Thomas Friedman, the New York Times Chief Foreign Correspondent, tells about the lion and the gazelle. He said, “Every night lions go to sleep knowing that in the morning when the sun comes up, if they can't outrun the slowest gazelle, they will go hungry. Every night gazelles go to sleep knowing that in the morning, when the sun comes up, if they can't outrun the fastest lion, they will be eaten. The one thing lions and the gazelles both know when they go to sleep each night is that in the morning, when the sun comes up, they had better start running”.

My observation is that many colleagues in agriculture are in a hurry; they are running. Everyone seems to be in a hurry to get to work, to lunch, to get home. Life is going too fast. There is not enough time to do all that must be done and very little time left to do what one wants to do. We drive and walk as we speak on our cell phones. We multi-task, work at the office and at home.

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Why are we running? The lion and the gazelle know why they are running. I am not sure we know either why we are running or where we are going. People in developed countries are, on average, 4 $^{1/2}$ times richer than their great-grandparents were at the end of the 19th century. But, they are not $4^{1/2}$ times happier. Greater consumption and more running have not made consumers any happier.

As we run to do so many things, we are trapped by the Conundrum of Consumption. A conundrum is a puzzle that has no satisfactory solution. The conundrum of consumption is an ethical and environmental problem. The conundrum is: limiting the consumer life-style to those in our world who have already attained it is not politically possible, ecologically sufficient, or ethically defensible.

The puzzle (the conundrum) is that if the life-style of developed nations is extended to all who want it, and many do, it will hasten the demise of the ecosystem that all are dependent on *and* it is ethically wrong to harm the system life depends on.

When you get up tomorrow morning, probably sometime after the sun comes up and you begin another busy day, perhaps with a running start, I suggest you think about where you are going and why you are running. We run in our scientific careers to do the experiments, write the papers, or get a grant. We run in our personal life to balance family and work, to care for others, and provide a good life for those we love. We run in our ethical life as we struggle to determine how to know what we ought to do. I ask myself and encourage you to ask if your running, your haste, causes you to miss important things.

Moving to the ethical realm and ethical assumptions, I ask "Does your running lead to greater happiness for you and others? Is achieving happiness for others something we simply assume will follow from our work? Should happiness for others be a goal of our work?"

I think all people may achieve the greatest happiness for themselves and others when their lives and work develop a capacity to feel the pain of other humans. The ethical position of agricultural science and of your research and teaching has a role in creating more or less happiness in the world. It is up to us.

Agricultural scientists have assumed that as long as our research and the resultant technology increased food production and availability, agriculture and its practitioners were somehow exempt from negotiating and re-negotiating the moral bargain that is the foundation of the modern democratic state (Thompson, 1989). It is a moral good to feed people and agriculture does that. Therefore, we assume that anyone who questions the morality of our acts or our technology simply doesn't understand the importance of what we do. We assume that we are technically capable and that the good results of our technology make us morally correct. Berry (1981) questions our assumption and reminds us of our obligation. We have lived by the assumption that what was good for us would be good for the world. We have been wrong. For it is only on the condition of humility and reverence before the world that our species will be able to remain in it.

How Do We Know What To Do?

An important question is - In view of the Conundrum of Consumption: "How do we know what to do?"

During what is called the axial age (900 to 200 BCE) all four of the world's major religions developed (Islam, Christianity, Hinduism, and Buddhism). Geniuses pioneered entirely new kinds of human experiences. Analysis of the time and what was created shows that what mattered in all religions was not what you believed, not your faith, but how you behaved. Religion was about doing things that changed you. It is one way to determine the right thing to do. By doing, by acting in the world, one can commit to an ethical life. Without self-understanding and self-sacrifice that are part of an ethical life, we will not progress toward the mutual goal of peace.

By the 17th century the scientific revolution marked the beginning of a whole new cosmology and world view that characterizes modern science. Traditional religious beliefs were not rejected but were seen as only indirectly relevant to understanding the natural world. They were no longer the only way to determine the right thing to do.

Comments about how all religions were concerned with doing things that changed you and determining the right thing to do may seem strange inclusions in a talk about ethics for weed science. But they are a useful example of how to determine the right thing to do, how to behave, how to become ethical scientists.

Ethics is also about doing things that change you. Ethical standards lead to the moral life - to live for others. To look beyond self-interest and extend one's activities to include others are common to all religious traditions[1].

Ethical standards guide people toward abandoning greed, selfishness, violence, and hatred and accepting an obligation to be compassionate toward their fellow humans. If one's ethical standards compel acting compassionately, to feed the hungry, give drink to the thirsty, welcome the stranger, and visit the imprisoned, regardless of who they are or why they are hungry, thirsty, strange, or imprisoned,

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[1]***Islam*** - No one of you is a believer until he loves for his brother what he loves for himself, ***Christianity*** - All things whatsoever ye would that men should do to you, do ye even unto them, ***Confucianism*** - Never do to others what you would not like them to do to you, ***Judaism*** - Thou shalt love thy neighbor as thyself, ***Hinduism*** - Men gifted with intelligence...should always treat others as they themselves wish to be treated, ***Taoism*** - Regard your neighbor's gain as your own gain, and regard your neighbor's loss as your own loss.

then such people are good, helpful, and sound. This may be one of the best tests of our ethical behavior in life and in the practice of agriculture.

However, I always ask myself, “How can I determine what to do? How do I know that what I choose to do is the right thing?” My task is to address and perhaps answer those questions. Scientists know what to do through experiments. The scientific **empiricist** goes and looks. We can know **pragmatically**. We test validity by practical results. What works best? Or we can be **skeptical** where the truth must always be in question. Each of these is an acceptable way to determine what is right.

There are other, more common, ways that many people use. We rely on **authority** - the government or a parent (My father says...). We rely on **tradition** - we have always done it this way in my family, church, or community, or in my university or research center. We rely on **legal authority** - it’s the law! We can know by **revealed truth** - found in religion. The latter is often done without examination to determine if we think we see the whole world when we tend, often in spite of our best efforts, to see only one aspect and think we have grasped the whole.

Finally, and of greatest importance this morning, we can know what is right by **reason**. Reason is the ability to think, form judgments, and draw conclusions. It requires thought and judgment based on logic and sound reasons. It is not easy.

Many ignore the simple test of their work - their ethical standard. What are the results? If their ethical standard makes them intolerant and unkind, the results are not good, independent of profit, crop yield, or scientific prestige. If, on the other hand one’s ethical standards compel acting compassionately toward others (feed the hungry, give drink to the thirsty, welcome the stranger and visit the imprisoned, regardless of who they are or why they are hungry, thirsty, strange, or imprisoned,) then such people are good.

We are all born with a sense of what is right and wrong, but that sense is often unexamined and not supported by careful reasoning. We must strive to be good in our personal lives and in our science.

The truest test of the moral condition of any scientific or other discipline is its willingness to examine its moral condition. As one explores agriculture’s dilemmas to determine what ought to be done rather than just what can be done, one finds surprising agreement about the standards used to decide what ought to be done. When we know the right and wrong things to do, there will still be conflicts, and there will still be choices as we seek answers to agriculture’s complex problems. There are often no easy choices between what is ethical and clearly not ethical. The choice is between two alternatives, neither of

which is all bad. And the end result of choosing is often not clear when the choice has to be made. Moral dilemmas are common and we need an ethical foundation to guide decisions between two choices where each has strong supporting arguments. For example: 1) Should we increase agricultural production, to feed more people, regardless of the environmental harm the technology that creates the production causes?; (2). Should we raise animals in confinement if it is harmful to the animals but makes meat cheaper for consumers?; (3) Should we mine water from deep aquifers or the Indus river to maintain irrigated farms in dry land areas even though the production system is not sustainable?; (4) Should we change soybean production systems to decrease soil erosion?; (5) Should we decrease nitrogen fertilizer use to reduce effects on fish and ecological stability?; (6) Should family farms be protected or allowed to die because they are economically inefficient, that is, they can't make sufficient profit?; (7) Should the US give more or less food aid to developing countries?;
(8) Should we accept or reject agricultural biotechnology?; and (9) Should we reduce herbicide and other pesticide use?

All the things in this partial list are difficult dilemmas for agriculture and each has a moral dimension. They are not just scientific questions. It is time for all involved in agriculture to think about and address the ethical dimensions of these and similar questions. It is our responsibility to provide the next generation of agriculture's practitioners, scientists and teachers with the intellectual tools required to guide decisions about agriculture's existing and future ethical dilemmas (Chrispeels, 2004).

However, my task today is not to comment on weed management. My task is to provide reasons for moral examination of our science and comment on how it can be done. I begin with three points about science and agriculture*, viz.* (1) Those engaged in agriculture are certain about the moral correctness, the goodness, of their activity; (2) The basis of that moral certainty (the supporting reasons) is not obvious to those who have it, and (3) In fact, agriculture's moral certainty is potentially harmful because it is unexamined by most of its practitioners.

Moral certainty and lack of moral debate inhibit discussion about what agriculture ought to do. Discussions of moral dilemmas will lead to foundational moral theories that provide a guide for change. These theories are guides, not absolute rules. They are the invisible, foundation on which our actions rest. Exploration of the moral certainty posited for agriculture will reveal several principles that can be used to answer important questions about agricultural practices.

The Benefits and Costs of Modern Agriculture

The success of modern agriculture may be the greatest story never told (Sidey, 1998). Few segments of the world's scientific-technological enterprise have such an impressive record. Developed country agriculture is a productive marvel and is envied by many societies where hunger rather than abundance dominates. Science and technology have created steady yield increases through development of higher yielding cultivars, synthetic fertilizers, better soil management, mechanization, and improved pest control (including weeds). Without yield increases since 1960, 10 to 12 million square miles would be required (roughly the land area of the U.S., the European Union and Brazil) to achieve present food production (Avery, 1997). Modern high yield agriculture may not be one of the world's problems but rather the solution to providing sufficient food for all, sufficient land for wildlife, and protecting the environment.

Agricultural producers are proud of these achievements. In the USA, the food production system is part of a large, vertically integrated commercial system (Blatz, 1995). The family farm as an independent and self-supporting entity is dying. As the number of farmers decreases, land in agriculture remains nearly constant because farm size increases. I suspect a similar, slower process in Pakistan: agriculture accounts for 25% of GDP, supports 3/4 of the people, and employs ½ the labor force.

When small farms and farmers disappear it is usually regarded as progress. There is little concern for the effects of the profit driven system that harms small farmers on the environment on which agriculture and life are dependent. The monetary rewards of the modern agricultural system have been good for the survivors. The social rewards of belonging to a caring community, the spiritual satisfaction of serving a larger public purpose, the communities and the businesses they need and support have been sacrificed to the bottom line (Goldschmidt, 1998). This is neither necessary nor desirable.

Successful agriculture has become a business in which producers seek high production at low cost. Agriculture in developed countries has become industrialized in terms of its size and methods of operation and in its values. The purpose is to produce as much as possible at the lowest cost of capital and labor to generate maximum profit (Blatz, 1995). Production is agriculture's and weed science's single, dominant ethical principle. We have a produce as much as possible ethic

Claims of agricultural abundance are true in many societies. No society should assume its agricultural abundance is assured. The system that produces food should not be treated as one that can manufacture abundance at will (Blatz, 1995). As you know, the weeds will always be with us.

When the foundational values of the any production system ignore protection of the land, maintenance of water quality, and, biodiversity its values are questionable. These are essential parts of production and maintenance of life. When we and the agricultural system regard food as just another industrial commodity that can be purchased by those with money, then the ethics of the system ought to be, and will become, a subject of societal concern.

It is not surprising that the endless pursuit of production and the associated technology conflict with societal values (Thompson, 1989). Agricultural and weed science technology have exposed people to risk. In the past most of the risks of agricultural technology were borne by the user. Now many risks are borne by others. Technology developers, and users, in their moral certainty, have not secured or even considered how to secure the public's consent to use technology that exposes people to involuntary risk (Thompson, 1989). Agricultural producers and the scientific community that supports them by developing technology have been seduced into thinking that, so long as they increased food availability, they were exempt from negotiating the moral bargain that is a foundation of modern democracies. Thoughtful people will not entrust their water, their diets, or their natural resources blindly into the hands of farmers, agribusiness firms, and agricultural scientists. Agricultural people must participate in the dialog that leads to social consensus about risks. They must be willing to understand the positions of their fellow citizens. For most non-agricultural segments of society, these are not new demands. For agriculture and weed science, they are. All who practice agriculture (e.g., farmers, scientists) have been so certain of the moral correctness of their pursuit of increased production that they failed to listen to and understand the positions of other interest groups (e.g., environmental, organic). Agriculturalists have not developed any value position other than the value of production and have not offered reasons why production ought to retain its primacy.

Goals for Agriculture and Weed Science

Production of abundant food and fiber must remain a dominant goal. However, we ought to ask what other goals should be considered and when and why one or more of these may take precedence over production. I do not have time to present all possible goals and will deal only with social and environmental goals.

Social Goals for Weed Science

Aiken (1984) suggested that sustainable, environmentally safe production that meet human needs, and contributes to a just social order may be of greater moral importance than profitable production. This is not the dominant view in agriculture or among weed scientists. Few agricultural voices speak of a just social order. There is no objection to achieving a just social order but it is not my job!

Many in agriculture think sustainability can be achieved by modification of the present, successful system. Achieving sustainability is thought of as a scientific problem. However, because agriculture is the largest and most widespread human interaction with the environment, achieving sustainability will have social and ecological effects.

Agricultural markets are powerful mechanisms, but often they are not just. If they were just, then my country, the world's richest nation, would not have hungry people. Producers need to recognize the connection between what they produce, the market that distributes it, and justice for all. Agricultural and weed scientists speak loudly about production and markets but are usually silent on justice.

As family farms and rural communities disappear, the virtues they instilled in past generations (love thy neighbor, be kind to animals, help those in need, etc.) are still valued by society. One way to encourage these virtues is for them to be prominently displayed in the social purpose of an economically central activity such as agriculture. To accomplish this, all agricultural and weed scientists are going to have to abandon the singular pursuit of production as their only goal and incorporate social goals as part of agriculture. This necessitates developing and then debating the reasons that determine what the right goals are.

Environmental Goals for Agriculture

Environmental goals for agriculture are linked to social goals. Sustainability is regarded by those in agriculture as primarily a production and secondarily an environmental goal, but others see it as a social goal. The view depends on what one wants to sustain. In agriculture, to sustain usually means protecting the productive resource (soil, water, gene pools) and maintaining production. Others argue the productive resource is important, but ranks below sustaining environmental quality, family farms, rural life, small agricultural businesses, and small communities. This debate goes to the heart of what agriculture ought to be. Agriculture has a major responsibility because it is so widespread and has the potential to care for or harm so much land. This is a different view from protecting only the productive ability of land. Land is not simply a productive resource. It is the basis of life. Without the land there will be no agriculture, no life, so land must be regarded as something more than other productive resources (e.g., fertilizer, machines, irrigation water, pesticides, or seed). To harm or destroy the land is to destroy something essential to life, and that certainly raises a moral question.

The challenge of social and environmental goals for agriculture is that they involve values. It is generally not recognized in agricultural science that values are not external to the science and technology but its basis (Capra, 1996). Scientists know they are responsible for the scientific integrity of their work and for its intellectual contribution. They do not as readily assume responsibility for the moral aspects of their work. Science is not value-free, it is value-laden. Moral questions are abundant.

Anyone can dismiss criticism of weed science by saying “Well, it is not true for me.” This makes our personal beliefs, our assumptions, absolutely secure, and provides no reason to examine them (Melchert, 1995). How any idea fits our assumptions, especially one that is critical of our profession, is not a reliable guide. It is best to know the arguments, the reasons that support the criticism. In science the data or theory that best explains the observations usually wins. In ethics the best reasons win. It is wise to avoid the temptation to ignore good reasons that disagree with our assumptions. We assume a lot in science, often incorrectly. Here are a few examples of scientific assumptions that were wrong and led to the wrong conclusion, *viz:* (1) Data on historical estimates of the distance from earth to the center of the universe - Copernicus (1473-1543), 0 Kilometers. Distance from the center of the universe - Galileo (1564-1642), 149,000,000 million kilometers. Current estimated distance from earth to the center of the Milky Way Galaxy is 8,000 light years; (2) Data on the estimated number of earth-like planets in the universe in Europe in 1500 = 7. Estimated number of earth-like planets in 2005, 3×10^{21}; and (3) Data on the estimated number of species on earth Linnaeus (1758) = 20,000. Now = 1,500,000 to 1,800,000. Estimated total number of species = 3,600,000 to 112,000,000].

When we think of the future of agriculture, it is important that we see that our scientific and moral assumptions and vision of the future affect (Harman, 1976) how we recommend agriculture be practiced. The research and teaching we do now involves assumptions and a view of a future we expect, desire, or fear (Harman, 1976). Do your running and your scientific assumptions lead to greater success and happiness for others? Does your work yield a moral good?

Most of my colleagues in U.S. Colleges of Agriculture are certain that their research and teaching are morally correct. They defend their objective approach to weed science and their objectivity in defending agriculture against emotional attacks from people who don’t understand it. The scientist’s frequent appeal to the value of objectivity in science is evidence of a lack of awareness of the inevitable subjectivity of science.

Re-moralizing Agriculture

To suggest re-moralizing is not a claim that agriculture lacks moral standards or that all past achievements must be abandoned. I am not going to suggest a new, correct set of moral standards for agriculture. I recommend examining where moral values come from; and what are or ought to be the source of moral values for agriculture.

The emphasis on increasing production and reducing production costs to increase profit identifies agriculture’s utilitarian ethical standard:

to provide the greatest good for the greatest number. This ethical position, accepted and largely unexamined within agriculture, has assumed that increasing production and reducing cost optimizes agriculture's social benefits. There has been almost no debate within agriculture about the standard's correctness. One result has been that many scientists, ignorant of their own social context and all results of their technology, have, without questioning, accepted the loss of small farmers and rural communities as part of the necessary cost of achieving the goal of maintaining a cheap food supply (Stout and Thompson, 1991).

The utilitarian standard is evaluated by results. Agriculturalists measure total production, crop yield and profit to evaluate what they do. They conclude that they are acting morally because all increase. The results are good. The cry for justice by the poor and the pleas of those concerned about loss of environmental quality are overwhelmed by achieving increased production.

None of what I have said should be interpreted as an attack on the moral standards of individual scientists. "Agricultural scientists have been reluctant revolutionaries". They have wanted to change agricultural practice and results but have neglected the revolutionary effects of their efforts. They believed that their work could be reduced to their little piece without considering the whole system. Increasing production was the goal, and, it was believed, it could be accomplished without revolutionary effects (Ruttan, 1991).

Intensive farming systems with chemical and energy intensive technology led to major increases in plant and animal production, increased the size of farms, minimized labor requirements, and maximized use of technology. These things allowed many nations to fulfill more adequately than any societies have the most important task in all human history: finding a way to extract from the ecosystem enough resources to maintain life. To do this, natural ecosystems were changed to make them more productive of the things humans need and want. The associated problem is that human societies have had difficulty balancing their demands against the ability of ecosystems to produce and survive. Intensive agriculture has met people's needs and many wants, a high value. But it is made unsustainable demands on the ecosystem, which was less valued. Agricultural scientists, use their success in meeting human needs to support their belief in the universal relevance and applicability of intensive farming. Western agriculturalists believe that all societies ought to adopt modern chemical, energy, and capital intensive agricultural methods and the associated values, because they embody the best, most rational, and most modern, thinking of humankind. This belief has three problems: it is false, it is immoral, and it is dangerous. Part of re-moralizing agriculture is to give up some of our pride about the moral correctness of all agricultural practices and values.

The goal of modern agriculture has been to produce more without any concern for the welfare of those whose lives were being destroyed. There was little thought about the effects of the system on the environment. Bottom line thinking has become the norm and is one thing we must reconsider if we are serious about our communities, and our agriculture.

As we reconsider the bottom line, there will be conflicting views on the nature of the problem and different views of sustainability (Allen, 1993). It is unusual to find anyone against sustainability. However, there are many views of what ought to be sustained and how to achieve sustainability. Re-moralizing requires that we give up the common agricultural defense against criticism, *viz*: (1) The first defense has been to deny that the suggested problem exists e.g., the loss of small farms is unfortunate but it is an economic not an agricultural matter, and (2) The second defense has been to explain that the reforms advocated (e.g., reductions in pesticide use, humane animal treatment) will make food too expensive and diminish the favorable balance of trade. The argument is that the public will not tolerate higher food costs to save a few small, inefficient farms, or to help citizens of developing countries. Reform may diminish the food surplus, and that is not politically acceptable.

Re-moralizing agriculture asks that we consider challenging views of agricultural practice. For example, in many countries agriculture is heavily subsidized and over harvests the resource. Exploitation of the land is never sustainable. Agricultural sustainability will not be achieved by adjustments to the present system, only by a new system. (Not all agree - See Federoff, *et al.,* 2010). It is a challenge that must be considered by the agricultural community.

CONCLUSION

I conclude that while agricultural scientists are ethical in the conduct of their science (they don't cheat, don't fake the data, give proper credit, etc) and in their personal lives (they earn their wages, take care of family, respect others, are responsible for their actions, etc.), they do not extend ethics into their work. Agricultural scientists are reluctant revolutionaries that Ruttan (1991) identified, but also realists. Realists run agricultural research and the world; idealists do not. Idealists attend academic conferences and write thoughtful articles (Kaplan, 1999). The action is elsewhere. The reality may be publish or perish in academia, but it is produce profitably or perish in the real agricultural world. Realism rules, and philosophical and ethical correctness are not necessary for useful work in science (Rorty, 1999).

I find that true, but I want more. I want us to accept the difficult task of analyzing the results of our science. We must strive for an analysis of what it is about weed science, agriculture and our society that limits our aspirations and needs modification. We must strive to strengthen features that are beneficial and change those that are not. We must be sufficiently confident to study ourselves and our institutions and dedicated to the task of modifying both. People don't want their assumptions about their science, its results, or their lives challenged, they believe their assumptions are correct and they want to use them.

A comment by the Russian author Leo Tolstoy[2] about art is relevant. Tolstoy urged us to question and debate the correctness of our scientific and moral assumptions. We need to examine our ethical foundation and our values. Tolstoy said: "I know that the majority of men who not only are considered to be clever, but who really are so, who are capable of comprehending the most difficult scientific, mathematical, philosophical discussions, are very rarely able to understand the simplest and most obvious truth, if it is such that in consequence of it they will have to admit that the opinion which they have formed of a subject, at times with great effort, - an opinion of which they are proud, which they have taught others, on the basis of which they have arranged their whole life,–that this opinion may be false".

To preserve what is best about modern weed science and to identify the abuses modern technology has wrought on our land, our people and other creatures, and begin to correct them will require many lifetimes of work (Berry, 1999). We ought to see agriculture in its many forms -- productive, scientific, environmental, economic, social, political, and moral. It is not sufficient to justify all activities on the basis of increased production. Other criteria, many with a clear moral foundation, must be included. We live in a post-industrial, information age society, but we do not and no one ever will live in a post-agricultural society. Societies have an agricultural foundation within their borders or elsewhere. Those in agriculture must strive to assure all that the foundation is secure.

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SHAPING THE FUTURE OF WEED SCIENCE TO SERVE HUMANITY IN THE ASIA-PACIFIC

Baki Bin Bakar[1]

ABSTRACT

The Asian-Pacific Rim comprises of farming communities with contrasting economic and agricultural development. With population exceeding three billions with significant differences in socio-economic, technological and digital divide, the economic well-being of the farming communities and consumers is always a difficult and perennial issue bothering political powerhouse, policy makers, agricultural scientists, extension agents and farm managers alike. It is a truism that the story of agriculture is also the story of weed interference. Weeds continue to be a perennial and constant threat to agricultural productivity, despite decades of modern weed control practices aimed at their elimination. Weeds, especially invasive ones, affect agricultural production, forestry, human health, the aesthetic quality of non-crop lands such as lawns, and parks, conservation areas, rights-of-way, drainage and irrigation canals, and other waterways, and rangeland. It is the objectionable nature of weeds arises from the reduction of food quantity and quality produced by crop systems primarily that has become the central focus of most research within the weed science fraternities worldwide. The control of agronomic weeds is a recognized necessity in order to maintain high levels of productivity in an increasingly globalized agricultural economy. While free trade devoid of tariffs and quotas promises to improve the world economy, it will create more and more pathways for movement of invasive species into new environments in different parts of the world. The homogenization of the world's flora and fauna and the lingering effects of introduced invasive species are unintended side effects of accelerating globalization. Both pose a consequential threat to agricultural sustainability, and managed production systems, and to ecosystem biodiversity. The development of herbicide-resistant weeds and weed population shifts continue to challenge the effectiveness of modern weed management practices. Because of the complexity of weed community, integrated approaches to weed management techniques fortified with scientific knowledge in a manner that considers the causes of weed problems rather than reacts to existing weed populations should be practiced with the goal to optimize crop production and grower profit through the concerted use of preventive tactics, management skills, monitoring procedures, and efficient use of control practices. Evidently, there is a dearth of information and a plethora of data showing the incremental benefits of judicious use of herbicides integrated with cultural, mechanical, and biological means in managing weeds, with high yields, yet minimized environmental

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impact. Weed scientists while facing complex and difficult challenges, must increase the sustainability of our current management approaches and help respond to invasive plants as a component of global change. Any effective response to these challenges will require participation and practice of public scholarship by weed scientists in addressing professional priorities. The future of weed science as a platform in serving humanity is dependent on a joint effort from industry, government regulators, and private and public sectors consisting of grower groups, department of agriculture, the universities and research institutions. I am of the opinion that weed science will be better positioned in serving humanity within the context of maintaining food security, and environmental safety, if research focus emphasize on research decision processes, weed biology and ecology, weed control and management practices, herbicide resistance, issues related to transgenic crops, environmental and health issues, and potential benefits of weeds. In the same vein, efforts spent on these research areas have benefited and will continue to benefit, not only growers, commodity groups, homeowners, and industry, but also society at large, through the maintenance of food and fiber production system, and environmental safety of agro- and non-agro-ecosystems worldwide.

Keywords: Asia Pacific, globalization, herbicide resistance, perennial weeds, environmental safety, weed science.

INTRODUCTION

"If there is no man,
there will be no woman,
If there is no agriculture,
there will be no mankind" (Baki, B.B. 2005)

The world's great civilizations, the root of what we call the developed world, are all based on agriculture. Agriculture is farming, fishing and ranching, and it is growing something for human needs and welfare. Agriculture is hard work and drudgery. It is what some must do, but it is *not* what most wants to do. Food production is not just hard work, it is a business, and it is profitable. In many Asian-Pacific countries, agriculture is still the mainstay of the national economy. This economic pursuit is prevalent and will be permanently relevant to feed the growing populace. Despite differences in emphasis in the economic activities in different countries, food security and food safety (FSFS) is in the top notch of economic and political agendas for policy makers, farmers, and farm managers alike. Agriculture is the most far-reaching land use changes in the transformation of vast areas of the Earth's surface. Today the ability of agriculture to produce enough food and fiber for the world populace is primarily dependent on modern weed science.

I am in the opinion that whatever shapes, the future of agriculture will also shape and impact the future of weed science. In this respect, the status of the natural resource base; climate change the extent of desertification and land degradation, advances in science andtechnology;urbanization;trade liberalization and commercialization; and strategic alliances and international agreements and conventions will impact agricultural development and weed science development and practices in the Asia Pacific.

The ensuing discussion in this paper will focus briefly on (i) managing strategy for weeds in agro-ecosystems; (ii) future research directions for weed science; (iii) standard operating procedures (SOPs) for research in weed science; and (iv) the ethics of weed science research, with reflections on (i) nature of weed research and scholarship; (ii) effective and ethical professional practice by weed scientists within broader contexts of agriculture and agricultural science, and (iii) roles of weed science in the service of humanity. The paper ends with note on future trends in weed science and challenges facing weed scientists in the Asia Pacific region.

WEEDS, AGRICULTURE AND MAN IN THE ASIA PACIFIC

"In the beginning, there were no weeds" (Baki, 2006a).

Weeds, Agriculture and Man: The Relationship

Weeds are not an innocent entity as they look. They can evolve, and they have! Weed is a human construction, its origin is man-made, just as hoes and herbicides used to kill them are human inventions. Weeds are adaptable, perhaps more adaptive than we are, and it is this characteristic that is disconcerting (Radosevich 1998). Indeed as Dekker has lamented "*the story of agriculture is indeed the story of weed interference",* not only crop protection over the past decades. In this regard, global monocultures have resulted in the appearance of global "*millennial weeds*" (Gressel, 2000) that are not being adequately controlled worldwide. However, it is common knowledge and everybody would agree that *Weed Science* has admirably risen to the challenge of scientists who hold that their work is founded on the most ethical and noble behaviour of all – feeding the world or serving humanity. Use of chemicals aligned with intensification, we usually at the expense of science fraternity define good agriculture as one that optimizes yield and maximizes profit with equitable concern for the environment. To many weed scientists like Zimdahl (2010) agriculture and indeed weed science quite often encourage widespread crop diversification and crop rotation – these sometimes contribute to the loss of small farms, and biodiversity on the farms and their fringes.

Weeds and Weed Management Practices: Prediction, Losses, Risks, and Impacts

The fallacies of modern agricultural practices give rise to weeds. It is such a pernicious aspect of food production that weeding is often the most important task (chore!) overshadows most others, most satisfying, aspects of farming. Perhaps because of this, Bishop (2004) rightly suggested that weeds should be put on the bio-security agenda at the national, regional, and international levels if weed impacts are to be effectively contained. Because of this, predictions of impacts and risks of weeds (as invasives!) on human welfare and its environment focus on two principal issues, *viz*. (i) precision in invasion predictions of plant species introduced intentionally or otherwise into an agro-ecosystem; and (ii) consequential impacts of such invasives on the environment. According to Bridges (1994), weeds impact on human endeavours. There are four sectors of economy that are directly impacted by weeds, *viz.* (i) agricultural production; (ii) forestry; (iii) non-crop land; and (iv) health. There are within the realms of economic, aesthetic, and health effects. But it is the economic impact that weeds are more worrisome to policy makers, agriculturalists and agriculturists alike. Such impacts are manifested in losses leading to the reduction in production, quality, efficiency, or functionality. Losses are sustained in every sector, and can be determined by the loss in value of productive output. Further, the costs or investments made in arresting weeds and their impacts to manage or control weeds, include inputs of labour, machinery, time, pesticides, etc. Irrespective of management tactic, costs can be ascribed to weeds. Ultimately, the total economic impact or the sum of losses and costs is the most tangible measure of the impacts that weeds have on man and his anthropogenic activities. Then there is the hidden cost to the environment due to weed infestation, namely the loss of biodiversity or environmental pollution due to non-judicious or indiscriminate use of herbicides.

To farmers, the most tangible losses due to weeds are those of crop yields and quality. Invariably, estimates of such losses are in the regions of 5% for developed economies, while in Asia Pacific, not including USA and Canada, the loss figures range from 10 to 25% (Baki, 2006b). There are also other losses such as weeds impact on man and animal health, and aesthetics, and these include direct costs health-related worker hazards and associated with medical intervention. There are notable impacts of weed poisoning and ingestion by farm animals and wildlife on reproduction, production and animal health. The persistent and indiscriminate use of herbicides for weed control may have adverse and untold damage to the end-users and environment. These include (i) impacts and risks on food safety and quality. Efforts are made to reduce pesticide resistance in target pest species, and the development of "Environmental Stewardship" efforts between relevant government agencies dealing with food production, and quality (including imported produce) and environmental safety; and (ii) impacts on soil and plant ecology, and the intricate relationships between repeated applications of herbicides and soil microbes are essentially unknown. Quite often the non-judicious use of herbicides i*mpacts on catchments and water. For example, in* US counties, no less than 46% contain ground water susceptible to contamination of herbicides, forming the bulk of agricultural chemicals used (USDA 1986, 2000). In the humid tropics, some herbicides may be delivered to surface water via groundwater through streams flow in rivers and lakes; the source of drinking water in many states. Again other risks and impacts following the indiscriminate use of herbicides include the poorly documented evidences of *herbicide run-offs on fishes and corals.* Today the increasing emergence and incidence of h*erbicide-resistant weeds pose e*cological concern worldwide. In Malaysia the high labour costs has led to the increasing dependence on herbicide-based control measures, especially in commercial crops like oil palm and rubber. It has led to parallel increase and the continuous incidence of herbicide resistant weeds in the country. Today no less than 18 weed species are resistant to commonly used herbicides such as 2,4-D, MCPA, propanil, and glyphosate. Adam *et al.,* (2009) recorded for the first time increasing resistance of *Eleusine indica* biotypes to glufosinate ammonium in Malacca and Pahang in Malaysia.

Today there are increasing evidences of gene introgressions from transgenics to weedy relatives thus impairing the benefits using transgenic resistant crops and create herbicide-resistant weeds. Gressel (2000) considered these as leading precursors to the emergence of super-weeds or millennial weeds, a case of grave concern to humanity now and in decades to come. In another circumstances, clearly, technology is not neutral. The indiscriminate use of 2,4-D and 2,4,5-T in Vietnam by the Americans in 1960s and 1970s is a disservice to humanity.

Public scholarship: linking weed science with public work

We in the weed science fraternity consider *weed scientists* as stewards of the public capacity. Although scientists in general and weed scientists in particular are largely utilitarian, it is normal for them to believe with firm conviction that their work is useful to humanity, pursued through vigorous scientific and technological progress, and this belief rests on an ethical foundation or utilitarianism of public scholarship. It is through public scholarship that enables weed scientists to pursue weed science with our highest goal, that is, commitment to serve as a civic profession that helps address major issues facing society that help create public goods, *viz.* contributions to greater commonwealth. Further, public scholarship approach is an original, creative, peer-evaluated intellectual work, fully integrated in a public-work project. It is the ultimate hope of within the weed science fraternity that bridging technology advancement generated through research via extension programmes is one way of public scholarship that ensures weed science, as a scientific and civic profession relevant to society's well-being. The paper by Zimdahl (2010) in this volume is a good example of ethics on weed science where public scholarship is an integral part of public duty that weed scientists must engage on. In the Asia Pacific, progress is underway to ensure that whatever technology advancements that are being made should be channelled to society at large. This is being so especially in the developing countries in the Asia Pacific, mostly through affirmative extension programmes with the focus to eradicate poverty through increased crop yields and quality products from agriculture.

MANAGING STRATEGY FOR WEEDS IN AGRO-ECOSYSTEMS IN THE ASIA PACIFIC

Rationale, Concepts and Ecological Considerations

The classical concept and practice of weed management is managing weed interference to minimize the effects of weed competition on the crops. Modern neoclassical, functional and economic approaches of weed management are knowledge-based, requiring knowledge-intensive management skills & inputs, *viz*. (i) Crop-weed ecology; (ii) Weed community dynamics; (iii) Economic thresholds; (iv) Production costs (including risk and ethical analysis, and costs to the environment following successive applications of herbicides); (v) Innovative ecologically based management practices; and (vi) Competitive crop cultivars, and transgenic crops.

Control Measures Against Weeds

A battery of methods is available to achieve satisfactory results in weed control. These include (i) Agro-technical and preventive methods comprising land preparation and tillage, water management, manual weeding, crop manipulation through seeding rates, planting density and allelopathy. Breeding for competitive cultivars, herbicide-resistant crop plants (HRCs) and transgenics are some of the new approaches in modern weed control. Herbicide-based weed control is a necessary package in modern agriculture, despite many environment-related problems associated with such measures. Others advocated biological control using bio-control agents or/and bio-herbicides to help alleviate the weed menace. Among them include the successful control of *Salvinia molesta* in the Sepik River in Papua New Guinea with the curculid beetles (*Cyrtobagous salviniae*). In Malaysia, the well-documented success in the control of *Cordia curassavica* by using *Schematiza cordiae* and *Eurytoma attiva* in the late 1970s in coconut plantations in Selangor. Other less remarkable success stories in the control of weeds using bio-agents include *Eichhornia crassipes* with *Neochetina bruchi, N. eichhorniae* and *Sameodes albiguttalis; Echinochloa crus-galli, E. oryzicola* and *E. picta* with *Emmalocera* sp. while the Australians were experimenting with some success in the control of *Mimosa pigra* with seed feeding bruchid beetles (*Acanthoscelides quadridentatus* and *A. puniceus*), the stem-boring moths, *Nuerostrota gunniella* and *Carmenta mimosa* and the stem-feeding beetle, *Chlamisus mimosae*.

No technology can be successful forever, especially if used as a single, "stand alone" technology. Weed scientists and extension agents world-wide including those in the Asia Pacific are advocating the integrated approaches, the Integrated Weed Management (Fig. 1) to control the weed menace. This holistic approach combines preventive measures, eradication, and control options through appropriate integration of chemical + mechanical practices + non-chemical and cultural practices + delayed crop seeding + tillage + black fallow + hand weeding + crop rotation + competitive cultivars + decision aids that directly lower selection pressure, restrict or delay the growth of resistant populations of weeds. It is expedient for farmers wherever possible to practice weed management options that facilitate increased use of conservation tillage crop production practices. The agriculture chemical companies should potentially provide opportunities for the use of more environmentally benign herbicides.

Prevention is better than cure. It is only sensible that farmers and those in the agricultural industry should be rigorous advocate and practice the concepts of good agricultural practice (GAP) in their weed management by (i) stop the introduction of noxious weed seeds or vegetative propagules; (ii) reduce the susceptibility of the ecosystem to invasive weed establishment; (iii) develop effective education and extension materials and activities; (iv) establish a knowledge-driven programme for farmers, extension agents, landowners for early detection and monitoring; (v) effective containment of neighbouring weed infestations; and (vi) strict quarantine enforcement. The extensive use of leguminous cover crops in young oil palm, rubber, and cocoa plantations in Malaysia is one of the many ways that GAP has helped to reduce chemical-based weed control measures, while

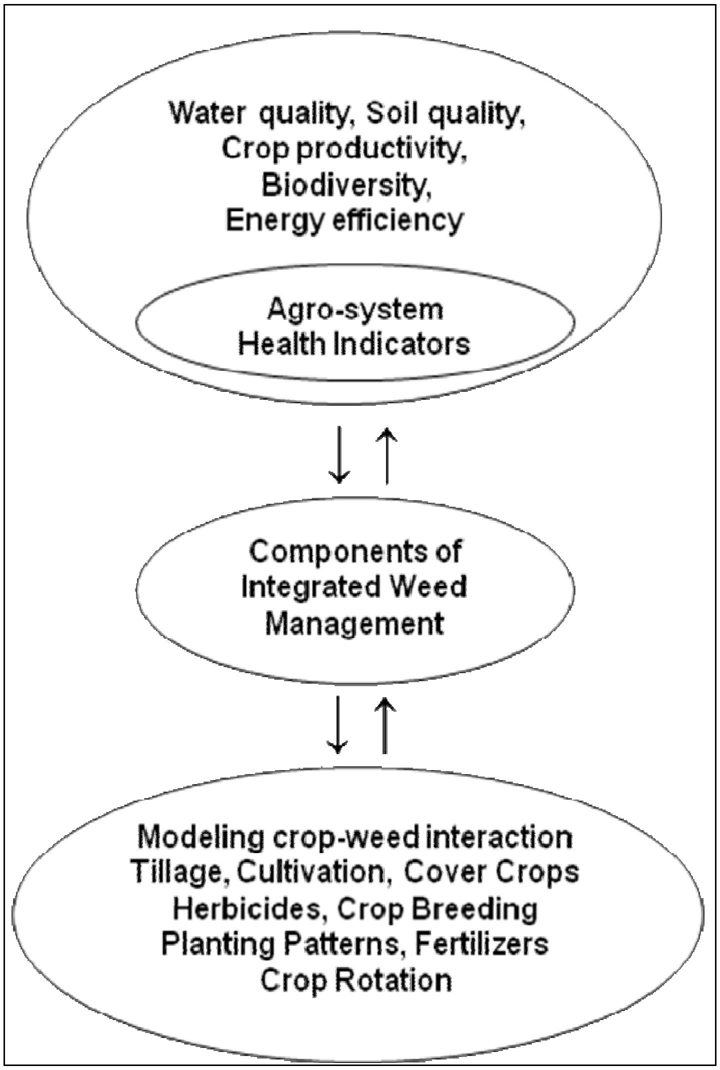

Fig. 1. The multi-faceted approaches of integrated weed management (Baki, 2006a).

enriching the soils. Another venue of the GAP is to be able to predict the rates of infestation and proliferation of weeds. This can be done by developing the expert systems for weed management. The computer-aided decision models or Expert Systems are used to assist farmers, extension agents, and weed managers in weed control decision-making for several crops. The examples include HADSS® (Herbicide Application Decision Support System) HERB®, and WebHADSS® which were designed to help farmers for weed control in cotton, peanut, corn and soybean, or WeedSOFT® which was developed to help farmers and consultants for PRE- and POST- weed control in soybean, corn, sorghum, sugar beet, and winter wheat. In this respect, the technological divide among farmers in the Asia Pacific is obvious with a sizeable number of peasantry farmers still engaged in back-breaking manual weeding in several developing countries in Asia and Latin America against their counterparts in USA, Canada, Japan, Australia and New Zealand.

RESEARCH DIRECTIONS FOR WEED SCIENCE IN THE ASIA PACIFIC

"If there is no man, there will be no woman,
If there is no weed science, there will be no agriculture,
If there is no agriculture, there will be no mankind" (Baki, 2006a).

Research Directions

I envisage that the future of weed science research will encompass the following broad aspects, *viz.* (i) Knowledge-Based and Systems Approach-Based Decision Processes; (ii) Weed Biology and Ecology; (iii) Weed Control and Management; (vi) Herbicide Resistance; (v) Issues Related to Transgenic Plants; (vi) Environmental Issues; (vii), and (viii) Potential benefits of plant species generally classified as weeds. Many of these aspects of research are knowledge-based decision support strategies (KBDSS), and systems approach-based decisions which are very dependent on database accumulated over the years. In many countries of the Asia Pacific, such approach may good on paper but will not be translated to farmers as problem-based solving technologies at the farm level. In the absent of affirmative extension systems, any information gathered in this manner remains within the realms of the academia. In any situation whether it is in the developed countries or the developing counterparts, the fundamental issue in any research adventure will be determined at least in part by resource availability vis-a-vis research plan.

In weed biology and ecology, research emphases leading to the understanding of weed response to selection pressure, weed competition and economic thresholds, and invasive alien weed remain the core activities. Then, of late, there is this new craze to understand weed genomics as fundamental tools to enhance the research capacity in herbicide resistance, issues related to transgenic plants, and potential benefits of weed species as nutraceuticals. In this endeavour, the need to explore genomics and employ molecular biology techniques to study differences between weed biotypes and analyze various traits of weeds is implicit.

Central to effective herbicide-based weed management systems is the research on herbicide efficacy enhancement. Of particular interest is area on precision agriculture or site-specific agriculture/site-specific weed management which optimizes agricultural inputs so as to match field heterogeneity in herbicide application rates. Strategically aligned to this the need to find or research into alternative weed management methods. These alternatives only suppress weeds as opposed to eliciting effective control while at the same must be efficacious and economical. Dr. Y. Fujii (*pers, comms.*) and his group at the National Institute of Agro-environmental Sciences (NIAES), Japan strongly advocated the search for new bioactive natural products, the allelochemicals as effective biochemicals to suppress weeds. Others advocate the need to develop simulation models on weed populations. Such models will require large database of weed ecology and biology characteristics. Such information can be used to continuously and systematically improve and refine weed management system simulation models. Such augmentation of information from the database will help to generate weed management tools for growers and extension agents.

Agriculture in the Asia Pacific to certain extent is laden with agrichemicals. The world's consumption of pesticides in 2000 was already in billions of US dollars, of which herbicides took the lion's share of the market (Underwood, 2000) (Fig. 2). Other than the environmental hazards posed by these herbicides, a worrisome phenomenon in chemical-based modern agriculture is the continuous emergence of herbicide resistant weeds, particularly in Canada, USA, and Australia to name a few Asia Pacific countries. Malaysia is not an exception with no less than 18 weed species showing moderate-to-strong resistance to commonly used herbicides (Baki, 2006a,b). The FAO has rated pesticide resistance as 3rd greatest problem in global agriculture, behind soil erosion and pollution. At the global scale, about 291 resistant weed biotypes in 174 species (104 dicots and 70 monocots) in over 270,000 fields were found (Heap, 2004). By 2010, the number of resistant weeds exceeds 300 biotypes (Heap, 2010). With the build-up of resistant weed biotypes, I suggest the need for more extensive research on the characterization the mechanism of herbicide resistance using modern techniques; monitoring and investigating herbicide cross- and multiple resistance and fitness of resistant populations in order to assess alternate control methods, and the potential for spread of resistance; assessment on the economic impact of herbicide-resistant weeds; and of course the development of IWM strategies to ameliorate the adverse effects of resistant weeds in cropping systems. All these need well-placed manpower and research funding. Because many countries in the Asia Pacific do not have the necessary funding and man-power expertise to tackle the continuous emergence of herbicide resistant biotypes, it is only proper that respective governments in the APEC (Asian-Pacific Economic Caucus) fraternity should find ways to share the burden of solving these common problems through training and information sharing. The HIRAC organization should be strengthened further to include new members from developing countries.

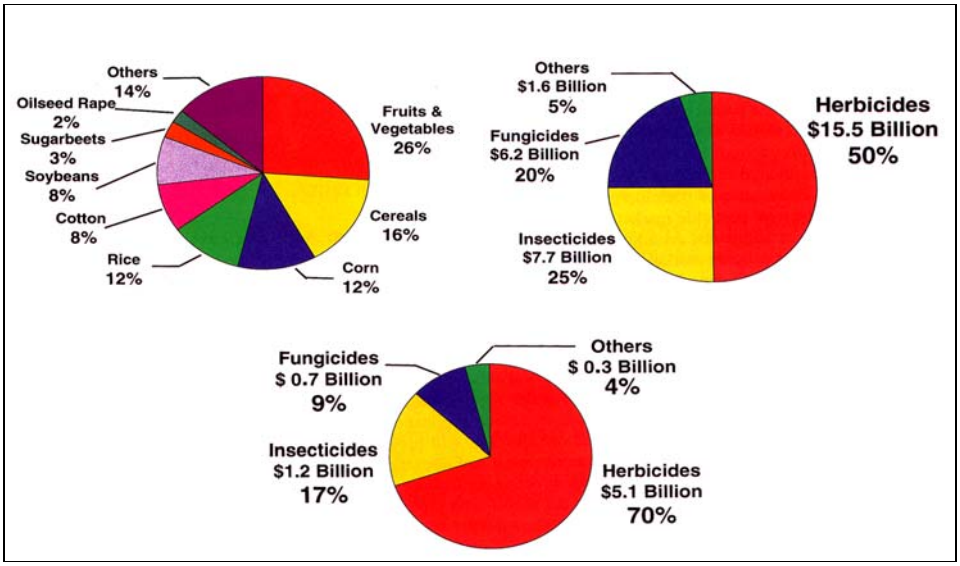

Fig. 2. Pesticides consumption at the global scale (Underwood, 2000).

One of the ways to tackle these herbicide-resistant weeds is through genetic engineering by producing herbicide-resistant crops (HRCs). Despite acceptance of these crops in many countries in the Asia Pacific, the HRCs especially the transgenics are not without controversy. There are pertinent issues related to the introduction of HRCs and transgenics. These include serious concerns on the safety of these crops not only to the environment but also to the consumers. A lot more research needs to be done before any universal acceptance of HRCs and transgenics and their produce by the consumers at large. Uncertainty is looming on the long-term agronomic and ecological effects of HRCs. Another argument against the adoption of HRCs and trangenics is that growing HRCs means a continuation of dependence on herbicide-based weed management. Further, successful introduction and adoption of HRCs will lead to considerable slowdown in the development of innovative non-chemical weed control methods. Again there are differences in opinion on the environmental quality of the herbicides for which HRCs and transgenic crops are being developed.

Proponents of HRCs and trangenics argue that these crops may hold benefits for sustainable agriculture, *viz.* (i) current herbicides may be replaced by those more environmentally-benign; (ii) may contribute to IWM by increasing the options of weed control; (iii) fit well with the goals of site-specific management because PRE would be replaced by POST treatment; (iv) promote systems for conservation tillage and mixed cropping; and (v) lower the costs of weed control. These being the case, the seed trade and the associated herbicides are being held by multinationals, many of which have invested a lot of funds for research, and thus are not likely keen to share the information and trade secrets, even pressed to do so by the governments of the day.

There are still many unanswered questions pertaining to the adoption of HRCs and transgenics. Serious in-depth non-partition research by government scientists and NGOs on HRCs and transgenics need to be done on several fronts, *viz.* (i) Analysis on the effects and potential consequences of widespread use of transgenic crops on weed population dynamics and weed ecology, and of increased weed resistance; (ii) Quantification of the effect of HRCs on the management of herbicide-resistant weeds; (iii) Determination on the potential of transgene introgression, particularly on the flow of resistance genes from transgenic crops to weeds, and (iv) Determine the socio-economic impacts of transgenic crops on the society.

A lot of weeds are reservoirs for nutra-ceuticals and the pharmaceuticals (Baki 2007, 2009). The mega-biodiversity centres like Malaysia, Indonesia, Thailand, Papua New Guinea and the Philippines are in fact natural reservoirs for the food and drug industries. Kim *et al*. (2007) compiled and edited a multi-authored book with useful information on the utilization of weeds, their relatives and resources.

Standard Operating Procedures (SOPs)

These are explicit step-by-step instructions for carrying out experimental tasks that are components of experimental plans for weed scientists. We in the weed science fraternity believe that the SOPs in weed science research will enhance data accuracy, precision, and reproducibility, thus forming part of their own statistical quality control procedures. By adopting the SOPs, weed scientists are to gain from threw advantages, *viz*. (i) facilitate document repetitive research methods; (ii) streamline the planning of experiments; (iii) facilitate concerted teamwork, supplement training, enhance communication and facilitate discussions among researchers; (iv) reference on safety, health or environmental concerns, sourcing supply checklists of equipments, chemicals, etc., assembling them completely before experimentation; (v) help maintain research continuity over time, especially in standardizing repetitive time-mediated research tasks; (vi) help coordinate research efforts and prevent procedural errors when several people contribute separately to cooperative and coordinate research projects; and (vii) ensure data reproducibility and variability are maintained consistently over time by all people contributing to team research projects.

Ethics of Weed Science Research in the Service of Humanity

It is often said that weed science is a microcosm of agriculture's "neckriddle" with many other agricultural disciplines. More importantly, weed science is in fact a microcosm of larger societal debate concerning many tools and tactics used in food production, and the consequences of current and future developments in agricultural technology. In the endeavour to provide solutions to farmers at large, weed scientists knowingly or unknowingly considers weed science as a "reductionist science". However, the catholic and cardinal issue for weed science is *technological determinism.* I believe that the traditional, empirical, and reductionist approach to weed science research will not likely to provide solutions to weed science's neckriddle. In the same vein, the long-term improvements in weed science research and application will require an intellectual convergence between traditional weed control practices and fundamental ecological theory. Such convergence will not be possible in many developing countries in the Asia Pacific due to lack of critical mass of weed scientists and researchers in weed science to achieve meaningful goals in the research endeavour. Quite often policy makers do not see the roles of weed science in the national economy well being, by providing insufficient funds for research and man-power training.

Invariably, weed science fraternities worldwide faced with philosophical and personal purgatory, thus influencing an individual's career path from early pre-tenure decisions to those faced by senior scientists on the path of retirement. Weed scientists, quite often faced pertinent questions on the ethics of research in the subject, *viz.* (i) What is the right topic for an individual, public sector weed scientist to choose for research? (ii) Is there an inherently unethical research topic? and (iii) Do public sector weed scientists have a moral obligation to pursue the best research topic they are capable of? Then there is this ethical foundation in inherent values and choice of topic, taking into consideration *inter-alia*, the following aspects, *viz*. (i) respect and credibility; (ii) making a contribution to the fraternity; (iii) funding and career advancement, and (iv) explicit and implicit employers' expectations, which at times may be in conflict with our values. From another perspective, tenure, peer pressure, dogma, and at times, current hot topic mentality, are in conflicts thus representing likely constraints in our choice in research priority.

Another serious problem facing weed scientists is confronting complacency. Every public sector researcher is responsible to God, employers, taxpayers, and themselves for the choices made in their research endeavour. It is often alleged that weed scientists lack diversity and unimaginative in our choice of research topics, and as generalists – tackling many research problems superficially, research programmes lacking focus and depths, and at times resist specialization. Further the herbicide industry dominates the research agenda focusing on herbicide efficacy, and less on agricultural sustainability and environmental safety.

FUTURE TRENDS AND CHALLENGES IN THE ASIA PACIFIC

"No less than 20% of the world's population, or 840 million people, are still hungry and in abject poverty. The greatest challenge to agriculture (and weed science) is to feed not only the burgeoning population but also the poor and the hapless" (Solh and Pingali, 2004).

The world's populace in general and Asia Pacific in particular are concerned with and facing challenges in three fronts (i) Food Scarcity and Food Security (FSFS), (ii) Agricultural Sustainability, and (iii) Environmental Health. These general concerns on FSFS which is synonymous with 21st century agriculture, lingers constantly in developing economies to feed the growing populace. The absorbing question on this issue of FSFS in many countries of the Third World in the Asia Pacific, is there a choice for the hungry and destitute? Antithesis to these issues would be (i) Is it not the social obligation of the government of the day to ensure food security for its populace so that hunger and famine will no longer haunt mankind? and (ii) Are not the goals of agriculture (akin to the goals of weed science) towards profitable production, sustainable production, environmentally-safe production, satisfaction of human needs, compatibility with just social order akin to the challenge of FSFS especially in the less developed countries of the Asia Pacific?

Another worrisome trend of world's agriculture is the tide of globalization and increased international trade in the 21st century which leads to breakdown of bio-geographical barriers and higher plateaus of species invasions, coupled with intentional, callous and clandestine introductions of plant (weeds!), many of them are invasive in nature, and these ultimately threaten community structure, and species interactions of native species. In this regard, the Global Invasive Species Program (GISP), engaging scientists, policy makers, legal experts , industry and government in serious deliberations under 11 elements on building a comprehensive approach needed for dealing with invasive species. These elements deal with synthesizing our current knowledge on invasives at the global scale and in the Asia Pacific where the need arise.

Future initiatives in weed science hinge on the ability to provide multi-dimensional approach in weed control technologies against not only the existing weed species but also the new waves of invasions of alien and *super* or *millennial weed species* due to anthropogenic activities and trade and the expected wider adoption of HRCs and transgenics by farmers even in the less developed countries in the Asia Pacific. Such initiatives are taken towards a socially permissible, environmentally sound, economically feasible, productive and sustainable agricultural system. In this respect, and among other things weed scientists playing key roles in the development and field evaluation of transgenic HRCs, and continued use of herbicides and adoption of HRCs comes the inevitable ecological risks to the environment. If such scenarios were to materialize, stringent ecological risk assessment of herbicide resistant crops and screening for increased incidence of herbicide-resistant weeds are to be in place.

With modernization comes the need to produce quality foods that are consumer-driven in increasingly affluent societies. At times, advances in biotechnology with tremendous shake-up in the agrochemical industry where the worrisome trends of a few dominant multinationals controlling significant shares of advanced germplasm and HRCs for the world's major crops. These multinationals with cutting-edge technology in agricultural biotechnology are antithesis to the development inspired in resource-poor developing economies of the Asia Pacific. With this backdrop on the advances in biotechnology, the weed science fraternity is facing major issues and challenges inharnessing cooperation and political will among policy makers and scientists through The Scientific Committee on Problems of the Environment (SCOPE) in collaboration with the United Nations Environment Programme) (UNEP), the International Union for the Conservation of Nature (IUCN) to ensure technology sharing for the benefits of mankind.

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PERFORMANCE OF DIFFERENT HERBICIDES FOR THE CONTROL OF WILD OATS AND YIELD OF WHEAT CROP UNDER ARID CLIMATE OF PUNJAB, PAKISTAN

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ABSTRACT

A field study was conducted at Adaptive Research Farm, Karor (District Layyah), during 2007-08, to evaluate the efficacy of different post emergence herbicides on narrow leave weed (Avena fatua) in wheat crop. The Experiments were laid out in Randomized complete block (RCBD) design with three replications and plot size was 8 m x 13 m during both the years. Four different herbicides viz. Topik @ 300 g ha^{-1}, puma super @ 625 mL ha^{-1}, Pujing @ 625 mL ha^{-1} and fenoxaprop @ 625 mL ha^{-1}. A control (untreated) treatment was also included in the trial. The observations i.e. number of weeds after spray/m^{2}, Plant height (cm), number of tillers m^{-1}, number of spikelets per spike, number of grains per spike and grain yield (kg ha^{-1}) were recorded. All the herbicides significantly decreased weed population over control and maximum grain yield (4167 kg ha^{-1}) was obtained where Topik @ 300 g ha^{-1} was applied. It was however, statistically at par with the grain yield obtained by the application of Puma super @ 625 mL ha^{-1}(4100kg ha^{-1}), Pujing @ 625mL ha^{-1} (3833 kg ha^{-1}) and fenoxaprop @ 625 mL ha^{-1} (3817 kg ha^{-1}. It is thus recommended that Topic and Puma super may be applied @ 300 g and 625 mL ha^{-1}, respectively for the control of narrow leave weeds of wheat.

Key words: Post emergence herbicides, narrow leave weeds, *Avena fatua*, wheat, arid, climate, Pakistan.

INTRODUCTION

Wheat is an important cereal grain crop of the world. It is staple food of majority of the people and meets the diversified food requirements of both the urban and rural population of Pakistan. During 2008-09, it was grown on an area of 9.062 million ha^{-1} with an annual production of 23.421 million tons of grains giving average yield of 2.60 tons ha^{-1} (Anonymous, 2009). Although there are many

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reasons for low productivity of wheat but weed infestation is a basic and major component of low yield in crop production system. In Pakistan, it is estimated that annual losses caused by weeds may be 28 billions rupees (Marwat *et al*., 2006). Because of the high competitive ability and high reproductive potential of weeds, it is imperative to check their infestation. Weeds compete with the crop plants for nutrients, moisture, space, light and many other growth factors which not only reduce crop yield but also deteriorate quality of farm produce and thereby reduce its market value (Cheema and Akhtar, 2005). The weed control has been practiced since the time immemorial by manual labour and/or animal drawn implements, but these practices were laborious, tiresome and expensive due to increasing cost of labour. The growing mechanization of farm operations and ever increasing labor wages has stimulated interest in the use of chemical weed control. Chemical weed control is the easiest and most successful alternative method. It is important to deal with wild oats early. That's because the time to protect your yield is before wild oats have done the damage.

Reports are available on the efficacy of different herbicides in wheat (Khan *et. al.*, 1999; Khan *et al*., 2001; Khan, *et al*., 2002; Hassan *et al*., 2003). The herbicide use in Pakistan is not widely practiced as in the agriculturally advanced nations. The interest around the testing of graminicides (Walia *et al*., 1998; Ormeno and Diaz, 1998) indicates the problem posed by grasses, whereas the studies of Khan *et al.*, (2002) showed synergistic response on combined use. In another studies researchers obtained an effective control of weeds in wheat through chemicals (Khan *et al*., 2003). The instant studies were undertaken to find out the most effective and economical herbicide (s) for control of narrow leave weed (wild oats) in wheat crop.

MATERIALS AND METHODS

The trial was laid out in randomized complete block design with three replications. The net plot size was 12m × 17 m. The test wheat variety was Bhakkar 2002. Sowing was done on November 20, 2007. The treatments in the experiment were: T_1 = Control, T_2 = Topik (clodinafop propergyl) @ 300 gha^{-1}, T_3 = Puma Super (fenaxaprop pethyl) @ 625 ml ha^{-1}, T_4 = Pujing (Fenaxaprop-p-ethyl) @ 625 mL ha^{-1} and T_5- fenaxaprop @ 625 mL ha^{-1}. Recommended dose of NPK (160-114-62 kg ha^{-1}) fertilizers were applied in the form of urea, triple super phosphate and sulphate of potash, respectively. Nitrogen fertilizer was applied in three splits i.e. one-third nitrogen was applied at the time of seedbed preparation and was thoroughly mixed into soil by ploughing and planking. The second and third dose was top dressed at the time of 1st and 3rd irrigation, respectively. Weedicides were sprayed with Knapsack spray machine using water @ 296 L ha^{-1} along with recommended dose of each weedicides after 45 days of sowing. Canal water was used for irrigation. Sowing was done with the help of Rabi drill in good moisture conditions. All other agronomic practices (sowing and harvesting) were kept uniform for both the experimental sites. The observations on the following parameters i.e. No. of weeds after spray m^{-2}**,** number of tillers m^{-2}, plant height, number of spikelets $spike^{-1}$, number of grains $spike^{-1}$ and grain yield were recorded during the course of study. Wheat crop growing and development stages for recording of parameters after sowing are as follows; germination m^{-2} 15 days after sowing (DAS), Number of tillers m^{-2} 40 DAS. Plant height after sowing of 150 days, Number of spikelets $spike^{-1}$ 150 days and yield contributing parameters after 150 days. The collected data were analyzed statistically using Fisher's analysis of variance technique and treatment means were compared by Least Significant Difference (LSD) test at 5% probability level (Steel *et al*., 1997). The data were analyzed by the "MSTAT-C" statistical package on a computer (Freed and Eisensmith, 1986).

RESULTS AND DISCUSSION

Number of weeds m^2 after spray

Weedicides had statistically significant effect on number of weeds after spray in wheat (Table-1). The maximum value of No. of weeds after spraym^{-2} (15.00) was observed in case of control (untreated) treatment followed by 2.60 and 2.33 in case of T5-fenaxaprop @ 625 mL $ha^{-1}$and T_4-Pujing (fenoxaprop-p-ethyl) @ 625 mL ha^{-1}. There were no weeds in case of T2-Topic (Clodinafop propergyl) @ 300 g ha^{-1} and T3- Puma Supper (Fenoxaprop-p-ethyl) @ 625 mL ha^{-1}. The present results of chemical weed control in wheat are in conformity with earlier findings of Hassan *et al*., (2003).

Plant height (cm)

Maximum plant height (93.27cm) was observed in T_2-Topik (clodinafop propergyl) @ 300 g ha^{-1} followed by T_3-Puma super (fenoxaprop-p-ethyl) @ 625 mL ha^{-1} (93.00cm) and minimum (88.58cm) was recorded in case of control. These results are in agreement with the plant height findings of Khan *et al*., 2004.

Number of tillers m^{-2}

Productive tillers are the key component of grain yield in wheat crop. A perusal of data (Table-1) revealed that effect of weedicides was found significant on no. of tillers m^{-2}. Maximum increase in number of tillers m^{-2} (6.15 % more than control) was observed in case of T_3-Puma Super (fenoxaprop-p-ethyl) @ 625 mL ha^{-1} which was statistically equal with treatment T_2-Topik (clodinafop propargyl) @ 300 g ha^{-1} showing 5.34 % more than control. Next to these, treatment T_5-fenaxaprop @ 625 mL ha^{-1} showed 2.72 % increase over control that was statistically similar with T_4-Pujing (fenoxaprop-p-ethyl) @ 625 mL ha^{-1} showing 2.56 % increase in No. of tillers m^{-2} over control. Higher number of fertile tillers in herbicide treated plots was due to healthy stand of crop and better utilization of soil nutrients. Similar results were reported by Cheema and Akhtar (2005).

Number of spikelets spike^{-1}

Weedicides had significant effect on spikelets spike^{-1}. Mean maximum number of spikelets spike^{-1} (14.80) were noted with T_2-Topik (clodinafop propargyl) @ 300 g ha^{-1}, followed by T_3-Puma Supper (fenoxaprop-p-ethyl) @ 625 mL ha^{-1} (14.60) showing 12.10 and 10.60 % increase over control, respectively. It was followed in descending order by treatments T_4-Pujing (fenoxaprop-p-ethyl) @ 625 mL ha^{-1} and T_5-fenoxaprop-p-ethyl @ 625 mL ha^{-1} which showed 5.53 and 5.07 % increase over control, respectively. Increased number of spikelets spike^{-1} was reported by Khan *et al*., (2003) due to the treatment in the herbicides.

Number of grains spike^{-1}

Maximum number of grains spike^{-1} (45.20) were observed with T_2-Topik (clodinafop propargyl) @ 300 g ha^{-1} and it gave 35.60 % increase in number of grains spike^{-1} than control. It was followed in descending order by T_3- Puma Super (fenoxaprop-p-ethyl) @ 625 mL ha^{-1}, T_4-Pujing (fenoxaprop-p-ethyl) @ 625 mL ha^{-1} and T_5-fenaxaprop @ 625 mL ha^{-1}which increased No. of grains spike^{-2} by 33.00, 18.60 and 16.60%, respectively, over control. These results are supported by earlier researchers (Hashim *et al*., 2002) who reported that herbicidal treatments significantly increased the grains per spike in wheat crop.

Grain yield (kg ha^{-1})

Grain yield is a function of interplay of various yield components such as number of fertile tillers per unit area, number of grains per spike and 1000-grain weight. Weedicides affected grain yield significantly (Table-1). Treatment T_2-Topik (clodinafop propargyl) @ 300 g/ha^{-1} being the most effective which produced a 28.80 % increase in grain yield compared with control. Next to it, T_3-Puma Super (fenoxaprop-p-ethyl) @ 625 mL ha^{-1}, T_5-fenaxaprop @ 625 mL $ha^{-1}$and T_4-Pujing (fenoxaprop-p-ethyl) @ 625 mL ha^{-1} showed 26.80, 18.00 and 18.50 % more grain yield respectively, over control. These results are corroborated by the findings of Khan *et al*., (2003) who obtained an effective control of weeds in wheat through chemicals. Similarly, Noor *et al*., (2007) conducted a field study to variable behaviour of three formulations of fenoxaprop viz. Puma Super 75 EW (1250 and 625 mL), Pujing 10 EC (1000 and 500 mL ha^{-1}) and Brake 10 EC (1000 and 500 mL ha^{-1}). It was observed that higher concentration of fenoxaprop formulation proved better for *Phalaris minor* and lower for *Avena* species in wheat crop.

CONCLUSION

The present study revealed that Topik and Puma Super gave the maximum control of wild oats after spray and maximum grain yield of wheat. Thus, it is recommended to use Topik (clodinafop propargyl) and Puma Super (fenoxaprop-p-ethyl) @ 300 g and 625 mL ha^{-1}, respectively to get maximum grain yield of wheat under the arid climate of Punjab, Pakistan.

Table-1. Effect of different weedicides for the control of narrow leaves weed (wild oats) of wheat (*Triticum aestivum*)(Mean values).

S.No	Treatments	No. of weeds after spray m^{-2}	Plant height (cm)	No. of Tillers m^{-2}	No. of Spikelet $spike^{-1}$	No. of grains $spike^{-1}$	Grain Yield (kg ha^{-1})
1	Control	15.00 a*	88.58 c	371.17 c	13.20 c	33.33 c	3233.00 c
2	Topik (clodinafop propargyl) @ 300 g ha^{-1}	0.00 c	93.27 a	391.00 a	14.80 a	45.20 a	4167.00 a
3	Puma Super (fenaxaprop-p-ethyl) @ 625 mL ha^{-1}	0.00 c	93.00 a	394.00 a	14.60 a	44.33 a	4100.00 a
4	Pujing (fenaxaprop-p-ethyl) @ 625 mL ha^{-1}	2.33 b	91.53 b	380.70 b	13.93 b	39.53 b	3833.00 b
5	fenaxaprop @ 625 mL ha^{-1}	2.66 b	90.73 b	381.30 b	13.87 b	38.87 b	3817.00 b
LSD 0.05		1.75	1.12	8.21	0.32	2.17	253.20

*Means sharing a letter in common in the respective column do not significantly by LSD test at $P \leq 0.05$

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MANAGEMENT OF SOME PROBLEMATIC WEEDS OF WHEAT BY METABOLITES OF *Drechslera* sp. PREPARED IN MALT EXTRACT MEDIUM

Muhammad Akbar[1] and Arshad Javaid

ABSTRACT

Present study was designed to evaluate the herbicidal activity of metabolites of four Drechslera species viz. D. australiensis, D. hawaiiensis, D. biseptata and D. holmii (prepared in malt extract broth) against some problematic weeds of wheat namely Rumex dentatus, Phalaris minor and Avena fatua in 2009. Metabolites of Drechslera spp. were employed in 100% (original) and 50% concentrations. These metabolites wrought appreciable reduction in the germination of test weed's seeds by 3-72%. Original metabolites of all the fungal species significantly reduced shoot length and biomass by 39-72% and 30-70%, respectively. Metabolites of D. australiensis D. hawaiiensis and D. biseptata showed pronounced phytotoxic activity against all tested weeds, D. holmii appeared to be least effective. Root growth was more susceptible to metabolites than shoot growth. The metabolites of Drechslera spp. reduced 56-97% and 27-92% in root and shoot biomass, respectively. The present study concludes that metabolites of all the tested Drechslera spp. contain phytotoxic constituents that can be used as benign method of weed control alternative to synthetic chemical herbicides for management of some weeds of wheat. Further studies regarding the isolation of effective ingredients are in progress.

Keywords: Alternate herbicides, *Avena fatua*, *Drechslera*, *Phalaris minor*, *Rumex dentatus*, weeds of wheat.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is regarded as the staple food of Pakistan. It occupied an area of 8.14 m ha during the year 2005-2006 with an average grain yield of 2278 kg ha^{-1} (MINFAL, 2007), which is very low as compared to yield potential possessed by most of its cultivars. Among the reasons for this low yield, weeds are the most important. Siddiqui and Bajwa (2001) and Qureshi and Bhatti (2001) reported 31 and 45 weed species in wheat growing areas of Punjab and Sindh, respectively. In these studies, *Phalaris minor*, *Avena fatua*,

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Medicago polymorpha, *Coronopus didymus*, *Melilotus parviflora*, *Rumex dentatus and Chenopodium album* were found to be the most frequently occurring and densely populated weeds. These weeds are known to cause 20-60% yield losses in different wheat cultivars (Siddiqui, 2005).

Several methods of the weed control and weed eradication have been devised. Among these, chemical method is the common one. Various chemical herbicides such as Topik, Puma Super, Affinity and Buctril Super etc. are very effective in controlling weeds of wheat in wheat fields of Pakistan (Bibi *et al.*, 2005; Cheema *et al.*, 2006). However, in recent years, the use of chemicals has increased consumer's concern and their use is becoming more restrictive due to carcinogenic effects, residual toxicity problems, environmental pollution, occurrence of microbial resistance and high inputs (Marin *et al.*, 2003; Rial-Otero *et al.*, 2005). For more sustainable, eco-friendly integrated disease management strategies, there is a growing trend toward alternatives to synthetic chemical herbicides, which are less pesticide dependant or based on naturally occurring compounds (Cuthbertson and Murchie, 2005). One such alternative strategy to manage the weeds is the isolation of natural herbicidal constituents from plants (Batish *et al.*, 2007) and fungi (Evidente *et al.*, 2008; Javaid and Adrees, 2009). The present study was carried out to evaluate the herbicidal activity of culture filtrates of four species of *Drechslera* against some problematic weeds of wheat.

MATERIALS AND METHODS

Selection and procurement of test fungal species

Four plant pathogenic fungal species viz. *Drechslera australiensis*, *D. biseptata*, *D. hawaiiensis*, and *D. holmii* were selected to be evaluated for their herbicidal potential against three weeds of wheat. These test species were procured by Fungal Culture Bank of Pakistan, Institute of Plant Pathology, University of the Punjab Lahore, Pakistan.

Preparation of culture filtrates of the test fungi

All the tested fungal species were sub-cultured on Malt Extract Agar (MEA) medium in 9 cm diameter Petri plates and stored at 4 °C. Two percent (w/v) malt extract broth was prepared in distilled water, poured into 250 ml conical flasks @ 100 ml medium in each flask. These flasks were then autoclaved at 121 °C for 30 minutes and were inoculated with 5 mm agar discs of each of the four test fungal species from the margins of actively growing fungal colonies. Inoculated flasks were incubated at 25±2 ºC in an incubator for 20 days. The grown cultures were filtered through sterilized Whatman filter paper No.1. These extracts were stored at 4 ºC in a refrigerator as original concentrations. Sterilized distilled water was added to the original filtrates (100%) to prepare dilution of 50% (Javaid and Adrees, 2009).

Laboratory bioassays

In laboratory bioassays, the effect of different concentrations of culture filtrates of the four selected fungal species was evaluated on germination and early seedling growth of test weed species. For this seeds of weeds were surface sterilized with 1% sodium hypochlorite for 10 minutes, 10 seeds of each test weed species were placed in sterilized 9 cm diameter Petri plates lined with a filter paper, moistened with 3 ml of different concentrations of fungal culture filtrates. Treatment in a similar manner but with 2 and 1% malt extract broth served as positive control. Similar treatment with distilled water was also made which served as negative control. Each treatment was replicated thrice. Petri plates were arranged in a completely randomized design in a growth room maintained at 25 °C and 10 h light period daily. After 20 days seed germination, root and shoot length and their fresh biomass were determined.

Statistical analysis

The data were analyzed by analysis of variance followed by Duncan's Multiple Range Test using computer software SPSS and COSTAT.

RESULTS AND DISCUSSION

Effect of fungal metabolites against *P. minor*

Data regarding the effect of culture filtrates of four *Drechslera* spp. against germination and seedling growth of *P. minor* are presented in Table-1. The effect of both 1% and 2% malt extract medium was insignificant on seed germination. Culture filtrates of both 50% and 100% concentration of all the four tested fungal species significantly reduced germination by 51-72%. Adverse effect of 100% culture filtrates on germination was more pronounced as compared to 50% concentration. The effect of the two concentrations of malt extract broth was insignificant on length as well as biomass of shoot. Shoot length was significantly reduced by culture filtrates of the test fungal species except 50% filtrates of *D. biseptata.* This concentration was also ineffective in reducing the shoot biomass while other treatments suppressed the shoot biomass to variable extents. Adverse effect of 100% culture filtrates of *D. biseptata* and *D. holmii* was significant as compared to control and two concentrations of malt extract broth. Root length was significantly suppressed by culture filtrates of all four *Drechslera* species. There was 50–97% reduction in root length due to different concentrations of the various culture filtrates as compared to control. Culture filtrates of *D. biseptata* were comparatively less effective against root length of *P. minor* as compared to filtrates of other fungal species. Root biomass was decline by 11–54% due to various culture filtrates treatments. The effect of all the treatments except 50% filtrates of *D. biseptata* was significant.

Table-1. Effect of original (100%) and diluted (50%) culture filtrates of four *Drechslera* spp. against germination and seedling growth of *Phalaris minor.*

Fungal species	Conc. (%)	Germination (%)	Shoot length (mm)	Shoot biomass (mg)	Root length (mm)	Root biomass (mg)
Control (water)	0	83 a	61 a	5.7 ab	72 b	4.6 a
Malt Extract Broth	1	85 a	60 a	5.4 ab	78 a	4.6 a
	2	77 a	64 a	5.9 a	77 a	5.0 a
D. australiensis	50	41 b	44 cd	4.0 abc	3 e	2.9 cd
	100	23 cde	35 d	4.0 abc	3 e	2.4 cd
D. biseptata	50	41 b	56 ab	5.7 ab	36 b	4.1 ab
	100	23 e	40 cd	3.0 c	13 c	3.3 bc
D. hawaiiensis	50	40 b	48 bc	4.4 abc	4 e	2.8 cd
	100	23 e	44 cd	3.7 bc	3 e	2.2 d
D. holmii	50	36 bcd	43 cd	4.2 abc	3 e	2.5 cd
	100	26 de	35 d	3.3 c	2 e	2.1 d

In a column, values with different letters show significant ($P \leq 0.05$) difference as determined by Duncan's Multiple Range Test.

Effect of fungal metabolites against *A. fatua*

Data regarding the effect of culture filtrates of four *Drechslera* spp. against germination and seedling growth of *A. fatua* are demonstrated in Table-2. The effect of both 1% and 2% malt extract broth on germination and various shoot/root growth parameters was insignificant. Different culture filtrate treatments reduced the germination by 8–47%. All except 50% culture filtrates of *D. hawaiiensis* and *D. holmii* significantly suppressed germination. All the culture filtrate treatments except 50% *D. biseptata* significantly reduced shoot growth of *A. fatua* in terms of length and biomass. Root growth was more susceptible and suppressed by culture filtrates of all the four *Drechslera* species. There was 14–65%, 2–43%, 44–95% and 29–92% reduction in shoot length, shoot biomass, root length and root biomass due to various culture filtrate treatments, respectively.

Effect of fungal metabolites against *R. dentatus*

Data regarding the effect of culture filtrates of four *Drechslera* spp. against germination and seedling growth of *R. dentatus* are summarized in Table-3. The effect of 1% as well as 2% of malt extract broth was insignificant on germination the target weed species. Original (100%) culture filtrates of *D. australiensis*, and *D. holmii* significantlt reduced germination while the effect of all other treatments was insignificant on studied parameter. Shoot length was reduced by 8-72% due to different culture filtrate treatments. Effect of all filtrate treatments except 50% *D. biseptata* was significant as compared to control. Original filtrates of *D. australiensis* were found most effective in suppressing shoot length of *R. dentatus.* Shoot biomass showed a response to different filtrate treatments similar to that of shoot length. Root growth was more susceptible to the application of culture filtrates of four *Drechslera* species. Root length and biomass were significantly reduced by 47–97% and 30–88% due to different fungal culture filtrate treatments.

Table-2. Effect of original (100%) and diluted (50%) culture filtrates of four *Drechslera* spp. against germination and seedling growth of *Avena fatua.*

Fungal species	Conc. (%)	Germination (%)	Shoot length (mm)	Shoot biomass (mg)	Root length (mm)	Root biomass (mg)
Control (water)	0	85 ab	115 a	48 a	163 a	51 a
Malt Extract Broth	1	88 a	107 a	46 a	165 a	48 a
	2	95 a	106 a	43 ab	158 a	51 a
D. australiensis	50	58 cd	66 bc	32 c	19 c	9 c
	100	58 cd	40 d	27 c	11 c	5 c
D. biseptata	50	63 cd	99 a	46 a	91 b	36 b
	100	55 cd	56 bcd	26 c	20 c	11 c
D. hawaiiensis	50	78 bcd	57 bcd	31 c	14 c	8 c
	100	58 cd	46 cd	27 c	14 c	7 c
D. holmii	50	65 bcd	73 b	33 c	17 c	10 c
	100	45 d	60 bcd	29 bc	8 c	4 c

In a column, values with different letters show significant (P≤0.05) difference as determined by Duncan's Multiple Range Test.

Table-3. Effect of original (100%) and diluted (50%) culture filtrates of four *Drechslera* spp. against germination and seedling growth of *Rumex dentatus.*

Fungal species	Conc. (%)	Germination (%)	Shoot length (mm)	Shoot biomass (mg)	Root length (mm)	Root biomass (mg)
Control (water)	0	98 a	15.4 a	10.5 b	34 b	2.6 a
Malt Extract Broth	1	93 ab	13.4 bc	14.7 a	42 a	2.9 a
	2	90 abc	15.2 a	15 a	40 a	2.7 a
D. australiensis	50	85 abc	6.4 f	6.5 de	1 e	0.9 c
	100	75 c	4.3 g	3.1 g	1 e	0.7 c
D. biseptata	50	93 ab	14.1 ab	9.2 bc	18 c	1.9 b
	100	85 abc	9.3 de	7.2 de	1 e	0.6 c
D. hawaiiensis	50	90 abc	12.3 c	8.1 cd	12 e	0.9 c
	100	95 ab	9.1 de	6.0 ef	1 e	0.4 c
D. holmii	50	95 ab	10.1 d	6.6 de	1 e	0.3 c
	100	80 bc	7.9 ef	4.7 fg	1 e	0.3 c

In a column, values with different letters show significant (P≤0.05) difference as determined by Duncan's Multiple Range Test.

Results of the present study showed that culture filtrates of different *Drechslera* species contain herbicidal constituents for the management of some problematic weeds of wheat. These finding are in agreement with the results of some earlier studies where culture filtrates of other *Drechslera* species exhibited herbicidal activity against weeds (Kastanias and Tokousbalides, 2000; Evidente *et al.*, 2005, 2006a; Javaid and Adrees, 2009). Various herbicidal constituents have been identified from different *Drechslera* species. Evidente *et al.*, (2006b) identified four herbicidal constituents from *Drechslera gigantea* viz. ophiobolin A, 6- epi-ophiobolin A, -anhydro-6-epi-ophiobolin A and ophiobolin I, which were very effective against several grass and dicotyledon weeds. In another study, Evidente *et al.*, (2005) reported Drazepinone, a trisubstituted tetrahydronaphthofuro azepinone from *Drechslera siccans* with herbicidal activity against monocot weeds. Earlier, Sugawara *et al.*, (1987) islated ophiobolin I from Drechslera maydis and Drechslera sorghicola that possessed herbicidal activity. Kastanias and Tokousbalides (2000) isolated pyrenophorol isolated from a *Drechslera avenae* pathotype that exhibited herbicidal potential against weeds. Further studies regarding the isolation of potential herbicidal constituents from the *Drechslera* species used in the present study, are in progress.

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EVALUATION OF DUAL PURPOSE HERBICIDES IN WHEAT *(Triticum aestivum* L.*)* UNDER DIFFERENT TILLAGE REGIMES

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ABSTRACT

Different doses of dual purpose herbicides (sulfosulfuron, metsulfuron-methyl 30 % + iodosulfuron–methyl–sodium 30 %, imazamethabenz- methyl and metribuzin) were studied to determine their effect on grain yield of wheat. The experiment was conducted at Islamic Azad University Experiment Station, Shooshtar Branch, Iran during 2006. Randomized complete block design was used having three replications, where two levels of tillage (conventional and minimum tillage) were assigned to the main plot while different levels of herbicides (sulfosulfuron 26.6 and 31 g a.i. ha^{-1}, metsulfuron–methyl 30 % + iodosulfuron – methyl l- sodium 30 % 350 and 400 g a.i. ha^{-1}, imazamethabenz - methyl 2 and 3 l ha^{-1} and metribuzin 200 and 300 g a.i. ha^{-1}) were assigned to sub-plots. The results showed that conventional tillage was better than minimum tillage in terms of weed control and significant difference was found between the tillage levels (P< 0.01). Using 31 g ha^{-1} sulfosulfuron in conventional tillage and 31 g ha^{-1} sulfosulfuron and 400 g ha^{-1} metsulfuron – methyl 30 % + iodosulfuron – methyl – sodium 30 % in minimum tillage were the best treatments. No significant differences were found in the tillage levels regarding broadleaf weed control although their density was more in conventional tillage. Using 31 and 26 g a.i. ha^{-1} sulfosulfuron, 350 g a.i. ha^{-1} and 400 g a.i. ha^{-1} metsulfuron – methyl 30 % + iodosulfuron – methyl – sodium 30 % in both tillage systems gave highest broadleaf weed control. Density of grassy weed was more in minimum tillage. The highest grassy weed control was observed using 31 and 26 g ha^{-1} sulfosulfuron, 350 g ha^{-1} and 400 g a.i.ha^{-1} metsulfuron–methyl 30 % + iodosulfuron –methyl–sodium 30 % in both tillage systems. There was no significant difference between two tillage systems regarding grain yield of wheat. Sulfosulfuron 26.6 and 31 g a.i. ha^{-1} and metsulfuron–methyl 30 % + iodosulfuron–methyl–sodium 30 % 350 and 400 g a.i. ha^{-1} had the highest level of wheat grain yield, respectively.

Key words: Wheat, tillage systems, weed, herbicide.

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INTRODUCTION

Weed infestations greatly decrease the wheat yield and quality and thus deprive millions of people of grains (Khan and Marwat, 2006). In advanced countries weeds are managed effectively and can cause minimum losses up to 5 % while in developing or under developed countries the losses may exceed 25 % in wheat. The increasing requirements of high crop production, energy crisis and minimizing weed control expenses have led us to use herbicides for weed control. Despite the facts that the use of chemicals deteriorates environment, herbicides are still the most common method of weed control (Montazeri, 2005). In minimum tillage systems, tillage is a part of the system and attached to herbicides. By using herbicides, the number of tillage operations could be decreased. In addition, using minimum tillage systems and tillage free system leads to moisture saving and reducing tillage expenses (Ross and Lembi, 1985). Usman *et al.,* (2009) reported that maximum weed density was observed in conventional tillage while minimum weed density was observed in zero tillage. However herbicides in combination will tillage greatly decreased the weed density and increased grain yield of wheat.

Despite using herbicides in minimum tillage system, there are limitations in selecting herbicides to control weeds in this tillage system and using a particular herbicide might lead to development of herbicide resistant broadleaf weeds and grasses (Holt, 1992).

Rojas *et al.,* (1984) compared conventional tillage (once with moldboard plow and twice with disk plow) and minimum tillage (once with disk plow) and without tillage by using herbicides found out that in minimum tillage weed population was less than other treatments; on the other hand, in zero tillage system, weeds were controlled better. Bradford and Calvin (2002) reported that in winter wheat, imazamethabenz-methyl herbicide in concentration of 0.36 kg ha^{-1} and 0.18 kg ha^{-1}, controlled wild oat up to 84 %. Using 0.18 kg ha^{-1} concentration in two stages showed 13 % more control of wild oat compared to one time application of 0.36 kg ha^{-1}.

The aim of this research work was to study weed control in wheat by using dual purpose herbicides and tillage systems and to select the best herbicide regarding the type of tillage as well as with respect to preventing acatalectic enzyme activity that decrease growth and finally destroy the weeds. These herbicides control weeds such as wild mustard as well as leave no undesirable effects on wheat growth. By increasing effectiveness of perennial broadleaf weed control, it is necessary to choose herbicides with better weed control and should be safe for the target crop and friendly to the environment.

MATERIALS AND METHODS

Field experiment was carried out in the Educational Research Experimental Farm, Faculty of Agriculture, Islamic Azad University, Shoushtar Campus in north Shoushtar, Iran; situated at 48° 50′ E longitude, 32° 3′ N latitude and at 67 m asl. This experiment was performed during 2006-2007 in randomized complete block design with split-plot arrangement replicated three times. To main plots two levels of tillage (conventional and minimum) and to the sub-plot were ten levels of herbicides (imazosulforon methyl 30 %, iodosulfuron methyl 30 %, 350 and 400 a.i. g ha^{-1}, sulfosulfuron 75 %, 26.6 and 31 g a.i. ha^{-1}, metribuzin 70 %, 200 and 300 g a.i. ha^{-1}, imazamethabenz methyl 25 %, 2 and 3 l ha^{-1}, a hand weeding and a weedy checks) were assigned. The distance between replications was 2 m and sub-plots were 1 m. The size of each main plot was 3.5x 30 and sub plot measured 3 x 2 m^2, respectively.

Imazasulfuron methyl 30 % and iodosulforon methyl 30 % as WDG (water diffusible granules) during the first stage of tillering alongwith surfactant moaning, 1.5 per thousand, sulfosulfuron 75 % as WDG in tillering stage plus one litre non-ionic moaning oil were used. Imazamethabenz-methyl with 25 % emulsion in the first stages of wheat tillering and metribuzin in powder formulation was applied as pre-emergence. In conventional tillage the land was prepared by plowing once with moldboard plow and plowings twice with disk plow vertical on each other. For minimum tillage, the land was plowed once with disk plow. On December 1, 2006, wheat was carefully cultivated manually with 400 bushes m^{-2} in homogenous spread in the experimental fields. Sampling was made in different stages of wheat growth until final harvesting. In each stage, samples were taken from middle lines of each plot by observing the margins from up and down with 50x50 cm frame. The samples were taken to the lab and data were recorded on harvest index of wheat and row and wheat yield m^{-2}. Weeds samples were taken before and after spray treatment. Number of weeds m^{-2} determined and the effects of herbicides were recoded. Counting, determining species, shape in terms of narrow leaf or broadleaf and dry weight of weeds were done 30 days after spray. Counting and sampling weeds were carried out in the center of the experimental field in one square meter area. The analysis of variance was run by MSTATC software, comparing mean averages by Duncan's multiple range test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The results showed that tillage system has a significant effect on controlling weeds. Weed control in conventional tillage was better than that of minimum tillage (Table-1). It was noted that using sulfosulfuron herbicides 31 g ha^{-1} in conventional tillage and sulfosulfuron 31 g ha^{-1}, metsulfuron methyl 30 % + iodosolforon methyl 30 % 400 g ha^{-1} in minimum tillage were more successful in reducing weed population. The higher doses of herbicides in both tillage systems were better in reducing weeds. Imazamethabenz methyl was poor in terms of weed control especially on broad leaf weeds. Hand *et al.,* (2002) also investigated metsulfuron methyl 30 % + iodosulfuron methyl 30 % had better performance in controlling broadleaf weeds in wheat. On the other hand according to Etzenberg and Wasser (2003), sulfosulfuron herbicide was superior in controlling narrow leave weeds. Metsulfuron methyl 30 % + iodosulforon methyl 30 % 400 g a.i. ha^{-1} and sulfosulfuron herbicides 31 g a.i. ha^{-1} were best in controlling broad leaf weeds (Fig. 1). However, metsulfuron methyl 30 % + iodosolforon methyl 30 % 350 g a.i. ha^{-1} were poor in controlling*Convolvulus arvensis*, sulfosulfuron 26.6 g a.i. ha^{-1} in controlling mallow and black bindweed (*Polygonum convolvulus*), imazamethabenz methyl herbicide 2 and 3 l ha^{-1} in controlling safflower, black bindweed and lesser bindweed (*Convolvulus arvensis*), metribuzin 200 and 300 g a.i. ha^{-1} in controlling lesser bind weed and mallow weeds, respectively.

Grassy weeds decreased in conventional tillage as compared to minimum tillage. It has been reported by Fenster *et al.,* (1969) that moldboard plow showed better narrow leave weed control than the disk plow. Mezasulfuron methyl 30 % + iodesolforon methyl 30 % herbicides 350 and 400 g ha^{-1} and sulfosulfuron 26.6 and 31 g ha^{-1} had highest effects in controlling grassy weeds. Dry weight of weeds was higher in conventional tillage. Desirable conditions in conventional tillage, high soil porosity and better gaseous exchange might have caused vigorous root growth of weeds which resulted in better weed growth and maximum utilization of resources. In contrary, dry weight of broad leaf weeds in minimum tillage were lower than that of conventional tillage, which might be attributed to lesser root growth under minimum tillage conditions (Zank**,** 1993).

There is no significant differences between tillage systems in terms of grain yield (Table-1); however, there was significant difference on grain yield in as much as sulfosulfuron 31 and 26.6 g ha^{-1} and mezasulfuron methyl 30 % + iodosulfuron methyl 30 % 350 and 400 g ha^{-1} were the most superior herbicides in grain yield; while imazamethabenz methyl 2 and 3 litre ha^{-1} was the weakest in wheat grain yield (Fig. 1). In terms of wheat stem height, there was a significant difference between tillage systems and conventional tillage was superior to minimum tillage (Table-1). Results showed control treatments had better height than herbicides treatments and followed by sulfosulfuron 26.6 g ha^{-1} and mezasulfuron methyl 30 % + iodosulfuron methyl 30 %, 350 and 400 g ha^{-1} (Fig. 2).

Table-1. Mean squares for measured characteristics in the experiment.

Source of Variation	Degree of Freedom	Weed density before application (m^{-2})	Weed density after application (m^{-2})	Density of broadleaf weeds (m^{-2})	Density of grassy weed (m^{-2})	Dry weight of weed ($g\ m^{-2}$)	Harvest index of Wheat	Performance increased (%)	Straw yield ($g\ m^{-2}$)	Grain yield ($g\ m^{-2}$)
Replication	2	$0/04^{ns}$	$0/087^{ns}$	$0/09^{ns}$	$0/015^{ns}$	$0/03^{ns}$	$0/83^{ns}$	4^{ns}	$827/25^{ns}$	$12/95^{ns}$
Tillage systems	1	$8/7^{**}$	$1/7^{**}$	$2/2^{**}$	$0/1^{**}$	$98/6^{**}$	$4/86^{**}$	1^{ns}	$572/08^{ns}$	5783^{ns}
Herbicides	9	$111/15^{**}$	$41/002^{**}$	$35/9^{**}$	$3/9^{**}$	$2914/1^{**}$	$101/7^{**}$	$4740/9^{**}$	148138^{**}	94246^{**}
Interaction	9	$0/2^{**}$	$0/4^{**}$	$0/50^{**}$	$0/1^{**}$	$39/2^{**}$	$9/5^{ns}$	$48/7^{**}$	$1153/4^{ns}$	912^{ns}
Coefficient of change		0/03	0/04	0/04	0/02	0/9	1/04	1/2	672/2	19/5

Ns *, **, non-significant, significant and highly significant, respectively.

In conventional and minimum tillage systems, there was no significant difference between wheat straw yield in as much that in conventional tillage and minimum tillage, due to surface wheat root, the existing space is used desirably without differences between the system; however, there was significant differences between the straw yield of the two systems (Table-1). The sulfosulfuron treatment 31 g ha^{-1} in both conventional and minimum tillage system increased wheat straw yield due to controlling weeds and no competition with farm plants and existence of suitable environment for root growth in soil. This increase in straw yield is a factor in increase in grains. Imazamethabenz methyl and metribuzin lower wheat straw yield due to burning effect, affecting growth of root and aerial parts of the wheat as well as their less efficient weed control. Marwat *et al.,* (2007) reported that conventional tillage decreased weed density and increased grain yield as compared to reduced tillage in maize.

In the light of our results it is concluded that using conventional tillage system along with herbicides effectively controlled weeds. By using higher dose of herbicides in minimum tillage system, we can achieve desirable weed control. Among herbicides, sulfosulfuron, 31 g ha^{-1} was more effective in controlling broadleaf as well as grassy weeds in both tillage systems, without damaging wheat. While, there was no significant difference on the yield and root growth of wheat under both tillage system.

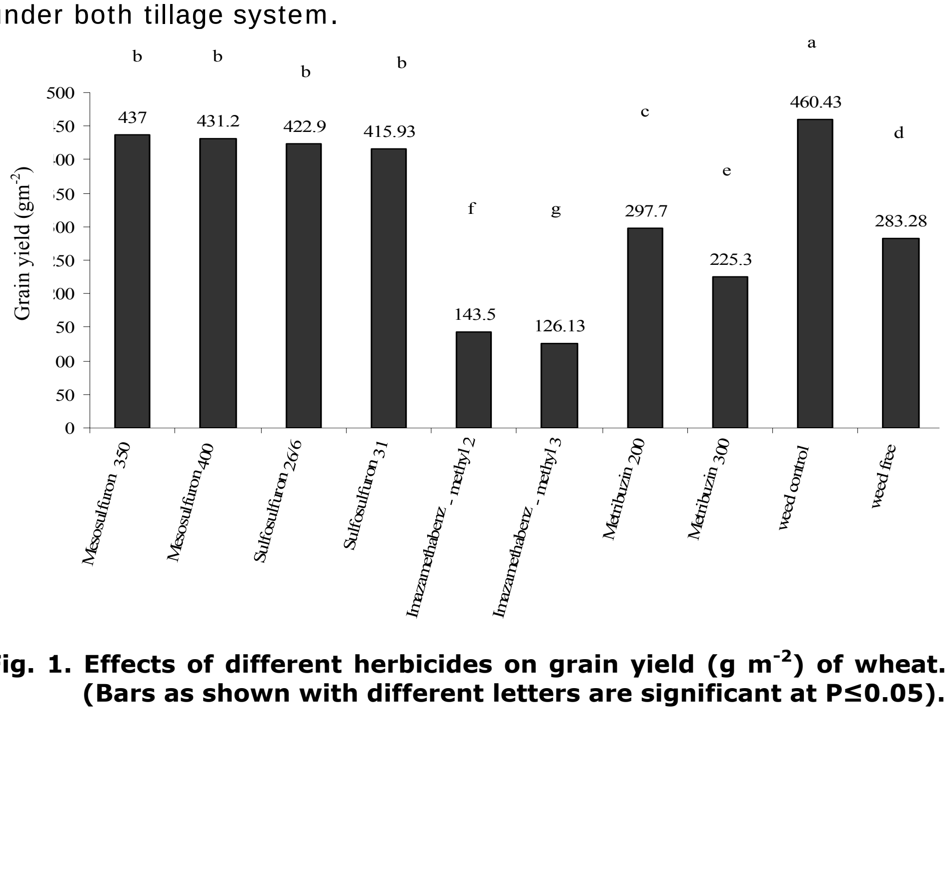

Fig. 1. Effects of different herbicides on grain yield (g m^{-2}) of wheat. (Bars as shown with different letters are significant at P≤0.05).

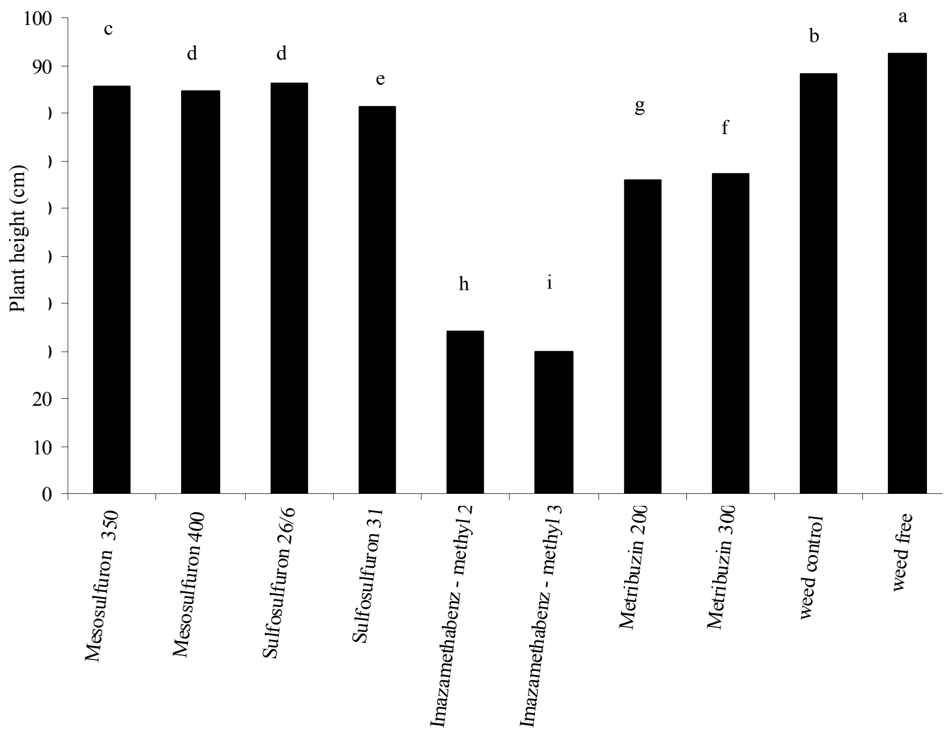

Fig. 2. Effects of herbicides on Plant height
(Bars as shown with different letters are significant at P≤0.05)

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EARLY WATERGRASS (*Echinochloa oryzoides*) AND LATE WATERGRASS (*Echinochloa phyllopogon*) CONTROL WITH FORAMSULFURON

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ABSTRACT

Early watergrass and late watergrass are predominant weeds of rice fields but can also occur in corn fields where it follows rice in rotation. Pot experiments were conducted to evaluate control of early watergrass and late watergrass with foramsulfuron applied alone and in mixture with dicamba, MCPA, sulcotrione, and mesotrione. Foramsulfuron applied at 45 g a.i. ha^{-1} provided 82% of early watergrass and 76% of late watergrass control at 3- to 4-leaf growth stage, whereas efficacy was only 71% for early watergrass and 62% for late watergrass at 5- to 6-leaf growth stage. Increased application rate of foramsulfuron provided better control of both species at any growth stage, with the highest application rate (59 g a.i. ha^{-1}) providing maximum control of both species. Mixtures of foramsulfuron with dicamba or MCPA showed lower control of both species than foramsulfuron applied alone. Moreover, sulcotrione applied in mixture with foramsulfuron improved control of both species, whereas the addition of mesotrione did not affect control of both species compared with foramsulfuron applied alone. Satisfactory control of early watergrass and late watergrass in corn can be achieved with increased application rates of foramsulfuron applied preferably at early growth stage. Mixtures of foramsulfuron with either dicamba or MCPA can reduce considerably the efficacy of foramsulfuron on both early watergrass and late watergrass. On the other hand, mixtures of foramsulfuron with either sulcotrione or mesotrione can be used for broadening spectrum of control without affecting negatively foramsulfuron activity on these grasses.

Key words: Antagonism, herbicide mixtures, early watergrass, late watergrass.

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INTRODUCTION

Early watergrass (*Echinochloa oryzoides*) and late watergrass (*E. phyllopogon*) are considered serious weeds of water-seeded rice in many rice production areas in Europe (Carretero, 1981) and in the United States (Hill *et al.*, 1985). Lately, these species have become serious weeds of rice fields in northern Greece. Early watergrass normally appears with a typically drooping, closed, dense inflorescence (the branches of the panicle are depressed to the main rachis), seeds ovate to almost round with long awn, and shows early flowering with panicle emergence about 62 to 67 d after germination (Damalas *et al.*, 2008). On the other hand, late watergrass normally appears with an erect, closed, dense inflorescence (the branches of the panicle are more or less erect except for the lowermost ones), seeds ovoid to oblong, commonly without awn (or with short awn), and shows late flowering with panicle emergence about 78 to 88 d after germination (Damalas *et al.*, 2008). Dense infestations of early watergrass and late watergrass, if not controlled, have been reported to cause more than 50% yield loss of rice (Hill *et al.*, 1985).

Rice is a small but very important cereal crop in Greece because its production covers the domestic needs and a surplus usually of Indica type is exported too (Ntanos, 1998). It is normally grown using very intensive cropping systems, where rice monoculture and heavy reliance on herbicides for weed control are common agronomic practices. The main crop rotation systems for rice cultivation are rice-rice or rice-fallow rotation. However, there is a significant area (80%) where rotation of three years with rice and one year with corn, sugarbeet, or cotton is normally applied (Ntanos, 1998). Although early watergrass and late watergrass are mostly weeds of rice fields, they can also occur in corn fields particularly where it follows rice in various rotation systems. Thus, these grasses can be a problem in corn. With the low prices for corn grain and silage, pest management issues are becoming increasingly problematic and particularly weed control which is the most important practice and has the greatest lasting effect if not dealt with. Weed control is important in corn to reduce weed competition and minimize yield losses, protect silage feed quality, and reduce the production of weed seeds for the following crops. Despite the existence of several grass herbicides used in corn, the activity of these herbicides has not been evaluated on early watergrass and late watergrass.

Foramsulfuron, a relatively new sulfonylurea herbicide, is used for postemergence control of grasses and some broadleaf weeds in corn (Bunting *et al.*, 2004a, 2005; Prostko *et al.*, 2006; Nurse *et al.*, 2007). Foramsulfuron acts through inhibition of the enzyme acetolactate synthase (ALS) which catalyzes the biosynthesis of the branched-chain amino acids valine, leucine, and isoleucine. These amino acids are necessary components of the growth processes in plant cell division. Inhibition of ALS results in slow or stunted plant growth and ultimate plant death. Visible signs of herbicidal activity after postemergence application of this herbicide are an almost immediate cessation of plant growth, followed by leaf yellowing, promotion of anthocyanin production (leading to a reddish coloration of leaves), and finally, progressive shoot death. Depending on the weed species and the environmental conditions, plant death will usually occur from 1-3 weeks after herbicide application. Selectivity of foramsulfuron in corn crop is due to herbicide metabolism and it depends on corn hybrid and corn growth stage at application (Bunting *et al*., 2004b, 2004c). The objective of the present research was to evaluate control of early watergrass and late watergrass with foramsulfuron applied alone and in mixtures with other herbicides used for broadleaf weed control in corn.

MATERIALS AND METHODS

Seeds of *E. oryzoides* and *E. phyllopogon* were collected by hand in September 2006 from mature plants growing in rice fields of the rural area of Thessaloniki in northern Greece. Seeds were collected at the time of natural dispersal and only seeds that fell off carefully shaken plants were used. Distinction between the two *Echinochloa* species was based mainly on morphological traits as morphology of the inflorescence as described by Carretero (1981) and the time of flowering of the species in rice fields. Nonetheless the classification of *Echinochloa* species is difficult because of the existence of numerous intergrading polymorphic complexes with many subspecies and varieties which often lack conspicuous identification characters. Identification key and nomenclature for the species are based on the classification proposed by Carretero (1981). After collection, seeds were dried in the greenhouse, air-cleaned to remove non-viable seeds and waste materials, and stored in plastic bags at 5-6 ^{o}C (in a refrigerator) until the initiation of the experiments.

Seeds of *E. oryzoides* and *E. phyllopogon* were planted in late May in 2-L plastic pots (13.5 cm diameter by 15.5 cm height) filled with a soil mixture (soil and sand 2:1 v/v). The physicochemical characteristics of the soil used in the experiments were clay 32%, silt 56%, sand 12% (silty clay loam), organic matter 1.6%, $CaCO_3$ 7.4%, pH (1:1 H_2O) 7.6 and cation exchange capacity (CEC) 27.7 meq/100 g. Pots were placed outdoors and watered once daily throughout the experiments by irrigating to soil saturation. One week after seedling emergence, plants were thinned to 30 per pot, where necessary, to obtain a uniform plant population in all pots. Plants grew normally throughout the studies without experiencing any particular environmental stress conditions.

Two experiments were conducted. In the first experiment, foramsulfuron was applied alone at 45, 52, and 59 g a.i. ha^{-1} at two growth stages (3-4 and 5-6 leaves) of each *Echinochloa* species. In the second experiment, foramsulfuron was applied alone at 45 g a.i. ha^{-1} and in mixture with dicamba at 288 g a.i. ha^{-1}, MCPA at 600 g a.i. ha^{-1}, sulcotrione at 450 g a.i. ha^{-1}, or mesotrione at 75 g a.i. ha^{-1} at two growth stages (3-4 and 5-6 leaves) of each *Echinochloa* species. A non-treated control for each growth stage was included in each experiment for comparison. There were four replications (pots) for each treatment in a completely randomized design. Herbicide treatments were applied with a propane-pressurized hand-held field plot sprayer at 250 kPa pressure using 300 L ha^{-1} of water. All experiments were repeated in time (two growing seasons) following exactly the same procedure. Environmental conditions during herbicide treatment applications were similar in both study periods.

Echinochloa species were evaluated by determining fresh weight of all live stems remaining at 45 days after herbicide treatments. Fresh weight data were expressed as a percent reduction from the non-treated control and were analyzed separately for each species using a combined over time analysis of variance (ANOVA) with four replications. In particular, for the first experiment the analysis of data was conducted using a 2 by 3 factorial approach (2 growth stages by 3 foramsulfuron rates) combined over time and for the second experiment the analysis of data was conducted using a 2 by 5 factorial approach (2 growth stages by 5 mixture treatments). Before the ANOVA, fresh weight data were log-transformed to stabilize variance. Transformation did not affect data interpretation and therefore original means are presented. Differences between means were compared at 5% level of significance using Fisher's protected LSD test. Because no experiment interaction occurred, fresh weight reduction means were averaged over time.

RESULTS AND DISCUSSION

Foramsulfuron applied alone at 45 g a.i. ha^{-1} provided 82% suppression of fresh weight over control of early watergrass and 76% control of late watergrass at the 3- to 4-leaf growth stage (Table-1). At the 5- to 6-leaf growth stage suppression for early watergrass and late watergrass decreased to 71% and 62%, respectively. For both species higher suppression was recorded with increasing application rate at any growth stage. Greatest control of both species at the early growth stage was observed with two higher rates of foramsulfuron, whereas at the late growth stage suppression was highest with the highest rate applied (Table-1). Early watergrass was more sensitive to foramsulfuron than late watergrass. Variability of these species in tolerance to other rice herbicides tested has been previously reported (Damalas *et al.*, 2006). This variability in tolerance to herbicides could be partially associated with growth rate differences between the two *Echinochloa* species (Damalas *et al.*, 2008), which may be responsible for differences in herbicide metabolism rate. Weed tolerance to herbicides is often associated with metabolic processes that result in herbicide degradation by the target plants (Devine *et al.*, 1993) and thus weed species can exhibit different levels of tolerance to a given herbicide even if they are similarly susceptible at their target site.

Table-1. Fresh weight reduction (% of non-treated control) of *E. oryzoides* and *E. phyllopogon* with foramsulfuron as affected by application rate and growth stage.

Treatment	Rate (g a.i. ha^{-1})	% Fresh weight reduction a, b	
		E. oryzoides	*E. phyllopogon*
		3-4 leaves	3-4 leaves
Foramsulfuron	45	82 c	76 cd
Foramsulfuron	52	88 ab	83 ab
Foramsulfuron	59	92 a	88 a
		5-6 leaves	5-6 leaves
Foramsulfuron	45	71 d	62 e
Foramsulfuron	52	79 c	71 d
Foramsulfuron	59	87 b	80 bc

a Means are pooled over two experiments.
b Different letters within each column indicate statistically significant differences at P=0.05.

Addition of dicamba and MCPA in mixture with foramsulfuron resulted in reduced efficacy on both species (Table-2). The reduced control with those mixtures was evident at both growth stages and it was more pronounced for the mixtures with MCPA. The reduced control of both species with the mixtures of foramsulfuron with MCPA or dicamba indicates some kind of herbicide interaction which alters the expected behavior of foramsulfuron. It seems possible that the presence of these herbicides in mixtures with foramsulfuron reduces the amount of foramsulfuron that is absorbed by the foliage of the treated plants or the amount of foramsulfuron that is translocated to the site of action of the treated plants, resulting in reduced grass control.

On the contrary, addition of sulcotrione in mixture with foramsulfuron resulted in increased efficacy on both species at both growth stages compared with foramsulfuron applied alone (Table-2). Addition of mesotrione in mixture with foramsulfuron did not affect control of both species compared with the single application of foramsulfuron (Table-2). Previous research indicated no antagonistic interactions for the control of large crabgrass with tank mixtures of foramsulfuron plus mesotrione (Schuster *et al.*, 2007). Conversely, Schuster *et al.*, (2007) showed that similar tank mixtures caused 20 to 30% antagonism for the control of yellow foxtail and green foxtail. Previous findings also showed a reduction in the efficacy of nicosulfuron in mixture with mesotrione which was attributed to decreased absorption and translocation of nicosulfuron in green foxtail and decreased absorption in yellow foxtail (Schuster *et al.*, 2007). However, tank mixtures of rimsulfuron with mesotrione did not result in reduced absorption or translocation of rimsulfuron in green foxtail, whereas in yellow foxtail the absorption decreased by 11% at 7 days after treatment. In a controlled environment, the addition of mesotrione in mixture with sulfonylurea herbicides had no adverse effects on the control of large crabgrass or velvetleaf. Tank mixing mesotrione with nicosulfuron or foramsulfuron, however, resulted in reduced control of green foxtail and shattercane by nicosulfuron and foramsulfuron (Schuster *et al.*, 2008). On the contrary, antagonistic interactions were not observed with foramsulfuron in tank mixtures with either topramezone or mesotrione for the control of large crabgrass, barnyardgrass, yellow foxtail, and green foxtail (Kaastra *et al.*, 2008).

Table-2. Fresh weight reduction (% of non-treated control) of *E. oryzoides* and *E. phyllopogon* with foramsulfuron (at 45 g a.i. ha^{-1}) as affected by mix partner herbicide and growth stage.

Treatment	Rate (g a.i. ha^{-1})	% Fresh weight reduction a, b			
		E. oryzoides		*E. phyllopogon*	
		3-4 leaves		3-4 leaves	
Foramsulfuron	45	82	b	76	bc
(+) dicamba	(+) 288	66	d	58	e
(+) MCPA	(+) 600	52	e	42	f
(+) sulcotrione	(+) 450	96	a	88	a
(+) mesotrione	(+) 75	84	b	80	b
		5-6 leaves		5-6 leaves	
Foramsulfuron	45	71	c	62	de
(+) dicamba	(+) 288	53	e	42	f
(+) MCPA	(+) 600	39	f	26	g
(+) sulcotrione	(+) 450	83	b	72	c
(+) mesotrione	(+) 75	73	c	66	d

a Means are pooled over two experiments.
b Different letters within each column indicate statistically significant differences at *P*=0.05.

It is concluded that satisfactory control of early watergrass and late watergrass in corn can be achieved with increased application rates of foramsulfuron applied preferably at early growth stage. Mixtures of foramsulfuron with either dicamba or MCPA can reduce considerably the efficacy of foramsulfuron on early watergrass and late watergrass. Mixtures of foramsulfuron with either sulcotrione or mesotrione can be used for broadening spectrum of control without affecting negatively foramsulfuron activity on these grasses.

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GROWTH AND YIELD OF HYBRID AND INBRED BORO RICE AFFECTED BY DIFFERENT METHODS OF WEED CONTROL

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ABSTRACT

A field experiment was carried out at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December, 2008 to May, 2009 to evaluate the growth and yield of hybrid and inbred boro rice as affected by different weed control methods. The experiment comprised of seven weeding treatments and three varieties of boro rice. The experiment was carried out in RCBD with three replications. Eight weed species belonging to four families were identified in the experimental field. Densities of weeds were recorded from 7 DAT to 50 DAT at 7 days interval. It was found that among the weed control treatments, application of Sunrice 150WP (ethoxysulfuron) 125 g a.i. ha^{-1} showed best performance in respect of the highest plant height (103.35cm), maximum tillers hill^{-1} (22.00), the maximum plant dry matter (192.8g hill^{-1}), effective tillers hill^{-1} (20.34), lowest number of ineffective tillers hill^{-1} (1.33) and consequently produced highest grain yield (9.50 t ha^{-1}), straw yield (10.25 t ha^{-1}) and harvest index (41.16) in comparison to all other treatments. Among the weed control treatments-Sunrice 150WP (ethoxysulfuron) 125 g a.i. ha^{-1} controlled 81% weed population, whereas Commit 500EC pretidachlor gave 62% and hand weeding only 52% control. The highest grain yield, straw yield as well as benefit cost ratio was obtained from the variety Sonarbangla hybrid dhan 6. under Sunrice 150 WP (ethoxysulfuron) 125 g a.i. ha^{-1} which increased 22.58% grain yield than Commit 500EC (pretidachlor) 750 ml ha^{-1} and 34.58% grain yield than two hand weedings, due to higher number of panicles hill^{-1} and number grains panicle^{-1}.

Key Words: Hybrid and Inbred *boro* Rice, Weeding, Weed density, Yield.

INTRODUCTION

Geographical and agronomic conditions of Bangladesh are favorable for rice (*Oryza sativa* L.) cultivation. Rice is the leading food for more than two billion people in Asia and for hundreds of millions of

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people in Africa and Latin America (IRRI, 2006). In Bangladesh rice occupies 10.58 million hectares of land which is about 77 percent of the cultivated area (BBS, 2008). The population of Bangladesh will increase to 173 million in 2020 which is 31 percent higher than the present level (FAO, 1998). National Agricultural Commission says that to feed the increased population in 2020, 47 million tons of rice will be needed to produce in the country. For food security of the country, rice production is needed to be increased from 3 tons ha^{-1} to 5 tons ha^{-1} in next 20 years (Mahbub, *et al.,* 2001). Weeds are the most destructive agricultural pest. Most of the weeds drive their nourishment through rapid development and manifested by quick root and shoot development. Competitive abilities of weeds poses a serious negative effect in crop production and responsible for marked losses in crop yield (Mamun, 1990). According to Willocquet *et al*., (1999), the losses due to infestation of weeds are greater than the combined losses caused by insect, pest and diseases in rice. Mamun, *et al.,* (1993) reported that weed growth reduced the grain yield by 68-100% for direct seeded *aus* rice, 22-36% for modern *boro* rice and 16-48% for transplanted *aman* rice. This loss is, therefore, a serious threat for the food deficit countries like Bangladesh and necessitates proper weed management for rice production. A number of studies (Mondol, *et al.,* 1995; Gill, *et al.,* 1992; Panwar, *et al.,* 1992) showed that weed control through both traditional and chemical methods influence plant height, tiller number, crop growth rate, yield attributes and yield of *boro* rice. Herbicides are used successfully for weed control in rice fields for rapid effect, easier to apply and low cost involvement in comparison to the traditional methods of hand weeding (Hasanuzzaman, *et al.,* 2009). In Bangladesh, few studies have attempted to establish the most suitable and economic integrated weed management system in *boro* rice. Present work was carried out to evaluate different weed control methods including chemical control in different *boro* rice cultivars in terms of crop growth, productivity, profitability.

MATERIALS AND METHODS

An experiment was conducted on *boro* rice at Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh ($90^0$33´ E longitude and $23^0$77´ N latitude). The soil of the experimental site was clay loam with a pH of 5.47-5.63. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications comprising seven different weeding treatments viz. no weeding, hand weeding at 30 days after transplanting (W_1), two hand weeding at 30 DAT and 50 DAT (W_2), Sunrice 150 WP (ethoxysulfuron) at 100g a.i. ha^{-1} (W_3), Sunrice 150 WP (ethoxysulfuron) 125 g a.i. ha^{-1} (W_4), Commit 500

EC (pretidachlor) 1000 ml ha^{-1} (W_5), Commit 500 EC (pretidachlor) 750 ml ha^{-1} (W_6). The seeds of inbred rice variety BRRI dhan29 was collected from Bangladesh Rice Research Institute, hybrid variety Hira-6 from Supreme Seed Company Ltd., Sonarbangla-6 was A. R. Malik's Co. (Priv.) Ltd., and sown in the seed bed on December 04, 2008. Thirty days old seedlings (2 for hybrid and 3 for inbred) were transplanted on January 04, 2009. The planting distance was maintained at 25 cm (row-row) × 15 cm (hill-hill). Fertilizers at 124:62:72:20:5 NPKSZn kg ha^{-1} were applied. All PKSZn were applied as basal dose at final land preparation. Urea (N) was top dressed in three equal installments; after seedling recovery (15 DAT) vegetative stage (35 DAT) and at 7 days before panicle initiation (50 DAT). Herbicides were sprayed with a hand sprayer in the mid-morning at 7 DAT. Intercultural operations such as gap filling, irrigation, insect and disease management were carried out as required. Density of weeds was recorded from 7 DAT to 50 DAT at 7 days interval. Plant growth characters were recorded from 20 DAT at 25 days interval. At harvest, yield contributing characters and yield were recorded. The collected data were analyzed using MSTST-C statistical package. Mean were compared with LSD test.

RESULTS AND DISCUSSION

Eight weed species belonging to four families were identified in the experimental field of which *Echinochloa colonum, Leersia hexandra, Cynodon dactylon, Cyperus rotundus, Scirpus mucronatus, Spilanthes acmella, Enhydra fluctuans* and *Desmodium trifolium.*

Weed control

The lowest weed density was observed in the hybrid variety Sonarbangla-6 (V_3) as compared to the other variety (Table-1). Weed density was significantly greater in the no weeding plots than other treatments (Tables-2&3). Similar results were also observed by Hasanuzzaman (Hasanuzzaman, *et al.,* 2007) and Ahmed *et al.* (1997). There was no significant difference in weed density at 30 DAT between one hand weeding (W_1) and two hand weeding (W_2) before second hand weeding. But, at 50 DAT, two hand weeding had lower weed density than one hand weeding. One hand weeding at 30 DAT (W_1) effectively reduced weed number which was similar to W_2 (two hand weeding; Fig.1). From Table-2 it was found that the lowest weed density was observed in the treatment Sunrice 150 WP (ethoxysulfuron) 125 g a.i. ha^{-1} (W_4) and Commit 500EC (pretidachlor) 750 ml ha^{-1} (W_6). The weed density was reduced by 81% with W_4 where W_6 it by 62%, Commit 500 EC (pretidachlor) 1000 ml ha^{-1} (W_5) by 56% and Sunrice 150 WP (ethoxysulfurao) at 100g a.i. ha^{-1} (W_3) by

55% which was higher than the hand weeding treatments (Fig.1). Gill *et al.,* (1992) also found similar results

Table-1. Weed density affected by different varieties of *boro* rice.

Treatment	Weed density m^{-2}						
	7 DAT	14 DAT	21 DAT	28 DAT	35 DAT	42 DAT	49 DAT
Hira-6 (V_1)	30.00	70.00	83.00	95.00	100.50	85.50	70.00
BRRI dhan29 (V_2)	25.00	62.00	68.00	76.50	36.50	30.00	23.00
Sonarbangla-6 (V_3)	22.00	52.00	67.00	74.00	35.50	29.50	21.00
$LSD_{0,05}$	5.783	5.067	10.65	8.869	10.15	12.53	11.13
CV (%)	14.23	10.75	16.57	10.05	12.80	17.96	18.95

Table-2. Weed density affected by different weed control methods of *boro* rice.

Treatment	Weed density m^{-2}						
	7 DAT	14 DAT	21 DAT	28 DAT	35 DAT	42 DAT	49 DAT
No Weeding	30.00	66.33	85.67	113.0	123.80	112.9	100.7
One (W_1)	25.00	44.00	67.83	76.50	36.33	30.17	23.67
Two weeding (W_2)	25.00	51.67	59.67	70.17	33.61	28.83	22.50
Sunrice 150 WG (Ethoxysulfuran) at 100g a.i. ha^{-1} (W_3)	20.00	9.00	17.33	34.50	39.17	31.83	25.67
Sunrice 150 WG (Ethoxysulfuran) 125 g a.i. ha^{-1} (W_4)	22.00	4.05	9.67	19.50	26.67	23.67	18.67
Commit 500 EC (Pretidachlor) 1000mlha^{-1}(W_5)	27.33	13.67	20.00	38.83	46.67	41.67	35.67
Commit 500 EC (Pretidachlor) 750 ml ha^{-} (W_6)	20.67	9.12	12.50	21.67	30.28	26.83	22.33
$LSD_{0,05}$	5.783	5.067	10.65	8.869	10.15	12.53	11.13
CV (%)	14.23	10.75	16.57	10.05	12.80	17.96	18.95

Table 3. Interaction effect of different weed control methods of *boro* rice.

Treatment	Weed density m^{-2}						
	7 DAT	**14 DAT**	**21 DAT**	**28 DAT**	**35 DAT**	**42 DAT**	**49 DAT**
V_1W_0	30	70	83	95	100.5	85.5	70
V_1W_1	25	52	68	76.5	36.5	30	23
V_1W_2	22	62	67	74	35.5	29.5	21
V_1W_3	20	11	13	29.5	40.5	30	22.5
V_1W_4	22	4	9.5	16	20	15	9
V_1W_5	25	11	16	36	45	38.5	30
V_1W_6	22	8.35	12.5	19	27.5	22	17.5
V_2W_0	35	70	93	134	146	133.3	118.5
V_2W_1	20	35	75.5	78	37	30	23.5
V_2W_2	30	58	65	71.5	34	28.5	21.5
V_2W_3	15	7.5	13.5	34.5	42	37.5	30
V_2W_4	20	3.65	9	12.5	20	18.5	15
V_2W_5	22	12	17	43.5	50	45.5	40
V_2W_6	24	9	12	16	22	20	17.5
V_3W_0	25	59	81	110	125	120	113.5
V_3W_1	30	45	60	75	35.5	30.5	24.5
V_3W_2	25	35	47	65	31.33	25	21
V_3W_3	30	15	25.5	39.5	35.5	30	24
V_3W_4	24	4.5	10.5	30	40	37.5	32
V_3W_5	35	18	27	37	45	41	37
V_3W_6	16	10	13	30	41.33	38.5	32
$LSD_{0,05}$	5.78	5.067	10.65	8.869	10.15	12.53	11.13
CV (%)	14.23	10.75	16.57	10.05	12.80	17.96	18.95

Agronomic traits

At both the stages, the weed infestation in the no weeding plots was severe resulting in intense competition with crop plants. The shortest plant height was observed in the hybrid variety (V_1-Hira-6 and V_3-Sonarbangla-6) with W_0 (no weeding; Fig. 2) and from Table-4 it was found that the tallest (103.35 cm) plants were in the inbred variety performed by the combined effect of BRRI dhan29 (V_3) and Sunrice 150 WP (ethoxysulfuron) 125 g a.i. ha^{-1} (W_4) (Table-4). The weed competition affected the production of new tillers at early vegetative stage. The small number of tillers hill^{-1} was observed with W_0 (no weeding) and the highest number of tillers hill^{-1} (22.00) was observed in V_3W_4 which performed by the interaction effect of Sonarbangla-6 and Sunrice 150 WP (ethoxysulfuron) 125 g a.i. ha^{-1} (Table-4). Islam *et al*., (2009) also reported that hybrid variety had more tillering capacity than inbred variety. Dry matter is an important crop character which contributes to yield. The highest dry matter produced by the treatment Sunrice 150 WP (ethoxysulfuron) 125 g a.i. ha^{-1} (W_4) which was statistically similar to W_6 (Fig. 3)

Yield components and yield

Yield components of *boro* rice were significantly affected by weed control methods. Effective tillers hill^{-1}and fertile grains panicle^{-1} were significantly influenced by different treatments. Maximum number of effective tillers hill^{-1} and fertile grains panicle^{-1} were observed in hybrid variety (V_1-Hira-6 and V_3-Sonarbangla-6) than inbred variety V_2 (BRRI dhan29) which contributed towards higher grain yield (Table-5). From Table-6 it was found that the lowest number of effective tillers hill^{-1} and fertile grains panicle^{-1} were in W_0 (no weeding) and the highest number of effective tillers hill^{-1} and fertile grains panicle^{-1} were in Sunrice 150 WP (ethoxysulfuron) 125 g a.i. ha^{-1} (W_4) which was statistically similar to Commit 500EC (pretidachlor) 750 ml ha^{-1} (W_6). Weeds always compete with crop for resources like light, water, nutrient which are needed for crop plant to produce healthy grains (Antigua, *et al.*, 1988). In this study, maximum number of effective tillers hill^{-1} (20.34) and fertile grains panicle^{-1} (187.2) were observed in treatment V_3W_4 while no weeding condition in V_3W_0 gave the minimum number of effective tillers hill^{-1} (7.67) and fertile grains panicle^{-1} (100.8) due to interaction effect (Table-7). These results corroborated with the results of Ahmed *et al*. (2005) and Smith and Moody (1979). From the data in Table-6 it was observed that weight of 1000 grains was significantly affected by weed control methods in the Sunrice 150 WP (ethoxysulfuron) 125 g a.i. ha^{-1} (W_4) which was statistically similar to Commit 500EC (pretidachlor) 750 ml ha^{-1} (W_6).

Among the weed control methods, the highest grain yield (9.50 t ha^{-1}) of rice was observed in treatment V_3W_4 which was statistically similar to V_1W_4 (Table-7). The highest grain yield was attributed to effective tillers hill^{-1}, panicles hill^{-1}, fertile grains panicle^{-1}, 1000 grain weight and the highest weed control efficiency in that treatment. The lowest seed yield was observed in the no weeding plots (W_0). Ahmed *et al*., (2005) also found similar results. Highest harvest index (%) was observed in treatment V_3W_4 which was statistically similar to V_1W_4 (Table-7).

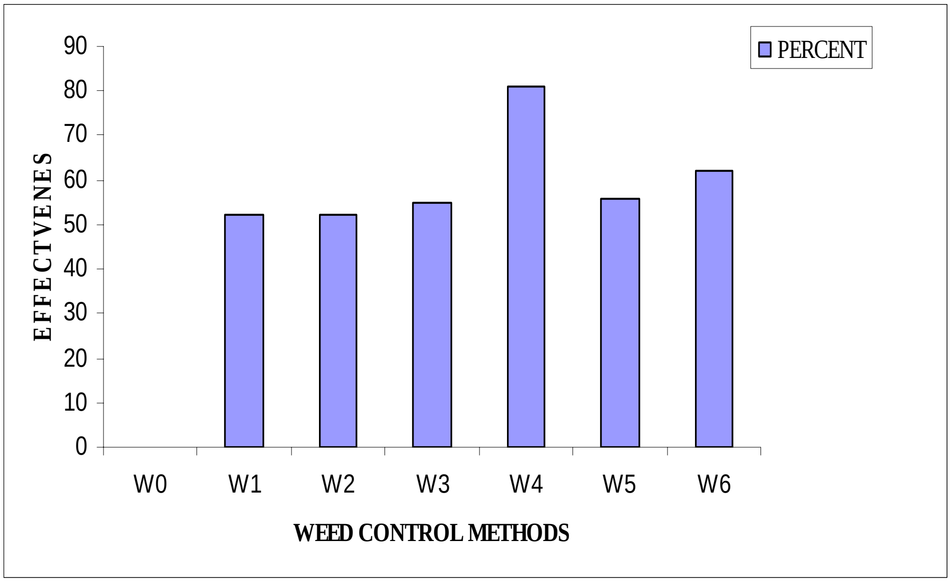

Fig. 1. Effectiveness of different weed control methods.

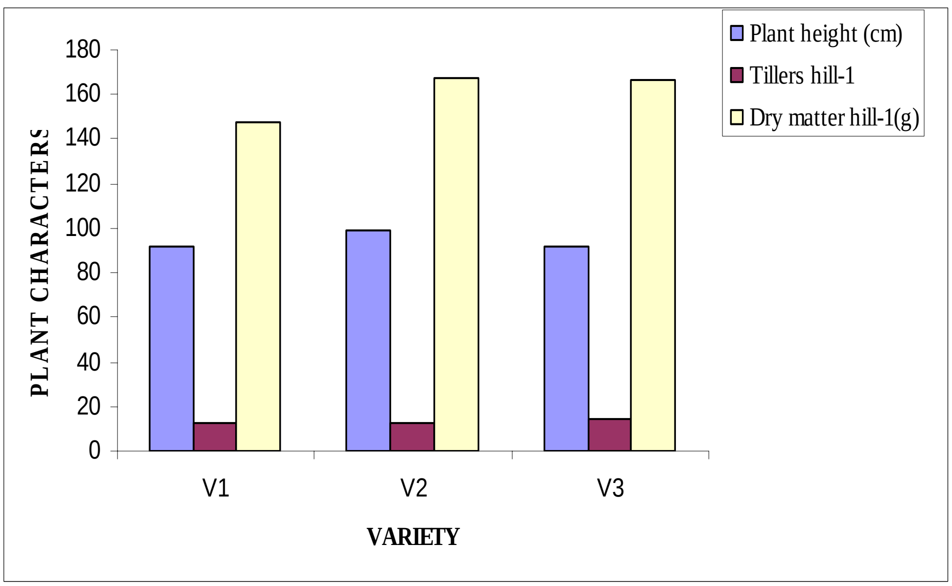

Fig. 2. Plant characters of *boro* rice affected by different varieties.

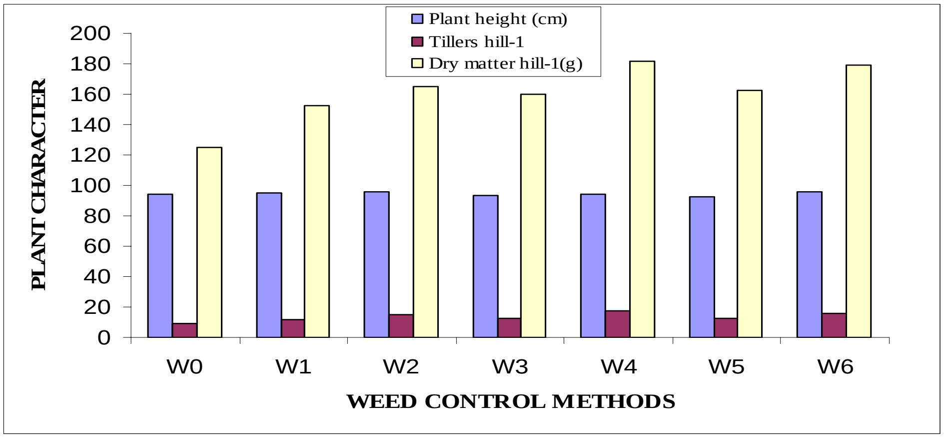

Fig. 3. Plant characters of *boro* rice affected by weed control methods.

Table-4. Interactive effect of different weed control methods on *boro* rice.

Treatment	Plant height (cm)	Tillers hill^{-1}	Dry matter hill^{-1} (g)
V_1W_0	90.74	8.11	118.8
V_1W_1	92.11	11.66	144.7
V_1W_2	92.37	13.55	152.1
V_1W_3	91.24	12.00	150.3
V_1W_4	93.56	14.89	160.7
V_1W_5	90.00	12.78	151.0
V_1W_6	95.11	14.00	158.2
V_2W_0	98.11	9.33	132.2
V_2W_1	100.80	11.22	165.7
V_2W_2	97.89	14.00	168.8
V_2W_3	100.60	12.89	158.8
V_2W_4	103.35	15.43	191.6
V_2W_5	99.89	12.45	166.7
V_2W_6	100.35	14.56	188.9
V_3W_0	92.55	9.33	122.9
V_3W_1	90.89	11.26	147.0
V_3W_2	97.67	16.36	174.1
V_3W_3	89.11	12.90	170.2
V_3W_4	92.33	22.00	192.8
V_3W_5	88.22	12.83	169.5
V_3W_6	91.56	18.86	190.5
$LSD_{0,05}$	5.843	1.926	6.769
CV (%)	3.75	8.74	2.55

Table-5. Yield contributing characters and yield of *boro* rice affected by different varieties.

Treatment	Effective tillers hill^{-1}	Fertile grain panicle^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})	Harvest Index (%)
Hira-6 (V_1)	13.56	155.9	24.29	6.28	34.86
BRRI dhan29 (V_2)	12.04	152.5	24.59	5.47	34.32
Sonarbangla-6 (V_3)	14.36	159.2	25.74	6.51	35.45
$LSD_{0,05}$	1.408	25.62	2.98	1.394	1.955
CV (%)	6.57	9.96	7.26	13.89	3.40

Table-6. Yield contributing characters and yield of *boro* rice affected by different weed control methods.

Treatment	Effective tillers hill^{-1}	Fertile grain panicle^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})	Harvest Index (%)
No Weeding	8.20	105.1	20.25	3.04	30.63
One (W_1)	10.74	140.8	23.72	4.73	34.42
Two weeding (W_2)	14.03	175.8	26.10	5.78	35.18
Sunrice 150 WG (Ethoxysulfuran) at 100g a.i. ha^{-1} (W_3)	12.59	154.3	24.89	6.75	33.95
Sunrice 150 WG (Ethoxysulfuran) 125 g a.i. ha^{-1} (W_4)	17.64	182.7	27.88	8.88	39.18
Commit 500 EC (Pretidachlor) 1000mlha^{-1} (W_5)	12.46	152.9	23.76	6.54	34.61
Commit 500 EC (Pretidachlor) 750 ml ha^{-1} (W_6)	15.25	179.4	27.50	6.87	36.18
$LSD_{0,05}$	1.408	25.62	2.98	1.394	1.955
CV (%)	6.57	9.96	7.26	13.89	3.40

Table-7. Interaction effect of different weed control methods on *boro* rice.

Treatment	Effective tillers hill^{-1}	Fertile grain panicle^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})	Harvest Index (%)
V_1W_0	8.87	108.9	22.19	3.19	30.44
V_1W_1	10.22	133.1	23.35	4.88	33.94
V_1W_2	12.48	174.7	25.06	5.93	35.19
V_1W_3	11.22	145.5	22.95	6.98	32.94
V_1W_4	15.80	180.0	26.16	9.10	40.23
V_1W_5	12.26	148.2	24.64	6.81	34.57
V_1W_6	13.44	176.9	25.67	7.04	36.69
V_2W_0	8.06	105.6	20.08	2.49	30.93
V_2W_1	11.56	140.4	23.63	4.18	34.57
V_2W_2	15.08	175.4	25.43	5.23	34.75
V_2W_3	14.11	159.4	24.83	6.17	34.57
V_2W_4	16.78	180.8	27.90	8.03	36.14
V_2W_5	13.78	150.7	22.52	5.98	34.21
V_2W_6	15.55	178.8	27.71	6.21	35.06
V_3W_0	7.67	100.8	18.48	3.45	30.53
V_3W_1	10.45	148.9	24.17	5.14	34.75
V_3W_2	14.52	177.3	27.80	6.19	35.60
V_3W_3	12.45	158.0	26.90	7.11	34.33
V_3W_4	20.34	187.2	29.58	9.50	41.16
V_3W_5	11.33	159.8	24.13	6.84	35.06
V_3W_6	16.77	182.4	29.12	7.35	36.75
$LSD_{0.05}$	1.408	25.62	2.98	1.394	1.955
CV (%)	6.57	9.96	7.26	13.89	3.40

CONCLUSION

Results suggest that different weed control methods greatly affected the weed control efficacy, crop characters, yield contributing characters and grain yield of *boro* rice. Application of Sun rice 150 WP (ethoxysulfuron) 125 g a.i. ha^{-1} increased grain yield by 22.58% than the application of Commit 500EC (pretidachlor) 750 ml a.i. ha^{-1} and increased 34.58% grain yield than two weeding. Weed control cost was the minimum for chemical weeding (herbicide) than hand weeding. Application of Sunrice 150 WP (ethoxysulfuron) 125 g a.i. ha^{-1} was also an effective weed control method which was more economic and effective than other treatments.

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PERFORMANCE OF MEFENACET+BENSULFURON METHYL 53% WP AGAINST WEED SUPPRESSION IN TRANSPLANTED PADDY

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ABSTRACT

The study was conducted during dry season of 2007 in two different agro-ecological zones of Bangladesh to evaluate the usefulness of Mefenacet + bensulfuron methyl 53% WP, for weed management in transplanted paddy. Mefenacet + bensulfuron methyl 53%WP @ 524,594 and 657g ai ha^{-1} was evaluated for its bio-efficacy against broad spectrum of weeds and safety to crop. Standard for comparison was butachlor 5G @ 1250g ai ha^{-1}. Weed flora in the experimental plots in the two different agro-ecological zones comprised of the grasses Cynodon dactylon, Echinochloa crus-galli, Leptochloa chinensis, the sedges, Cyperus difformis, Scirpus juncoides and the broadleafs Enhydra fluctuans, Monochoria vaginalis, Lindernia anagallis, Marsilea minuta and sphenoclea zeylanica. Pre-emergence application of Mefenacet + bensulfuron methyl 53%WP @ 594g ai ha^{-1} led to higher weed control efficiency and lowest number and dry weight of weeds which ultimately resulted in higher yield attributes and grain yield of rice that were comparable to the standards at both location.

Key words: Mefenacet+bensulfuron methyl 53%WP, broad spectrum weed control, transplanted paddy.

INTRODUCTION

In Bangladesh, severe weed infestation reduces the grain yield by 70-80% in Aus rice (early summer), 30-40% for transplanted Aman rice (Late summer) and 22-36% for modern boro rice (winter rice) cultivation (BRRI, 2006; Mamun, 1990). Severe infestation of weeds is one of the major factors responsible for the low productivity of rice. Hence, proper weed management practices are essential to obtain better yields in transplanted paddy. Quite a lot of pre and post emergence herbicides such as butachlor, pretilachlor, oxadiazone, pyrazosulfuron ethyl, ethoxysulfuron alone or supplemented with one hand weeding have been found to be useful for weed management in transplanted paddy. Continuous use of these herbicides has to be

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restricted to avoid undesirable inter and intra-specific weed shift (Singh *et al.,* 2005). Sometimes single use of these herbicides cannot control a broad spectrum of weeds. Use of single herbicide might be effective for only sedges or only grass or broad leaf weeds. Mefenacet whose chemical name is N-methyl –n-phenyl-2-(1,3 benzothiazol-2-yloxy) acetamide has recently been developed for pre–emergence control of graminaceous weeds having a high efficacy on *Echinochloa crusgalli*, but also has adverse effect on broadleaf weeds. Bensulfuron methyl whose chemical name is Methyl-2[[[[(4,6-dimethoxy-pyrimidin-2-yl)amino]carbonyl]amino] sulfonyl]methyl]benzoate has been developed for selective pre- and post-emergence control of annual and perennial weeds and sedges. Bensulfuron methyl has a unique effect on broadleaf weeds and sedges but also has adverse effect on *Echinochloa crusgalli*. Mefenacet + bensulfuron methyl 53% WP together have a wonderful effect on broad leaf and sedge weeds. So herbicide combination can make up the deficiency of single use. Furthermore such type of herbicide mixture is almost new perception in Bangladesh for control of weeds. So to give farmers a wider choice of effective herbicide there is a need to develop environmental eco friendly molecules of newer chemistries with different mode of action. In view of this, the present study has been undertaken to evaluate the usefulness of Mefenacet + bensulfuron methyl 53% WP for broad spectrum control of weeds for the use of farmers as an effective weed control option in rice.

MATERIALS AND METHODS

Mefenacet + bensulfuron methyl 53% WP; a new pre emergence herbicide, was evaluated at Bangladesh Rice Research Institute farm, Bhanga, Faridpur (Included AEZ 12- Lower Ganges River Floodplain) and at Burichang of Comilla district (Included AEZ 19- Old Meghna Estuarine Floodplain) during winter season (Boro), 2007 to observe its weed control efficiency, impact on plant growth and yield of rice. The treatments were i) Mefenacet + bensulfuron methyl 53% WP @ 524 g a.i.ha^{-1} ii) Mefenacet + bensulfuron methyl 53% WP @ 594 g a.i. ha^{-1} iii) Mefenacet + bensulfuron methyl 53% WP @ 657 g a.i. ha^{-1} iv) Butachlor 5G @ 1250 g a.i. ha^{-1} v) Weed free by hand weeding and vi) Control (Un weeded). Butachlor 5G was used to compare the new herbicide. The experiment was laid out in a RCB design with 3 replications. Forty days old seedlings of BRRI dhan28 were transplanted on 12th January, 2007 at 20x20 cm spacing with 2 seedlings $hill^{-1}$ at BRRI farm Bhanga, Faridpur and on 5th February at Burichang, Comilla with same spacing and design. For Comilla location rice variety Eratom-6 was used. Fertilizer was applied following BRRI recommended dose. Butachlor 5G were sprayed at 5 days after transplanting, Mefenacet+ bensulfuron methyl 53% WP was mixed with urea and scattered in the treated plots 6 DAT as pre-emergence action. In weed free treatment, the plots were kept weed free up to 50 DAT by two hand weeding. Weed control efficiency (WCE%) was calculated using the formula according to Rao (1985). Mefenacet+ bensulfuron methyl 53% WP herbicide is innovative in Bangladesh and its phytotoxicity needs to be evaluated on rice crop. The phytotoxicity of the herbicide to rice plants was determined by visual observations (Yellowing leaves, burring leaf tips, stunting growth etc). The degree of toxicity on rice plant was measured by the following scale used by IRRI (1965).

1. No toxicity
2. Slightly toxicity
3. Moderate toxicity
4. Severe toxicity
5. Toxic (plant kill)

The rating of toxicity was done within 7 days after application of herbicides. It was observed three times at 3,5 and 7 days after application of herbicide and the mean rate was calculated from 10 sample plants of a unit plot. Yields and yield contributing characters of rice were recorded after harvest. The data were analyzed following analysis of variance (ANOVA) technique and mean differences were depicted by multiple comparison test (Gomez and Gomez, 1984) using the statistical program MSTAT-C (Russell, 1986).

RESULTS AND DISCUSSION

Phytotoxicity of herbicides on rice plant

The degree of toxicity of the herbicide to rice plants and the symptoms produced on plant are presented in Table-1. It is observed that Mefenacet + bensulfuron methyl 53%WP @ 524 g a.i. ha^{-1} and 594 g a.i. ha^{-1} showed very slight yellowing of leaves while Mefenacet+bensulfuron methyl 53% WP @ 657 g a.i. ha^{-1} showed temporary yellowing of leaves. It is observed that phytotoxicity symptoms were not more prominent for using this herbicide.

Table-1. Rating of herbicide toxicity on rice plant under different treatments.

Treatment	Rating	Symptom observed on rice crop
T1= Super clean 53% WP @ 523 g a.i.ha^{-1}	1.14	Sometimes very slight yellowing of leaves.
T2= Super clean 53% WP @ 594 g a.i.ha^{-1}	1.16	Sometimes slight yellowing of leaves.
T3= Super clean 53% WP @ 657 g a.i.ha^{-1}	1.30	Temporary slight yellowing of leaves which required 5-7 days to recover
T4= Butachlor 5 G @ 1250 g a.i.ha^{-1}	1.11	No toxicity

Efficacy of herbicide on weed species

Bio efficacy data of Mefenacet+ bensulfuron methyl 53% WP @ 594 g a.i.ha^{-1} spraying at 6 DAT against weed suppression indicated that at BRRI farm Bhanga, 80% control of *Cyperus difformis,* 82% control of *Enhydra fluctuans*, 81% control of *Echinochloa crus-galli,* 86% control of *Monochoria vaginalis*, 87% control of *Scirpus juncoides*, 85% control of *Leptochloa chinensis* and only 36% control of *Cynodon dactylon* was achieved (Table-2).

Table-2. Effect of Mefenacet + bensulfuron methyl 53% WP on weed and weed control efficiency on BRRI dhan 28 in Boro, 2007 at BRRI farm, Bhanga, Faridpur.

Weed Name	T1		T2		T3		T4		T5		*WCE (%)
	W1	W2	W1	W2	W1	W2	W1	W2	W1	W2	
Cyperus difformis	7	7.01	3	1.53	5	2.41	6	6.06	18	7.80	80
Cynodon dactylon	6	9.16	4	7.38	3	4.37	6	9.48	14	11.29	36
Enhydra fluctuans	4	3.55	2	1.47	3	0.36	4	4.73	9	8.13	82
Echinochloa crus-galli	4	5.47	2	1.76	3	0.65	3	4.51	9	9.43	81
Monochoria vaginalis	3	2.90	3	1.70	2	0.41	4	2.84	13	12.32	86
Scirpus juncoides	3	2.33	2	0.97	2	0.62	3	2.05	14	7.71	87
Leptochloa chinensis	3	3.07	2	0.85	1	0.46	2	2.23	7	6.01	85

Bio efficacy data of Comilla experiment showed 80% control of *C. difformis,* 84% control of *Lindernia anagallis,* 82% control of *E. crus-galli, 81%* control of *Marsilea minuta, 80%* control of *Sphenoclea zeylanica* and only 35% control of *C. dactylon* was achieved with Mefenacet+ bensulfuron methyl 53% WP @ 594 g a.i.ha^{-1} (Table-3). Kim and Im (2002) reported that the mixture of Mefenacet + bensulfuron-methyl gave 90% control of annual and perennial weeds.

Table-3. Effect of Mefenacet+ bensulfuron 53% WP on weed and weed control efficiency on rice in Boro, 2007 at Burichang, Comilla.

Weed Name	T1		T2		T3		T4		T5		*WCE (%)
	W1	W2	W1	W2	W1	W2	W1	W2	W1	W2	
Cyperus difformis	4	3.00	3	1.89	3	1.97	4	3.39	13	9.64	80
Cynodon dactylon	3	6.36	4	5.71	4	4.18	4	4.92	8	8.80	35
Lindernia anagallis	3	2.03	3	1.40	2	1.54	3	2.36	7	8.74	84
Echinochloa crus-galli	4	2.23	2	1.80	2	1.82	3	3.48	7	9.97	82
Marsilea minuta	2	1.04	3	0.87	2	0.60	2	2.11	6	4.71	81
Sphenoclea zeylanica	2	1.15	2	0.82	2	0.79	2	1.37	3	4.13	80

T1 = Mefenacet+ bensulfuron 53 WP @ 523 g a.i.ha^{-1}
T2 = Mefenacet+ bensulfuron 53 WP @ 594 g a.i.ha^{-1}
T3 = Mefenacet+ bensulfuron 53 WP @ 657 g a.i.ha^{-1}
T4 = Butachlor 5G @ 1250 g a.i.ha^{-1}, T5 = Control (Unweeded), W1= Weed number m^{-2}
W2 = Weed dry matter weight (g m^{-2}), *WCE = Weed Control Efficiency= % Control of weed species by Mefenacet+ bensulfuron 53 WP @ 450g acre^{-1} over no weeding

Yield and yield attributes

Effect of Mefenacet+bensulfuron methyl 53% WP on growth, yield and yield contributing characters are showed in Table-4. Different doses of Mefenacet+bensulfuron methyl 53% WP spraying at 6 DAT significantly influenced the No. of panicle m^{-2}, filled grains panicle^{-1} and grain yield in both Faridpur and Comilla locations. Plant height did not differ significantly due to different treatments. But numerically higher plant height was observed in weed free plot and un-weeded plot obtained lower plant height in both locations. In Faridpur location, the highest panicle m^{-2} (382) was observed from weed free plots which are alike with other treatments except un-weeded plots. The lowest panicles m^{-2} (254) was observed from un-weeded plots. Number of filled grains panicle^{-1} was statistically higher in weed free plot (130) which is statistically at par with other treatments except un-weeded plot. The lowest grains panicle^{-1} (75) was observed in un-weeded plots. Similar trend in results was found in Comilla region. In Faridpur location, weed free plot gave the highest grain yield (7.42 t ha^{-1}) which was statistically comparable with other herbicide treatments except Mefenacet+bensulfuron methyl 53% WP @ 594 g a.i.ha^{-1} and un-weeded check. The lowest grain yield was obtained from un-weeded plot (4.55 t ha^{-1}). In Comilla location similar trend of grain yield was found but grain yield was little lower than Faridpur Region. Pacanoski and Glatkova (2009) found significant increase in rice grain yield with the use of Mefenacet+ bensulfuron methyl in comparison with untreated control.

Table-4. Effect of Mefenacet+ bensulfuron 53% WP on growth and yield attributes of rice in Boro, 2007 at Faridpur and Comilla district.

Treatment	Plant ht. (cm)		Panicle m^{-2}		Filled grain $panicle^{-1}$		Grain yield t ha^{-1}	
	L_1	L_2	L_1	L_2	L_1	L_2	L_1	L_2
T1	114.47	92.66	347.66a	341.00a	106a	102a	6.69b	6.22c
T2	114.40	92.66	371.33a	346.33a	111a	108a	7.03ab	6.90ab
T3	113.10	91.66	373.33a	355.00a	112a	113a	7.05ab	6.92ab
T4	112.73	92.33	363.33a	343.33a	110a	107a	7.00ab	6.48bc
T5	115.36	93.66	382.33a	358.00a	130a	119a	7.42a	7.14a
T6	112.26	85.00	254.00b	245.33b	75b	75b	4.55c	4.31d
CV (%)	2.56	9.18	9.21	5.92	13.74	11.80	5.44	6.55
LSD $_{(0.05)}$	NS	NS	58.39	35.73	26.78	22.33	0.065	0.56

T1 = Mefenacet+ bensulfuron 53% WP @ 523 g a.i.ha^{-1}
T2 = Mefenacet+ bensulfuron 53% WP @ 594 g a.i.ha^{-1}
T3 = Mefenacet+ bensulfuron 53% WP @ 657 g a.i.ha^{-1}
T4 = Butachlor 5g @ 1250 g a.i.ha^{-1}
T5 = Weed Free
T6 = Control(Un weeded)
L_1 = Bhanga, Faridpur
L_2 = Comilla
NS = Not significant

CONCLUSION

From the above discussion it is concluded that Mefenacet+ bensulfuron methyl 53% WP @ 594 g a.i.ha^{-1} controlled many weeds effectively and produced optimum grain yield in both agro-ecological zones (AEZ 12 and 19) of Bangladesh in Boro rice. No plant injury was observed during the crop growing period due to the application of Mefenacet + bensulfuron methyl 53% WP.

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INFLUENCE OF TILLAGE AND WEED MANAGEMENT METHODS ON CHICKPEA (*Cicer arietinum* L.). I. YIELD AND YIELD COMPONENTS

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ABSTRACT

An experiment was conducted at the Agricultural College farm Duhok University Iraq to study the effect of different methods of weed control on chickpea growth and yield during the growing season of 2009. Ploughs types included disc plow, mould board plow, and cultivator. Weed management practices involved hand hoeing, trifluraline (soil incorporated), Aloxy and paraquat. Results indicated that plough types had no significant effect on any traits of growth or yield of chickpea. Hand hoeing significantly gave highest seed yield and weight of 100 seeds which were 120.4 kg per Donum (1 Donum = 1000m^2) and 30.8 g respectively. Both hand-hoeing and paraquat treatments were superior in number of primary branches (3.5 and 3.4), number of pods per plant (12.3 and 11) and hay yield per donum (363.9 and 318.2 kg), respectively. The interaction of hand hoeing with cultivator and mould board was significant for most of traits under study. In addition, the interaction of paraquat with cultivator was significant in plant height and height of the lowest pod traits which were 41.3 and 23.1 cm, respectively.

Keywords: Yield, growth, chickpea, management, herbicides, tillage.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is considered as one of the most important grain legumes all over the world. It is used widely in public foods, and in various commodities and recipes. Chickpea has great nutritive value as it contains a high percentage of protein. In Iraq, it ranks as a second grain legume after faba bean. Its cultivation is concentrated in the northern governorates including Sulaymania, Duhok, Erbil and Ninevah, covering an area of 14,000 ha with average yield of 0.74 t ha^{-1} (Abbas, 1990), which comprises 6.4% only of the total consumption and the remaining is imported. The limited area cultivated under chickpea and its low productivity per unit area rather than suitable climatic conditions, is due to numerous factors. One of these serious obstacles that have great effect on chickpea quantity and

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quality is weed invasion and competition, in addition to the shortage in mechanization and improved cultivars. Farmers lose a high percentage of their production from chickpea because of weeds. Hand hoeing still widely practiced for controlling which is costly for local farmers. Therefore, searching for other alternative methods of weed control is important. Weeds may be controlled by different methods. Type of ploughs (tillage) affect weed population, soil moisture or soil seed bank dynamics during stirring the soils. Herbicides are also involved; pre-planting herbicide treatment may be effective for weed control before crop is sown. Certain herbicides act on germinated seeds while, others may kill seeds. Pre-emergence herbicides are applied after sowing but before crop emergence. These chemicals may control weeds by killing weed seedlings. Post-emergence herbicides are applied on emerged crop and weed plants which are normally selective chemicals of no or little damage to crop plants.

Barker (2007) mentioned that pre-plant (soil-applied herbicide) such as Isoxaflutole requires rainfall to activate and move it into the soil which converted to its active form through hydrolysis to effectively control weeds, therefore water is required for this chemical reaction to occur. Incorporation would not likely improve control since it could dry the soil and reduce the likelihood of hydrolysis occurrences. Ahmad *et al.,* (1990); Vaishya *et al.,* (1995); Yasin *et al.,* (1995) and Kayan and Adak (2005) demonstrated that the yield and its components chickpea were not increased significantly by herbicides, while hand hoeing led to significant yield increase. On the other hand, Kumar *et al.,* (1989) found that both hand hoeing and fluchloralin (0.5 kg ha^{-1}) in soil applied treatment produced significant yield of chickpea. Varshney and Arya (2004) illustrated that both hand hoeing and pre-emergence herbicides (Isoproturon and pendimethalin) significantly increased chickpea yield, weight of 100 seeds, but both herbicides had no significant effect on number of pods per plant and number of seeds per pod. Similar results were found by Iqbal *et al.,* (1991); Tewari and Tiwari (2004) and Dungarwal *et al.,* (2002) using pendimethalin, while trifluralin herbicide doesn’t show any significant effects. Chaudhary *et al.,* (2005) noted significant effect of hand hoeing and pendimethalin herbicide on number of pods per plant, number of seeds per pod and grain yield of chickpea. Singh *et al.,* (2003) reported significant increase in seed and hay yield of chickpea using pre-emergence herbicides, but number of branches, pods per plant and plant height were not significantly changed.

Khattak and Khan (2005) stated that the type of ploughs had significant effect on seed yield per unit area of chickpea. Chisel plough once and tine cultivator three times surpassed mould board and disc harrow and gave 18.9% yield higher than no tillage treatment and this might be due to better control of weeds. Barzegar *et al.,* (2003) demonstrated that the mould board has no significant effect on yield of chickpea and gave lower yield (541 kg ha^{-1}) as compared to chisel plow which gave 620 kg ha^{-1}. In contrast, Kayan and Adak (2005) demonstrated that mould board plow surpassed rotary tiller and gave significant yield of chickpea. Hemmat and Iraj (2004) mentioned that ploughs including mould board and chisel plows not significantly affected chickpea yield compared to minimum tillage (sweep plowing). Similarly, Kakarash (2007) reported no significant differences in plant growth due to different plough types including cultivator, mould board and disc harrow. This experiment was conducted to investigate the effect of different methods of weeds control on growth and yield of chickpea under rain fed conditions at Duhok province, Kurdistan Region of Iraq.

MATERIALS AND METHODS

This experiment was carried out at the fields of Agricultural College, Duhok University, Iraqi Kurdistan Region during 2009 growing season (situated between longitudes 43.01º E, latitudes 36.847º N, and altitude 583 meters). The total rainfall for February to June was 158.5 mm and the experiment was planted on silty clay soil. Local chickpea (*Cicer arietinum* L.) seeds (Marakshi) were obtained from Agricultural Research Station and treated with Dithane M45 WP fungicide 2g/kg before sowing. Seeds viability was estimated by standard germination test according to ISTA (1985) and was 100%.

The field was plowed as strips by specific ploughs (Mould board, Disc plow and Cultivator) on 14th January 2009. The field was leveled and the smooth seed bed was prepared manually. The field was divided into plots according to Strip Plot Design with the distances of 2 by 1m; each plot consisted of 4 lines; 20cm apart and 20cm between plants. Each treatment was replicate three times. The experiment included two factors: type of ploughs as a main plot and methods of weed control consisted control (check), hand hoeing, general herbicides paraquat (Gramoxone), soil herbicide trifluralin (Treflan) and, and Aloxy (haloxyfop-p-methyl 10.8% EC) in the sub plot. Trifluralin herbicide was incorporated into the soil on 2 February 2009 at a rate of 600ml/donum; (1 Donum = 1000m^2) 13ml; mixed with 14L water and spread on specified area (1.5L for each unit). Seeds were sown on 15 February 2009 at a depth of 7cm (Siddique and Loss, 1999). Paraquat (Gramoxson) 20% was applied on 10 March 2009 after planting and before emergence of seedlings at a rate of 1 L/donum; 14.5ml mixed with 15L of water and spread on the specified units. Aloxy herbicide for narrow-leaved weeds was added on April 7, 2009 at a rate of 187.5 ml / donum when the weeds were in 5-8 leaves stage; meantime hand hoeing was practiced. At full mature stage, five plants were randomly selected (5 days before harvesting) from the middle lines of each plot for measurement of plant height, height of lowest pod and number of primary branches and then the average of these plants was calculated for each replicate. Another five plants from the middle lines of plot were taken randomly, air dried and kept in paper bags for further measurements on number of pods per plant, number of seeds per plant, and absolute weight of 100 seeds. All plants in the two middle lines were harvested to determine seed and hay yield per unit area.The most common weeds found in chickpea field were *Polygonum aviculare* L. *Carthamus oxycantha*, *Xanthium strumarium*, *Lathyrus annuus*, *Cichorium intybus*, *Centaurea iberica*, *Hypericum perforatum*, and *Sinapis arvensis*. All data were statistically analyzed according to the strip plot design using the statistical analysis system (SAS. 2001). Duncan's multiple range test was used for means separation at 0.05 probability level (Duncan, 1955).

RESULTS AND DISCUSSION

The results in Tables 1 and 2 indicated no significant effects of ploughs types on plant height and height of lowest pod. Similar results were also reported by Hemmat and Iraj (2004) and Kakarash (2007). While weed management practices significantly influenced both traits. Both trifluraline and Aloxy suppressed plant height and the height of lowest pod, this may be due to the shortage in soil moisture necessary to activate soil-applied herbicides and also reflected on the effectiveness of Aloxy herbicide. These results are in agreement with those reported by Barker (2007). Cultivator with trifluraline significantly impaired both plant height and height of the lowest pod among all other interactions which were 34.1 and 18.8 cm, respectively. It may be due to the surface plowing of cultivator and drought season that exposed the herbicide to the environmental conditions. These results are in harmony with those of different workers (Iqbal *et al.,* 1991; Dungarwal *et al.,* 2002; Varshney and Arya, 2004; Tewari and Tiwari, 2004).

Table-1. Effect of ploughs types and weed management practices and their interactions on chickpea plant height (cm).

Ploughs	Weeds Management Practices					Mean of ploughs
	Control	Hand hoeing	Gramoxone	Trifluraline	Aloxy	
Disc plow	36.34ab	35.20ab	40.27ab	35.94ab	36.3ab	36.82
Mould board	36.94ab	39.14ab	38.54ab	35.20ab	36.14ab	37.19
Cultivator	37.07ab	41.20a	41.33a	34.14b	35.74ab	37.90
Mean of weed management	36.78ab	38.52ab	40.09a	35.09b	36.07b	

For main factor or their interaction, the values that shared the same letter are not significantly different according to Duncan's multiple range test at 0.05 probability.

Table-2. Effect of ploughs types and weed management practices and their interactions on height of lowest pod (cm).

Ploughs	Weeds Management Practices					Mean of ploughs
	Control	Hand hoeing	Gramoxone	Trifluraline	Aloxy	
Disc plow	20.40ab	21.54ab	22.07ab	19.88ab	19.8ab	20.75
Mould board	20.34ab	20.34ab	22.07ab	19.67ab	21.54ab	20.79
Cultivator	22.14ab	22.60a	23.14a	18.80b	21.14ab	21.56
Mean of weed management	20.96ab	21.49ab	22.43a	19.45b	20.85ab	

For main factor or their interaction, the values that shared the same letter are not significantly different according to Duncan's multiple range test at 0.05 probability.

Ploughs types had no significant effect on the number of primary branches (Table-3). However, weed management practices have significant effects on number of primary branches per plant. Triluraline resemble the check plot in this trait, while hand hoeing and Gramoxone or Aloxy significantly enhanced the number of primary branches which gave 3.49, 3.40 and 3.12, respectively. The interaction of cultivator with trifluraline had the worst effect on number of branches (2.73); while the interaction of cultivator with hand hoeing gave the highest number of primary branches per plant (3.7).

Table-3. Effect of ploughs types and weed management practices and their interactions on the number of primary branches per plant.

Ploughs	Weeds Management Practices					Mean of ploughs
	Control	Hand hoeing	Gramoxone	Trifluraline	Aloxy	
Disc plow	2.80b	3.33ab	3.20ab	2.86ab	3.20ab	3.08
Mould board	2.86ab	3.46ab	3.46ab	3.00ab	3.06ab	3.18
Cultivator	2.86ab	3.66a	3.53ab	2.73b	3.06ab	3.18
Mean of weed management	2.85b	3.49a	3.40a	2.87b	3.12ab	

For main factor or their interaction, the values that shared the same letter are not significantly different according to Duncan's multiple range test at 0.05 probability.

Table-4 also showed no significant effect of ploughs on the number of pods per plant. Hand hoeing was the best among weed management practices and gave highest number of pods (12.67) per plant. The interaction of ploughs and weeds management practice was significant. The interaction of mould board plough with hand hoeing gave the highest number of pods per plant (13.67). These results are in agreement with those of other researchers (Ahmad *et al.,* 1990; Vaishya *et al.,* 1995; Yasin *et al.,* 1995) but in conflict with those of Kayan and Adak (2005).

Table-4. Effect of ploughs types and weed management practices and their interactions on the number of pods per plant.

Ploughs	Weeds Management Practices					Mean of ploughs
	Control	Hand hoeing	Gramoxone	Trifluraline	Aloxy	
Disc plow	9.87bc	11.60a-c	11.60a-c	11.47a-c	11.57a-c	11.22
Mould board	9.80bc	13.67a	10.47a-c	10.07a-c	9.87bc	10.78
Cultivator	10.57a-c	12.74ab	10.74a-c	9.74bc	8.47c	10.45
Mean of weed management	10.08b	12.67a	10.94ab	10.43b	9.97b	

For main factor or their interaction, the values that shared the same letter are not significantly different according to Duncan's multiple range test at 0.05 probability.

Results in Table-5 revealed no significant effects of ploughs types and weed management or their interaction on number of seeds per plant.

Table-5. Effect of ploughs types and weed management practices and their interactions on the number of seeds per plant.

Ploughs	Weeds Management Practices					Mean of ploughs
	Control	Hand hoeing	Gramoxone	Trifluraline	Aloxy	
Disc plow	8.67	11.14	10.14	10.47	11.74	10.43
Mould board	9.07	11.67	9.34	9.20	9.34	9.72
Cultivator	10.47	10.07	9.94	8.72	8.00	9.44
Mean of weed management	9.40	10.96	9.80	9.46	9.69	

Table-6 showed no significant effects of ploughs types on the weight of 100 seeds. Hand hoeing surpassed all other methods and gave 30.8g; while other treatments were not significantly different from the control. The interaction between ploughs types and weeds control methods was significant. The interaction of hand hoeing with both cultivator and disc plow gave the highest values which were 31.59 and 31.42g, respectively. This may be because of low competition of weeds (low weeds density) which led to more nutrients absorption from the soil that positively influenced seed weight. These results are confirmed by Varshney and Arya (2004); Iqbal *et al.,* (1991); Tewari and Tiwari (2004) and Dungarwal *et al.,* (2002).

Table-6. Effect of ploughs types and weed management practices and their interactions on weight of 100 seeds (gm).

Ploughs	Weeds Management Practices					Mean of ploughs
	Control	Hand hoeing	Gramoxone	Trifluraline	Aloxy	
Disc plow	25.13b-d	31.42a	25.16b-d	25.15b-d	25.16b-d	26.41
Mould board	22.07cd	29.38ab	27.70a-c	23.86b-d	24.59b-d	25.52
Cultivator	26.52a-c	31.59a	25.88ab-d	25.50a-d	20.07d	25.91
Mean of weed management	24.57b	30.80a	26.25b	24.84b	23.28b	

For main factor or their interaction, the values that shared the same letter are not significantly different according to Duncan's multiple range test at 0.05 probability.

Table-7 clearly showed that ploughs types have no significant effect on the hay yield per donum. Weed management methods significantly affected hay yield. Both hand hoeing and paraquat significantly increased hay yield which were 363.9 and 318.2 kg; respectively. The interaction of ploughs types and weed management was significant. Mould board and hand hoeing interaction significantly gave the highest hay yield per unit area. While trifluraline with mould board gave the lowest value (173.85). These results agree with those of Singh *et al.,* (2003). Hand hoeing and paraquat were effective in controlling weeds, which gave more vigorous chickpea plants.

Table-7. Effect of ploughs types and weed management practices and their interactions on hay yield (kg) per donum.

Ploughs	Weeds Management Practices					Mean of ploughs
	Control	Hand hoeing	Gramoxone	Trifluraline	Aloxy	
Disc plow	198.40ed	340.98a-c	362.08ab	175.23e	248.38a-e	252.53
Mould board	228.38b-e	384.70a	262.98a-e	173.85e	198.25ed	249.62
Cultivator	212.23c-e	365.93ab	329.58a-d	193.68ed	206.35c-e	261.55
Mean of weed management	213.00b	363.88a	318.20a	180.93b	217.68b	

For main factor or their interaction, the values that shared the same letter are not significantly different according to Duncan's multiple range test at 0.05 probability.

Table-8 demonstrated no significant effects of ploughs types on yield of chickpea per donum. Hand hoeing was the only operation that significantly increased seed yield, and most effective weed control measure increased crop growth and yield. Seed yield showed similar trend to that of hay yield. Low crop yield was mainly due to drought conditions since total rainfall from March to June was only 158.5 mm. Hand hoeing gave the highest yield (120.4 kg) followed by paraquat which gave only 78.4 kg. The interaction of hand hoeing with both cultivator and mould board gave the highest yield per donum which were 127.5 and 126.6 kg, respectively. These results agree with those of different workers (Ahmad *et al.,* 1990; Vaishya *et al.,* 1995; Yasin *et al.,* 1995; Kayan and Adak 2005; Varshney and Arya 2004; Iqbal *et al.,* 1991; Tewari and Tiwari, 2004; Dungarwal *et al.,* 2002; Singh *et al.,* 2003).

Based on the obtained results, hand hoeing is recommended for controlling weeds when possible in small areas. Herbicides such as paraquat can be used efficiently for weed control, while more research is still needed on possible use of other herbicides in large areas when hand hoeing is not practiced. It has to be supported by economic feasibility estimation to compare the cost of labor with the cost of herbicides. It must be taken in consideration that plowing may expose soil to more loss of moisture and may negatively affect growth of crop plants.

Table-8. Effect of ploughs types and weed management practices and their interactions on seed yield (kg) per donum.

Ploughs	Weeds Management Practices					Mean of ploughs
	Control	Hand hoeing	Gramoxone	Trifluraline	Aloxy	
Disc plow	47.41c	107.00ab	83.92a-c	51.25bc	68.5bc	71.62
Mould board	46.50c	126.58a	65.08bc	51.58bc	54.00bc	68.75
Cultivator	55.75bc	127.50a	86.17a-c	48.92c	35.92c	70.85
Mean of weed management	49.89b	120.36a	78.39b	50.58b	52.81b	

For main factor or their interaction, the values that shared the same letter are not significantly different according to Duncan's multiple range test at 0.05 probability.

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INFLUENCE OF TILLAGE AND WEED MANAGEMENT METHODS ON CHICKPEA (*Cicer arietinum* L.). II. EFFECT ON WEEDS

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ABSTRACT

An experiment was conducted at the Agricultural College farm Duhok University, Iraq to investigate the effectiveness of different types of tillage and weed management practices on weed control in chickpea field during the growing season of 2009-10. Tillage types included the use of disc plow, mouldboard plow, and cultivator and weed management practices included no weed control, hand hoeing, trifluraline (Treflan), haloxyfop-p-methy (Aloxy) and paraquat (Gramoxone). Results indicated that the plough type had no significant effect on number of weeds or their dry weight. Hand hoeing followed by paraquat herbicide were superior in number and dry weight of broad-leaved weeds (8 weeds m^{-2} and 11 g m^{-2}) and (35.22 weeds m^{-2} and 53 g m^{-2}), respectively. The interaction of hand hoeing with all types of tillage systems was significant. The interaction of paraquat with disc plow gave the lowest dry weight of broad leaved weeds (35 g m^{-2}). Neither the number of narrow-leaved weeds nor their dry weight had any marked effect on chickpea.

Keywords: Weeds, chickpea, management, herbicides, control, tillage systems.

ITRODUCTION

Chickpea (*Cicer arietinum* L.) ranks as the third most important grain legume in the world after dry bean and peas (Singh and Saxena, 1999). It is a poor competitor to weeds because of slow growth rate and limited leaf area development at early stages of crop growth and establishment. The demand for chickpea has increased as it is used in many public national food crops, and in various commodities and recipes. Weed competition is considered as one of the most important causes of low and inferior quality of chickpea produce and it is the limiting factor for expanding the area cultivated by this economically important crop in Iraqi Kurdistan Region. The situation is worse especially for the early local cultivars.

Weed control usually is done by different methods, tillage or types of ploughs may have their effect on weed population affecting

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soil moisture or soil seed bank dynamics during pulverizing the soil seed bed preparation. Chemical control of weeds also involves various options, pre-planting treatment is applied before crop is sown, where the herbicides used are acting on germinating seedlings. Pre-emergence treatments are applied after seeding but before the crop emerges; chemicals may control weeds by killing weed seedlings. While post emergence herbicides are applied after the emergence of crop plants and weeds; with selective herbicides weeds are killed with little damage to crop plants due to differential tolerance of the crop and weed to the herbicides.

The types of weeds that may be controlled depend on their susceptibility, and the tolerance of the crop to the herbicide. Treatment at the proper stage of crop development is important. Since most weeds are more susceptible to chemicals when young. Early treatments require less herbicide and result in less damage to crops from weed competition and from spray equipment.

Many studies refer to the above statements. Hand hoeing and tillage are the traditional methods practiced for a long time in most parts of the world (Solh and Pala, 1990). Ascandary (1981) stated that the use of mould board plow in spring has no significant effect on soil moisture. Similarly, Kakarash (2007) indicated that no significant differences in grown plants due to different plough types were evident including cultivator, mouldboard and disc harrow; Hassan (1987) demonstrated that plow types including mouldboard, vertical disc plow, and chisel plow have no significant influence on total fresh or dry weight of weeds in three locations in northern Iraq (Telafer, Hamam Al-Ali, and Sumail). While Khattak and Khan (2005) demonstrated during the use of different kinds of ploughs (chisel plow, mouldboard plow, disc harrow) with cultivator for covering the seeds, that the highest yield of chickpea were obtained from chisel plow with cultivator due to better control of weeds. They mentioned also that weed density m^{-2} increased because of increasing the rain during the growing season.

Regarding weed management practices, Yasin *et al.,* (1995) stated that chemical control of weeds will not be economical if weed interference is low because of low weed density. They also mentioned that the use of pre and post emergent herbicides reduced the total weed dry weight but the reduction did not effectively control grassy weeds. Chopra *et al.,* (2001) mentioned that the use of pre-planting herbicide (fluchloralin) with hand weeding gave the highest weed control efficiency. Similarly, Chaudhary *et al.,* (2005) found the lowest number and dry weight of total weeds was due to weeding at 20 and 40 days after sowing. In this context, Kayan and Adak (2005) stated that hand hoeing was more effective than herbicide application in terms of reducing weed population and increasing chickpea yield. Kumar *et al.,* (1989) and Ahmad *et al.,* (1990) also confirmed that hand-weeding was superior to some pre planting (Fluchloralin) and pre-emergence (Pendimethalin and Oxadiazon) herbicides and reduced weed yield by 87% compared as compared to non-weeded control. Therefore, an experiment was designed to investigate the effect of different types of tillage methods and different methods of weed management on weed types and their population in chickpea field.

MATERIALS AND METHODS

An experiment was undertaken at the fields of Agricultural College, Duhok University, Iraqi Kurdistan Region during 2009 growing season (situated between longitudes 43.01º E, latitudes 36.847º N, and altitude 583 meters). The average rainfall for the months February to June was 158.5 mm. The data were statistically analyzed according to the strip plot design using the statistical analysis system (SAS, 2001). Duncan's multiple range test was used for mean separation at 0.05 probability level (Duncan, 1955).

Local chickpea (*Cicer arietinum* L.) seeds (Marakshi) were obtained from Duhok Agricultural Research Center, Iraq and treated with Diathane, M45 WP fungicide at a rate of 2g kg^{-1} before planting. Seeds viability was estimated by standard germination test according to ISTA (1985) which was 100%. The field was plowed as strips by specific ploughs (Mould board, Disc plow and Cultivator) on 14 January 2009. The field was leveled and the surface of soil was smoothed manually. The field was divided into plots according to Strip Plot Design with the distances of 2 by1m; each plot consisted of 4 lines; 20cm apart and 20cm among the plants.

The distance between tillage treatments in the same replicate was 1m. the experiment included two factors: type of ploughs as a main plot and methods of weed control comprising of control unit (weedy check), hand hoeing, non-selective herbicide (paraquat or Gramoxone), soil herbicide (trifluralin or Treflan) and grass specific herbicide (haloxyfop-p-methyl or Aloxy 10.8% EC) in sub plots. Trifluralin herbicide was applied to the soil in February 02, 2009 at the rate of 600 ml/donum (1 donum = $1000m^2$; 13ml mixed with 14L water and spread on specified units (1.5L for each unit). Seeds were sown at February 15, 2009 at a depth of 7cm (Siddique and Loss, 1999). Gramaxone 20% soil-applied on 10 March 2009 after planting and before emergence of seedlings at a rate of 1000ml/donum; 14.5ml mixed with 15L of water and spread on the specified units. Aloxy herbicide which was used to control narrow leaved weeds was applied on 7 April 2009 at a rate of 187.5 ml /donum when the weeds were at 5-8 leaves stage. In the meantime hand-hoeing was practiced in the required treatment. Samples of weeds were taken on 16 May 2009 from the two middle rows (1 m^2) and they were sorted into narrow or broad leaved and then incubated in oven at 75 C° for 48 hrs. The most common weeds found in chickpea field were *Polygonum aviculare* L., *Carthamus oxycantha*, *Xanthium strumarium*, *Lathyrus annuas*, *Cichorium intybus*, *Centaurea iberica*, *Hypericum perforatum*, and *Sinapis arvensis*.

RESULTS AND DISCUSSION

Results in Table-1 reveal that the type of ploughs had no significant effect on the number of broad leaved weeds per square meter in the field, although mouldboard plow recorded more number of broad leaved (41.33). The least No. of broadleaf weeds were found in the Cultivator (28.80). In respect to the methods of weed control, hand hoeing was the most superior among all treatments having only 8 weeds m^{-2} while all other treatments were not significantly different among themselves and even from the weed check. Aloxy herbicide inferred among them which gave 42.33 weeds m^{-2}very close to the weedy check, because it does not cause any phytotoxicity to broadleaf weeds. The interaction of each of disc and cultivator ploughs with hand hoeing gave significant control of broadleaf weeds among other interactions of tillage methods and weed control treatments (Table-1). The mouldboard plow recorded more number of broad leaved which could be attributed to the possibility of soil pulverization, which moved soil seed bank to soil surface and increased germination of broadleaf weed seeds. These results are in accordance to those of Ascandary (1981), Hassan (1987) and Kakarash (2007), who concluded that the different tillage methods have no effect on weed infestation. However, Khattak and Khan (2005) reported variable chickpea yield under different tillage regimes. Hand hoeing was more efficient among all methods of broad-leaved weed control.

Similarly, Hassan *et al.,* (2003) also observed a differential weed infestation under different methods of tillage systems. A perusal of data in Table-2 showed that the types of ploughs had non significant effect on dry weight of broad leaved weeds per square meter however; cultivator gave the lowest dry weight of broad leaved weeds (53.87 gm^{-2}). Hand hoeing was superior most among the weed control treatments, as it gave lowest dry weight of broadleaf weeds of only 11.00 gm^{-2}, followed by paraquat (53.00 gm^{-2}). The interaction of hand hoeing gave the lowest dry weight of broad leaved weeds per square meter across all the main-plots. The interaction of paraquat with disc plough also gave low and significant value (35 gm^{-2}) compared to the other interactions (Table-2).

Table-1. Effect of ploughs types and methods of weeds managements and their interactions on number of broad leaved weeds per square meter area.

Weed management methods / Ploughs types	Control	Hand hoeing	Gramoxone	Trifluralin	Aloxy	Means of ploughs
Disc plough	43.33d-f*	4.33a	20.33a-c	44.00d-f	35.00c-f	29.40
Mouldboard plough	43.66d-f	11.66ab	55.33f	42.00c-f	54.00ef	41.33
Cultivator	36.00c-f	8.00a	30.00b-d	32.00b-e	38.00c-f	28.80
Means of weed managements methods	41.00b	8.00a	35.22b	39.33b	42.33b	

*Means of the main effects and interaction shared by the same letter are not significantly different at the probability 0.05 Duncan's Multiple Range Test.

Table-2. Effect of ploughs types and methods of weeds managements and their interactions on dry weight of broad leaved weeds per square meter area (gm).

Weed management methods / Ploughs types	Control	Hand hoeing	Gramoxone	Trifluralin	Aloxy	Means of ploughs
Disc plough	78.00d-f*	7.66a	35.00b	161.66i	99.00g	76.27
Mould board plough	95.00fg	15.33a	70.33c-e	127.00h	88.66e-g	79.27
Cultivator	59.66cd	10.00a	53.66bc	72.33c-e	73.66c-e	53.87
Means of weed managements methods	77.55c	11.00a	53.00b	120.33d	87.11c	

*Means of the main effects and interaction shared by the same letter are not significantly different at the probability 0.05 Duncan's Multiple Range Test.

Table-3. Effect of ploughs types and methods of weeds managements and their interactions on number of narrow leaved weeds per square meter area.

Weed management methods / Ploughs types	Control	Hand hoeing	Gramoxone	Trifluralin	Aloxy	Means of ploughs
Disc plough	0.33	0.00	0.00	1.00	0.33	0.33
Mould board plough	0.00	0.33	0.66	0.66	0.00	0.33
Cultivator	1.33	0.00	0.33	0.66	0.00	0.46
Means of weed managements methods	0.55	0.11	0.33	0.77	0.11	

Table-4. Effect of ploughs types and methods of weeds managements and their interactions on dry weight of narrow leaved weeds per square meter area (gm).

Weed management methods / Ploughs types	Control	Hand hoeing	Garmoxone	Trifluralin	Aloxy	Means of ploughs
Disc plough	2.66	0.00	0.00	6.33	2.66	2.33
Mould board plough	0.00	3.00	4.00	8.66	0.00	3.13
Cultivator	0.00	0.00	2.33	12.66	0.00	3.13
Means of weed managements methods	0.88	1.00	2.11	9.22	0.88	

With regard to narrow-leaved weeds, neither plough types nor methods of weeds control and their interactions significantly affected the number of weeds or their dry weight per square meter (Tables-3 and 4), respectively. The data in the Table-3 exhibits that very few grassy weeds infesting the experiment, hence the control methods could not establish any differential efficacy. Aloxy herbicide; the grass specific herbicide failed to significantly differ from the other herbicides and hand weeded and weedy checks. Similar findings have been communicated by Chopra *et al.,* (2001), Chaudhary *et al.,* (2005), Kayan and Adak (2005), Kumar *et al.,* (1989) and Ahmad *et al.,* (1990).

The dry weight of broad-leaved weeds per square meter (Table-2) is coincide with the number of broad leaved (Table-1), and similarly the cultivator, hand hoeing and their interactions gave the lowest value. Tables-3 and 4, obviously showed that there were no significant effects of both plough types or methods of weed control and their interactions on the number of narrow-leaved weeds or on their dry weight per square meter, respectively. These results were in agreement with those of Yasin *et al.,* (1995).The explanation which can be offer for the results of narrow-leaved weeds, due to their existence in soil seed bank. Hand-hoeing surpassed all herbicides treatments which were similar to check plot (no treatment). Therefore, further studies are still required to compare the cost and economy of hand-hoeing compared with chemicals to detect the economic feasibility of chemical application.

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ALLELOPATHIC POTENTIAL OF *Brachiaria brizantha* AND *B. milliformis* ON SEED GERMINATION OF SELECTED BIOASSAY SPECIES

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ABSTRACT

Brachiaria brizantha and B. milliformis are widely grown improved pasture species of the coconut plantations in Sri Lanka. Field observations indicate that these two grass species suppress ground vegetation in coconut plantations. Therefore, the aim of this study was to test the allelopathic effect of B. brizantha and B. milliformis using their root components from where they possibly release allelochemicals to the environment. Soils where B. brizantha and B. milliformis are grown and root exudates, aqueous extracts of fresh and dry roots were investigated to verify their allelopathic effect on seed germination of five bioassay species; Raphanus sativus, Capsicum annum, Lycopersicom esculantum, Crotalaria junica and Chromoleana odorata. Fifty seeds from each bioassay species were placed in a petri dish containing root exudates, root extracts and contaminated soil and the percentage of seed germination was examined after 3 days. The experiment was repeated four times. Seed germination percentage of Capsicum annum, Lycopersicom esculantem and Chromoleana odorata was significantly inhibited by B. brizantha contaminated soil. However, the degree of inhibition varied among the bioassay species. The fresh aqueous root extracts of B. brizantha was highly phytotoxic and it significantly reduced seed germination of all the bioassay species than the dry root extract. The maximum reduction in seed germination of all the bioassay species was caused by root exudates of the two grass species. B.brizantha and B. milliformis species incorporated root aqueous extracts; root exudates and its rhizosphere soil suppress seed germination of the five bioassay species and suggest that these responses are attributed to allelopathic effects which should be investigated further in the field.

Key words: *Brachiaria brizantha*, *B. milliformis*, allelopathy, seed germination, root extracts.

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INTRODUCTION

Coconut is a tropical perennial plantation crop and its canopy structure requires wide spacing between palms, which permit abundant sunlight to the understory. It does not fully utilize all incoming radiation or all of the available moisture and nutrients. As a result, the unutilized space beneath the plantation is invaded by a wide range of perennial and annual weed species (Senarathne *et al.*, 2003). The establishment and maintenance of a good herbaceous pasture in the coconut under story can provide livestock feed, while also preventing the invasion of non–nutritious, yet aggressively competitive weeds (Plucknet, 1974). The positive effect of integration is therefore the "replacement" of non productive weed species with grass species such as *B. brizantha* and *B. milliformis*. Both are high biomass productive perennial, vigorously grown grasses found in coconut plantations in Sri Lanka. The introduction of high yielding grasses into mature plantations may be expected to exert a stronger competitive effect than natural vegetation, primarily due to the increased demand for nutrients and moisture. *B. brizantha* grown in monoculture with routine agronomic practices caused a 13% nut yield reduction in mature coconut plantations, which could be due to significant absorption of soil water (Vidhana, 1998). Humphreys (1991) stressed that the yield of plantation crops may be positively or negatively affected by pasture systems, depending on the nature of the interference and the net effects on the crop environment. Therefore, managing pasture under coconut is very important to achieve maximum herbage production of good quality, without affecting the coconut yield. It is to be noted that aggressive pasture species such as *B. brizantha* are likely to compete with coconut, unless they are well managed (Liyanage, 1999). If allelopathic effects persist, the adverse effect could be accelerated and provide unprofitable results for the coconut growers.

The term of "allelopathy" coined by Molish (1937) generally refers to any direct or indirect effect of the plant (including microorganisms) on the germination, growth or development of other plants, through the production of chemicals that escape into the environment (Rice, 1984). Allelochemicals can be released either through leaching, decomposition of plant residues, volatilization, or root exudation (Chou, 1999). There is increasing attention to explain the development of plant communities and as an important aspect is a weed-crop interaction (Aldrich, 1987; Rice, 1987). However, there has been no basic information about the phytotoxic activity of *B. brizantha* and *B. milliformis* in coconut soils. A better understanding of the allelopathic potential of *B. brizantha* will provide a basis for improving knowledge of plant population changes in coconut plantations. The present study was conducted to determine if aqueous extract of fresh and dry roots of *B. brizantha* and *B. milliformis* and contaminated soil and root exudates were allelopathic to the growth of bioassay species.

MATERIALS AND METHODS

The experiments were carried out in the plant house and laboratory of the Coconut Research Institute located in the Low country Intermediate Zone of the North Western province of Sri Lanka from March to August, 2009. In the plant house, petri dishes received photosynthetically active radiation (PAR) ranging from 500-1150 $\mu molm^{-2}s^{-1}$ and the average day and night temperatures were in the range of 30-34°C and 26-30°C respectively. Relative humidity varied between 35-60% during the day and 20-27% during the night. In the bioassay, *Raphanus sativus*, *Capsicum annum*, *Lycopersicom esculentum*, *Crotalaria junica* and *Chromoleana odorata* seeds were used as the test species due to their high sensitivity to the phytotoxic activity of *B. brizantha* and *B. milliformis*, as observed in preliminary study. Seeds of the selected weed species namely *Chromoleana odorata* and *Crotalaria junica* were collected from five different locations in the major coconut growing regions of Sri Lanka between February to March 2009 and were stored at 5^0C under dark conditions. Seeds of Radish (*Raphanus sativus*), Chillies (*Capsicum annum*), and Tomato (*Lycopersicom esculentum*) were taken from the Seed and Plant Material Development Centre, Department of Agriculture, Sri Lanka. The selected treatments of the experiments were arranged in a Completely Randomized Design (CRD) with ten replicates (each Petri dish and pot representing one replication of a single species in each trial) in the respective studies.

Effect of residual toxicity of contaminated soil on seed germination of bioassay species

B. brizantha and *B. milliformis* grown soil was classified as Madampe soil series (light textured high productive soil series; bulk density = 1.48 ± 0.02 g/cm^3; total available water = 5.71 ± 0.89%; penetrometer resistance = 240 ±16.3 N/cm^2) was located in Bandirippuwa Estate, Lunuwila in the low country Intermediate climate zone (08°02N, 79°E, 35m altitude) (Vidhana, 2009). Contaminated soil was collected to a depth of 10cm from a field where *Brachiaria spp.* had been grown for the last five years and soil from a field that did not have *Brachiaria spp.* was used as a control. Soil was dried at room temperature and sieved through a 2mm mesh. Ten grams each of test and control soils were uniformly spread in 9cm diameter petri dishes, separately. Fifty seeds of selected bioassay species were placed uniformly on the soil. Seeds were covered with the same soil. Soil was adequately moistened with distilled water. The dishes were kept in plant house at 27-30C^0. Each treatment was replicated ten times.

Effect of aqueous extracts of dry roots on seed germination of bioassay species

Root portions of the selected grass species were cut into small pieces with scissors, dried under full sunlight for 1 week, ground to a powder with an electrical grinder (Thomas Wiley, Thomas Company, U.S.A). The dried powdered roots were immersed in distilled water in the ratio of 1:20 w /v and agitated for 24 hours on an orbital shaker at room temperature (29^{0}C). The extract was strained through two layers of filter paper (Whatman No. 02). The extract was refrigerated at 5^{0}C until use. One concentration of the dry root aqueous extract was used in this experiment. Fifty seeds each of selected bioassay species were placed separately in 9cm diameter petri dishes lined with cotton wool. Treatments were applied in 5 ml volumes per dish and distilled water was used for the control. The perti dishes were kept in a plant house for 72 hours at 28-30^{0}C. Treatments were replicated ten times.

Effect of aqueous extracts of fresh roots on seed germination of bioassay species

The fresh root parts of *B. brizantha* and *B. milliformis* cut into 1-2cm lengths were put into distilled water in the ratio of 1:2 w /v soaked in a flask and agitated for 24 hours on an orbital shaker at room temperature (29^{0}C). The extract was strained through two layers of filter paper (Whatman No. 02). The extract was refrigerated at 5^{0}C until use. One concentration of the fresh root aqueous extract was used in this experiment. Fifty seeds each of selected bioassay species were placed separately in 9cm diameter petri dishes lined with cotton wool. Treatments were applied in 5 ml volumes per dish and distilled water was used for the control. The perti dishes were kept in a plant house for 72 hours at 28-30^{0}C. Treatments were replicated ten times.

Effect of root exudates on seed germination of bioassay species

Plants of *B. brizantha* and *B. milliformis* were planted in the plastic pots kept in the plant house. After 2 months well grown mature 5 plants were selected from the 2 species. Plants were placed in Aluminum potting racks, the bottom of the pots were covered by using polythene bags. Thereafter, 100ml of distilled water was added to the pots to bring the soil to field capacity and the root exudate was obtained. The exudate was refrigerated at 5^{0}C until use. One concentration of the root exudates was used in this experiment. Fifty seeds each of selected bioassay species were placed separately in 9cm diameter petri dishes lined with cotton wool. Treatments were applied in 5ml volumes per dish and distilled water was used for the control. The perti dishes were kept in a plant house for 72 hours at 28-30^{0}C. Treatments were replicated ten times.

Data collection

The Petri dishes were kept in a plant house and supplied with adequate light for seed germination. Germination of *Raphanus sativus*, *Capsicum annum*, *Lycopersicom esculentum*, *Crotalaria junica* and *Chromoleana odorata* were recorded daily; during 12 days according to the method of the Association of Official Seed Analysis (1985).

Numbers of germinated seeds were converted to % as per following formula.

$$\text{Germination \%} = \frac{\text{No of Germinated seeds}}{\text{Total No. of seeds}} \times 100$$

Statistical analysis

Data analysis of the above experiment was conducted using Analysis of Variance (ANOVA) using Statistical software and the significance was tested using the Least Significant Differences (LSD) at P=0.05 (SAS Institute, 1999).

RESULTS AND DISCUSSION

Residual toxicity of contaminated soil on seed germination

Soil collected from the *B. brizantha* rhizosphere had a strong inhibitory effect on the seed germination of some bioassay species such as *Lycopersicom esculentum*, *Capsicum annum* and *Chromoleana odorata* (Table-1). However, there was no significant difference of the allelopathic effect of *B. brizantha* and *B. milliformis* on *Crotalaria junica* and *Raphanus sativus* seeds. The lowest germination percentage (17%) was recorded in *Chromoleana odorata* seeds, when those seeds were sown on the *B. brizantha* contaminated soil, while the highest germination percentage was found in *Lycopersicom esculentum* seeds, when compared with that of *Capsicum annum* seeds (44%) (Table-1). Furthermore, with *B. milliformis* contaminated soils, the lowest inhibition of germination percentage (23%) was found in *Chromoleana odorata* seeds and the highest germination percentage (73%) was recorded in *Lycopersicom esculentum* seeds (Table-1). This is in agreement with the results of Chung and Miller (1995) who reported the inhibitory effect of soil collected from the surrounding area of alfalfa plants on their test bioassay species. This inhibition may be due to the release of phytotoxic substances by the root itself or through interaction between microorganisms and tissue litter.

However, this interpretation needs further study because several factors are involved in allelopathic activity and seed germination. In addition, the alteration of the physico-chemical characteristics of the soil may affect the quantitative and qualitative status of phyto-chemicals, which, in turn influences the allelopathic expression of plants (De-Moral and Muller, 1970). However *B. brizantha* inhibited germination of the above species to a greater extent than of *B. milliformis*. Overall results showed that the contaminated soil of *B. brizantha* and *B. milliformis* adversely affected the seed germination of *L. esculentum*, *C. annum*, and *C. odorata*. Therefore, it can be concluded that allelopathic nature of soil was due to the leaching of toxins from *B. brizantha* and *B. milliformis*.

Table-1. Effect of residual toxicity of contaminated soil on seed germination of selected species.

Treatments	Seed germination %				
	Raphanus sativus	***Lycopersicom esculentum***	***Capsicum annum***	***Crotalaria junica***	***Chromoleana odorata***
T_1 Control	66 a	81a	66a	21 a	62 a
T_2 *B. brizantha*	40 b	44b	23 b	17 a	17 b
T_3 *B. milliformis*	64 ab	73a	24 b	19 a	23 c
Significance	ns	**	**	ns	**
LSD (P = 0.05)	-	16.59	23.44	-	17.14

*Significant ** Highly Significant.
Within a column, means followed by the same letter are not significantly different by LSD (P=0.05).

Effect of dried root extract on seed germination of selected bioassay species

Air dried root extract of *B. brizantha* and *B. milliformis* significantly ($p \leq 0.05$) reduced the seed germination of bioassay species when compared to the control (only distilled water) (Table-2). Application of *B. brizantha* dried root extract significantly reduced the seed germination and the lowest germination percentage (7%) was found in *C. juncia*, while the highest germination percentage (72%) was found in *R. sativus* seeds (Table-2). With the air dried root extract of *B. milliformis*, the lowest germination percentage (19%) was also observed in *C. junica* seeds, while the highest germination percentage (82%) was recorded in *R. sativus* seeds (Table-2).

Moreover, *B. brizantha* significantly suppressed seed germination of *C. junica* and *C. odorata* when compared to that of *B. milliformis.* These results are supported by the findings of Helgeson and Konzak (1950) who reported that aqueous extracts of field bindweed (*Convolvulus arvensis)* and canada thistle (*Cirsium arvense*) inhibited the germination of seeds and growth of seedlings of many crops. Overall results suggested that allelopathic effect of dried roots extract of *B. brizantha* and *B. milliformis* significantly ($p \leq 0.05$) suppressed the seed germination of *C. junica*, *C. odorata*, *L. esculentum*, *C. annum* and *R. sativus* (Table-2).

Table-2. Effect of dried roots extract on seed germination of bioassay species.

Treatments	Seed germination %				
	Raphanus sativus	***Lycopersicom esculentum***	***Capsicum annum***	***Crotalaria junica***	***Chromoleana odorata***
T_1 Control	95a	82a	77a	45a	46b
T_2 *B. brizantha*	72b	27b	36b	7c	23b
T_3 *B. milliformis*	82b	42b	44b	19b	33ab
Significance	**	**	**	**	*
LSD (P = 0.05)	11.82	20.07	10.25	11.30	14.63

*Significant ** Highly Significant
Within a column, means followed by the same letter are not significantly different by LSD (P=0.05).

Effect of fresh root extract on seed germination of selected bioassay species

Fresh root extracts of *B. brizantha* and *B.milliformis* significantly ($p \leq 0.05$) reduced the germination percentage of seeds of selected species when compared to the control (only distilled water). However, there was no significant effect of treatments on seed germination of *C. junica*. The lowest germination percentage (18%) was recorded in *C. odorata* seeds, with *B. brizantha* fresh root extract. The highest germination percentage was found in *L. esculentum* seeds when compared to that of *R. sativus* and *Capsicum annum* seeds (37%). Applications of fresh root extract of *B. milliformis* on to the seeds of the above species reveal that the lowest inhibition of germination percentage (30%) was found in *C. odorata* seeds whilst the highest germination percentage (58%) was recorded in *C. annum* seeds (Table-3).

Table-3. Effect of fresh root extract on seed germination of bioassay species.

Treatments	Seed germination %				
	Raphanus sativus	***Lycopersicom esculentum***	***Capsicum annum***	***Crotalaria junica***	***Chromoleana odorata***
T_1 Control	68a	80a	82a	17a	44a
T_2 *B. brizantha*	35b	37c	26c	4b	18c
T_3 *B. milliformis*	42b	53b	58b	12ab	30b
Significance	**	**	**	ns	**
LSD (P = 0.05)	13.30	13.20	16.47	-	11.98

*Significant ** Highly Significant
Within a column, means followed by the same letter are not significantly different by LSD (P=0.05)

There was a significant difference ($p \leq 0.05$) in the germination of *L. esculentum*, *C. annum* and *C. odorata* seeds in *B. brizantha* and *B. milliformis* treatments. These findings are supported by the findings of Noor and Khan (1994) who reported a high reduction in *Zea mays* seed germination by *A. samana* fresh root extracts. The results presented in Table-3, indicate that the allelopathic effect of fresh roots extract of *B. brizantha* and *B. milliformis* were adversely affecting the germination of *C. odorata*, *Capsicum annum*, *R. sativus* and *L. esculentum* seeds.

Effect of root exudates on seed germination of selected bioassay species

Root exudates of *B. brizantha* and *B. milliformis* reduced the germination percentage of seeds when compared to control treatment (distilled water). With the application of *B. brizantha* root exudates to the seeds, the lowest germination percentage (2%) was found in *C. junica* whilst the highest germination percentage was in *L. esculentum* seeds when compared with *R. sativus* and *C. odorata* seeds which were 60% (Table-4). After the application of *B. milliformis* root exudates to the seeds, the lowest germination percentage (5%) was found in *Crotalaria junica* seeds whilst the highest germination percentage (71%) was recorded in *Lycopersicom esculentum* seeds.

Table-4. Effect of root exudates on seed germination of bioassay species.

Treatment	Seed germination %				
	Raphanus sativus	***Lycopersicom esculentum***	***Capsicum annum***	***Crotalaria junica***	***Chromoleana odorata***
T_1 Control	79a	89a	79a	21a	58a
T_2 *B. brizantha*	44b	60b	42c	2b	29b
T_3 *B. milliformis*	53b	71b	55b	5b	37b
Significance	*	**	**	**	**
LSD (P = 0.05)	20.27	13.1	9.98	9.15	15.6

*Significant ** Highly Significant

Within a column, means followed by the same letter are not significantly different

B. brizantha and *B. milliformis* root exudates caused a significant difference ($p \leq 0.05$) in the germination of *C. annum* seeds However, the highest germination percentages were recorded in the control treatment, which were *R. sativus* (79%), *L. esculentum* (89%), *C. annum* (79%), *C. junica* (21%) and *C. odorata* (58%), respectively. These results agree with those of Helgeson and Konzak (1950), who found that root exudates of Canada thistle (*Cirsium arvense*) injured oat plants in the field while root exudates of *Euphorbia* and *Scabosia.* Our results suggested that allelopathic effect of roots exudates of *B. brizantha* and *B. milliformis* adversely affected the germination of all the bioassay species seeds.

CONCLUSIONS

The selected bioassay species were more sensitive to inhibitory effects of root extracts, exudates and contaminated rhizosphere soil of *B. brizantha* than those of *B. milliformis.* Hence, *B.*

bizantha has a greater allelopathic potential and releases allelopathic substances to the environment. However, the sensitivity to allelochemicals and extent of inhibition varied between species. The allelopathic effect of *B. brizantha* may be an important mechanism involved in invasive success of this plant. Under natural conditions, where a greater number of interactions with other organisms occur, these allelopathic effects can enhance or restrain plant growth and species diversity. Field experiments must be carried out to test the effectiveness of the allelopathic potential of above grass species under natural conditions.

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ALLELOPATHIC EFFECTS OF *Lantana camara* LEAF EXTRACT ON GERMINATION AND GROWTH BEHAVIOR OF SOME AGRICULTURAL AND FOREST CROPS IN BANGLADESH

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ABSTRACT

Lantana camara, an invasive weed in the secondary degraded and plantation forests of Bangladesh is becoming a problem not only competing with the crops but also releases alleochemicals to associated crops. The present study showed that water soluble allelochemicals of L. camara inhibit the germination and initial growth of both the selected agricultural (Oryza sativa L., Triticum aestivum L., Vigna sinensis (L.) Hassk., Cucurbita pepo L., Abelmoschus esculentus (L.) Moench, Amaranthus tricolor L.) and forest crops (Acacia auriculiformis A. Cunn. ex Benth. & Hook., Paraserianthes falcataria (L.) Nielson, Albizia procera (Roxb.) Benth.) in the laboratory conditions. The results revealed that different concentrations of Lantana camara leaf extracts caused significant inhibitory effect on germination, root and shoot elongation and development of lateral roots of the receptor crops. Bioassays also indicate that the inhibitory effect was proportional to the concentrations of the extracts and higher concentrations had the stronger inhibitory effect, whereas, the lower concentrations showed stimulatory effect in some cases.

Key words: *Lantana camara*, allelopathy, agricultural crops, forest crops, germination, growth inhibition.

INTRODUCTION

The term 'allelopathy' signifies the interactions between plants might lead to either stimulation or inhibition of growth. In addition to allelopathic effects, weeds also act as enemies to the crop plants and have harmful effects on agricultural crops due to several factors such as competition for space, light and nutrients. Organic chemicals released as leaf leachates, affect the desired crop plants. Weeds species are considered as rich source of secondary metabolites (allelochemicals) and these chemicals modify the environmental system on other plants growing in their vicinity and the phenomenon is known as allelopathy (Nandal *et al*., 1994). Few researchers consider only the deleterious interactions as allelopathy, while, the latest thinking includes allelopathy to both harmful and beneficial

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interactions between the plants (Rizvi *et al*., l986). In agriculture, the inhibitory effect of weed species on germination and growth of crops has been attributed to phytotoxic chemicals released from the leaf litter and roots. Further, Rice (1974) observed that many species of weeds produce toxins that are inhibitory to other weeds and often to themselves. *Lantana camara*, one of the world's 10 worst weeds was introduced in the Indian subcontinent during the early part of the nineteenth century (Bansal, 1998). The weed is aggressively growing in forest, agriculture, tea garden and wastelands of all over the country (Ahmed, 1997). This obnoxious weed poses a serious problem to flora and fauna because of its toxic substance and it contains certain allelopathic compounds (Jain *et al.*, 1989). Although several researches have so far worket on the invasion and allelopathic effects of *Lantana* on various agricultural crops throughout the world (Bansal, 1998) however such scientific activities are scarce in the context of Bangladesh (Ahmed *et al.*, 2007). The present work was an attempt to explore the allelopathic effects of *L. camara* in the forest and agricultural crops commonly grown in Bangladesh.

MATERIALS AND METHODS

Receptor crops

The receptor agricultural crops used in this experiment were *Oryza sativa* L., *Triticum aestivum* L., *Vigna sinensis* (L.) Hassk., *Cucurbita pepo* L., *Abelmoschus esculentus* (L.) Moench. and *Amaranthus tricolor* L. The receptor forest crops were *Acacia auriculiformis* A. Cunn. ex Benth. & Hook., *Paraserianthes falcataria* (L.) Nielson and *Albizia procera* (Roxb.) Benth.

Donor plant and preparation of leaf extracts

In the present experiment, *L. camara was* used as the donor plant. Aqueous extract of *L. camara* leaves was prepared as under 200g of fresh *L. camara* leaves were soaked in 1000 ml distilled water and kept at a room temperature of 28-30°C. After 24 hour, the aqueous extract was filtered through the sieve and then some of the extracts was diluted to make the concentrations to 10, 25, 50 and 75 % (on the basis of volume) and stored for seed treatment experiments.

Treatments

Five treatments T_0, T_1, T_2, T_3, T_4 and T_5 were used during the experiment: $T_{0:}$ Seeds of receptor plants grown in distilled water only (control) whereas T_1,T_2, T_3, T_4 and $T_{5:}$ were Seeds of receptor plants grown in extracts of 10, 25, 50, 75 and 100% concentrations, respectively.

Germination and growth records

The germination test was carried out in the sterile Petri dishes (12cm dia) lined with filter paper Whatman No. 3. Each concentration of the extract was added to each Petri dish of respective treatment daily in such an amount just to keep the seed moist enough to get favorable condition for germination and growth. The control treatment was treated with distilled water. Twenty seeds of each receptor species were placed in the petridish replicating five times. The Petri dishes were set in the analytical laboratory of the Institute Of Forestry and Environmental Sciences, Chittagong University, Bangladesh at room temperature ranging from 28-30°C. The experiment was extends over a period of seven days to allow the last seed germination A seed was considered as germinated, when radical emerged. The germination was recorded on daily basis. The results were determined by counting the number of germinated seeds, number of lateral roots and measuring the lengths of both primary and main shoot on seventh day (in case of agriculture crops) and twelfth day (in case of forest crops) of the experiment. The data were subjected to analysis of variance and Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Germination (%) of agricultural crops

The germination percentages of the 6-receptor plants are shown in Table-1. In most cases, variation of the germination percent varied evenly due to different concentrations. With the increase of concentration, the inhibitory effect was progressively increased. In all cases, the maximum inhibitory effect was found at T_5 treatment (100% concentration). The highest inhibitory effect (-35.08%) was found in *C. pepo* at T_5 treatment followed by -34.61% in *A. tricolor* in the same treatment.

Table-1. Germination percent of receptor agricultural crops to distilled water (T_0) and different concentration of *Lantana camara* leaf extracts (T_1-T_5).

Treatment	*O. sativa*	*T. aestivum*	*V. sinensis*	*C. pepo*	*A.esculantus*	*A. tricolor*
T_0	96.67 a*	88.33 a	91.67 a	95.00 a	81.67 a	86.67 a
T_1	88.33 ab (-8.63)	80.00 ab (-9.43)	88.33 ab (-3.64)	88.33 ab (-7.02)	78.33 a (-4.09)	81.67 a (-5.77)
T_2	86.67 bc (-10.34)	78.33 b (-11.32)	83.33 ab (-9.09)	85.00 ab (-10.53)	80.00 a (-2.04)	75.00 ab (-13.46)
T_3	80.00 bcd (-17.24)	73.33 bc (-16.98)	86.67 ab (-5.45)	80.00 bc (-15.79)	70.00 a (-14.29)	75.00 ab (-13.46)
T_4	78.33 cd (-18.97)	68.33 cd (-22.64)	75.00 bc (-18.18)	70.00 cd (-26.32)	68.33 a (-16.33)	65.00 bc (-25.00)
T_5	73.33 d (-24.14)	61.67 d (-30.18)	63.33 d (-30.92)	61.67 d (-35.08)	61.67 a (-24.49)	56.67 c (-34.61)

*- Values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments.

The maximum relative germination ratio was found in *A. esculantus* (97.96%) at T_2 treatment while the minimum (64.92%) was occurred in *C. pepo* at T_2 treatment. Allelopathic effects of *Lantana camara* on germination and growth behavior of some agricultural crops was reported (Ahmed *et al.*, 2007). The researchers found that aqueous extracts of *L. camara* inhibited the seed germination of some agricultural crops. It was also observed that leaf extracts of *L. camara* significantly delayed the germination in all the receptor crops compared to the control treatment. The allelopathic effect of *Bambusa arundinacea* on *Arachis hypogaea* was also reported (Eyini *et al*., 1989) to conclude that, aqueous extract of weeds inhibited the germination of selected crops.

Shoot elongation

The average shoot lengths (cm) of the germinated seedlings of agricultural crops in all the receptor crops are shown in Table-2. The study revealed that in some cases stimulatory effect was found at T_2 treatment in comparison to control and the inhibitory effect was progressively increased with the increase of concentration. Statistically significant effect was found at T_5 treatment followed by T_4 and T_3 treatments, respectively. Complete inhibition (-100%) occurred in *A. esculentus* at T_5 treatment. Among the survivors, the highest inhibitory effect was found on *V. sinensis* (-86.30%) at T_5 treatment and the lowest inhibitory effect was found on *C. pepo* (-0.21%) whereas the highest stimulating effect was found on *O. sativa* (+1.43%) at T_2 treatment. Maximum elongation of shoot (17.30cm) was observed in *V. sinensis* at T_0 treatment.

Table-2. Shoot elongation (cm) of receptor agricultural crops to distilled water (T_0) and different concentration of *Lantana camara* leaf extracts (T_1-T_5).

Treatment	*O. sativa*	*T. aestivum*	*V. sinensis*	*C. pepo*	*A. esculantus*	*A. tricolor*
T_0	4.90 a*	11.62 a	17.30 a	14.30 a	8.03 a	5.47 a
T_1	4.76 ab	6.43 b	15.87 b	14.27 a	5.29 b	4.32 b
	(-2.86)	(-44.66)	(-8.27)	(-0.21)	(-34.12)	(-21.02)
T_2	4.97 a	4.90 c	13.71 c	13.89 a	4.29 c	3.75 c
	(+1.43)	(-57.83)	(-20.75)	(-2.87)	(-46.58)	(-31.44)
T_3	4.56 b	4.52 c	9.62 d	14.24 a	4.11 cd	3.39 d
	(-6.94)	(-61.10)	(-44.39)	(-0.42)	(-48.82)	(-38.03)
T_4	4.23 c	3.29 d	4.22 e	5.18 b	3.58 d	3.26 d
	(-13.67)	(-71.69)	(-75.61)	(-63.78)	(-55.12)	(-40.40)
T_5	4.48 bc	1.95 c	2.37 f	3.45 c	0.00 e	2.72 e
	(-8.57)	(-83.22)	(-86.30)	(-75.87)	(-100)	(-50.27)

***-** Values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments.

Root elongation

The root lengths of all the 6 bioassay species were found to be greatly inhibited with the increase of the extract concentration except for *O. sativa* and *A. tricolor*. In *O. sativa* and *A. tricolor* stimulating effect was observed and relative elongation ratio was found to be +8.01% and +4.43% at T_1 treatment respectively (Table-3). The inhibitory effect was much more pronounced at T_5 treatment followed by T4, T_3 and T_2 treatments respectively. Complete inhibition was occurred in *A. esculantus* at T_5 treatment. Among the survivors, the highest inhibitory effect (-95.32%) was found on *C. pepo* at T_5 treatment followed by *V. sinensis* at T_5 treatment (-85.44%). Maximum elongation of root was observed in *C. pepo* (25.01cm) at T_0 followed by 22.48cm in T_2 treatment (Table-3).

Table-3. Root elongation (cm) of receptor agricultural crops to distilled water (T_0) and different concentration of *Lantana camara* leaf extracts (T_1-T_5).

Treatment	*O. sativa*	*T.aestivum*	*V. sinensis*	*C.pepo*	*A.esculantus*	*A.tricolor*
T_0	6.24 ab*	10.63 a	10.92 a	25.01 a	6.98 a	4.51 b
T_1	6.74 a	7.25 b	6.35 b	20.13 bc	5.20 b	4.71 a
	(+8.01)	(-31.79)	(-41.85)	(-19.52)	(-25.50)	(-4.43)
T_2	6.42 ab	6.56 c	5.61 c	22.48 b	4.58 c	3.84 c
	(+2.88)	(-38.29)	(-48.63)	(-10.12)	(-34.38)	(-14.86)
T_3	6.35 ab	6.45 c	4.61 d	18.39 c	4.62 c	3.39 d
	(+1.76)	(-39.32)	(-57.78)	(-26.47)	(-33.81)	(-24.83)
T_4	5.89 b	5.52 d	1.86 e	1.97 d	3.43 d	3.24 d
	(-5.61)	(-48.07)	(-82.97)	(-92.12)	(-50.86)	(-28.16)
T_5	5.34 c	3.23 e	1.59 f	1.17 d	0.00 e	2.58 e
	(-14.42)	(-69.61)	(-85.44)	(-95.32)	(-100)	(-42.79)

*** -** Values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments.

Number and Development of lateral roots

Considering the number of lateral root development, it was revealed that this phenomenon is significantly inhibited with the increasing concentration. In all cases most significant effects was found at T_5 treatment. Complete inhibition occurred at the same treatment (T_5) in case of both *A. esculentus* and *A. tricolor*. The effect was more or less evenly increased from 10% concentration to onward. In all cases control had the highest average lateral root number in comparison to other treatments except for that in *O. sativa* on which stimulating effect (+12.60%) was found at T_1 treatment.

Among the survivors, highest inhibitory effect (-96.96%) was found on *V. sinensis* at T_5 treatment and the lowest (-0.93%) was found on *O. sativa* at T_5 treatment whereas maximum number of lateral roots (96.89) were found in *C. pepo* followed by 91.34 both in same species in T_0 and T_2 treatment respectively (Table-4). Lateral root development was completely inhibited in *A. esculantus* seedling at T_5 treatment. The survivors exhibited varying degree of necrosis and chlorosis, thin and grayish in color. Many seedlings lost their ability to develop normally as a result of reduced radical elongation and root necrosis. So, it can be concluded that the inhibitory effect of *Lantana* extract dependent very much on their concentration which was also reported by Daniel (1999).

Table-4. Number of lateral roots in receptor agricultural crops to distilled water (T_0) and different concentration of *Lantana camara* leaf extracts (T_1-T_5).

Treatment	*O. sativa*	*T. aestivum*	*V. sinensis*	*C. pepo*	*A. esculantus*	*A. tricolor*
T_0	35.33 b*	16.11 a	31.22 a	96.89 a	17.56 a	4.67 a
T_1	38.00 ab	11.22 b	18.78 b	77.00 c	7.78 b	3.44 b
	(+7.56)	(-30.35)	(-39.85)	(-20.53)	(-55.69)	(-26.34)
T_2	39.44 a	5.89 c	15.11 c	91.34 b	5.67 c	1.89 c
	(+11.63)	(-63.44)	(-51.60)	(-5.73)	(-67.71)	(-59.53)
T_3	39.78 a	2.67 d	11.33 d	77.11 c	3.00 d	1.11 d
	(+12.60)	(-83.43)	(-63.71)	(-20.41)	(-82.92)	(-76.23)
T_4	38.22 ab	1.78 de	07.45 e	11.55 d	2.00 e	0.56 e
	(+8.18)	(-88.95)	(-76.14)	(-88.08)	(-88.61)	(-88.00)
T_5	35.00 b	0.67 e	0.95 f	9.33 d	0.00 f	0.00 f
	(-0.93)	(-95.84)	(-96.96)	(-90.37)	(-100)	(-100)

*** -** Values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments.

Germination for forest crops

The germination percent of the 3-receptor forest crops is shown in Table-5. In most cases, variation of the germination varied evenly due to different concentrations. With the increase of concentration, the inhibitory effect was progressively increased.

Table-5. Germination percent of receptor Forest crops to distilled water (T_0) and different concentration of *Lantana camara* leaf extracts (T_1-T_5).

Treatment	*A. auriculiformis*	*P. falcataria*	*A. procera*
T_0	76.67 a*	85.00 a	78.33 a
T_1	55.00 bc (-28.26)	73.33 b (-13.73)	55.00 b (-29.78)
T_2	56.67 b (-26.09)	56.67 c (-33.33)	48.33 bc (-38.30)
T_3	46.67 bcd (-39.13)	43.33 d (-49.02)	40.00 cd (-48.93)
T_4	45.00 cd (-41.31)	53.33 cd (-37.26)	45.00 cd (-42.55)
T_5	40.00 d (-47.83)	41.67 d (-50.98)	38.33 d (-51.07)

*** -** values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments.

In all cases, the maximum inhibitory effect was found at T_5 treatment (100% concentration). The highest inhibitory effect (-51.07%) was found in *A. procera* at T_5 treatment followed by (-50.98%) in *P.*

falcataria at the same treatment. The maximum relative germination ratio was found in *P. falcataria* (86.27%) at T_0 treatment while the minimum was (48.93%) in *A. procera* at T_5 treatment. These results are more or less similar to the findings of Bora *et al.* (1999), who found the allelopathic effects of leaf extracts of *Acacia auriculiformis* on seed germination of some agricultural crops.

Shoot elongation

The average shoots length (cm) of the germinated seedlings of forest crops in all the receptor are shown in Table-6. The study revealed that in *P. falcataria*, stimulatory effect was found at T_5, T_3 and T_1 treatment in comparison to control and the inhibitory effect was progressively increased with the increase of concentrations. Statistically significant effect was found at T_4 treatment followed by T_3 and T_2 treatment respectively (Table-6). Complete inhibition (-100%) was occurred in *A. procera* at T_4 and T_5 treatment, though maximum elongation of shoot (8.43cm) was found in *A. procera* at T_0 treatment. Among the survivors the highest inhibitory effect was found on *A. auriculiformis* (-46.84%) at T_4 treatment and the lowest inhibitory effect was found on *A. auriculiformis* (-7.93%), whereas, the highest stimulating effect was found on *P. falcataria* (+8.05%) at T_5 treatment.

Table-6. Shoot elongation (cm) of receptor Forest crops to distilled water (T_0) and different concentration of *Lantana camara* leaf extracts (T_1-T_5).

Treatment	*A. auriculiformis*	*P. falcataria*	*A. procera*
T_0	8.07 a*	6.83 b	8.43 a
T_1	7.43 b (-7.93)	7.07 ab (+3.51)	6.41 b (-23.96)
T_2	6.52 c (-19.21)	5.96 c (-12.74)	5.77 c (-31.55)
T_3	4.98 e (-38.29)	7.28 a (+6.59)	5.09 d (-39.62)
T_4	4.29 f (-46.84)	5.80 c (-15.08)	0.00 e (-100)
T_5	5.49 d (-31.97)	7.38 a (+8.05)	0.00 e (-100)

*** -** values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments.

Root elongation

The root length of all the 3 tree species were found to be significantly inhibited with the increase of the extract concentration, except in *P. falcataria* where stimulating effect was observed and relative elongation ratio was +27.38% and +6.53% at T_1 and T_5 treatment respectively (Table-7). The inhibitory effect was much more pronounced at T_3 treatment followed by T_2 and T_1 treatments respectively. Complete inhibition was occurred in *A. procera* at T_4 and T_5 treatment. Among the survivors, the highest inhibitory effect (-77.5%) was found on *A. procera* at T_3 treatment followed by *A. procera* at T_2

treatment (-70.92%). Maximum elongation of roots (5.49cm) was observed in T_1 of *P. falcataria* followed by 4.31cm in T_0 treatment (Table-7).

Table-7. Root elongation (cm) of receptor Forest crops to distilled water (T_0) and different concentration of *Lantana camara* leaf extracts (T_1-T_5).

Treatment	*A. auriculiformis*	*P. falcataria*	*A. procera*
T_0	4.20 a*	4.31 ab	3.20 a
T_1	3.83 b (-8.81)	5.49 a (+27.38)	1.14 b (-64.38)
T_2	3.17 c (-24.52)	4.12 ab (-4.41)	0.93 bc (-70.94)
T_3	2.77 d (-34.05)	3.53 bc (-18.10)	0.72 c (-77.5)
T_4	2.00 f (-52.38)	2.62 c (-39.21)	0.00 d (-100)
T_5	2.37 e (-43.57)	4.60 ab (+6.53)	0.00 d (-100)

*** -** Values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments.

Number and Development of lateral roots

Considering the number of lateral root development, it was revealed that root development was significantly inhibited with the increase of extract concentrations (Table-8). In all cases, most significant effect was found at T_4 treatment and complete inhibition was occurred at T_4 and T_5 treatments in *A. procera*. The effect was more or less evenly increased from 10% concentration to onward. In all the treatments, control had the highest average lateral root number in comparison to other treatments. Among the survivors, highest inhibitory effect (-90.44%) was found on *A. auriculiformis* at T_4 treatment and the lowest (-37.11%) was found on *P. falcataria* at T_5 treatment whereas the maximum number of lateral roots (16.22 nos.) were found in *A. auriculiformis* (Table-8). Lateral root development was completely inhibited in *A. procera* seedling at T_4 and T_5 treatments.

The results of the study confirms the findings of Bansal (1998), who reported the suppressed seed germination and seedling growth in all associated weeds and the suppressive effects increase with an increase in percent content of *Lantana* extracts. The result also revealed that root elongation and lateral root development of receptor crops were markedly inhibited in comparison to that of shoot elongation. These may be due to the direct contact of roots with leachates.

These findings also were in accordance with the results of Alam (1990); Chou *et al*. (1986) and Zackrisson and Nilsson (1992), in which root growth was more sensitive and responds more strong to the increasing concentration of the aqueous extracts. The suppressive effect of *Lantana* on other weeds may be caused by allelopathy.

Lantana has also been reported to be allelopathic against milk weed vine (*Morrenia odorata*), velvet leaf (*Abutilon theophrasti*) and fern (*Cyclossus dentatus*) because of phenolic compounds (Jain *et al.*, 1989).

Table-8. Number of lateral roots in receptor Forest crops to distill water (T_0) and different concentration of *Lantana camara* leaf extracts (T_1-T_5).

Treatment	*A. auriculiformis*	*P. falcataria*	*A. procera*
T_0	16.22 a*	10.78 a	3.89 a
T_1	10.11 b (-37.67)	5.56 bc (-48.42)	2.22 b (-42.93)
T_2	7.22 c (-55.49)	4.11 d (-61.87)	1.11 c (-71.47)
T_3	3.00 d (-81.50)	5.89 b (-45.36)	0.67 cd (-82.78)
T_4	1.55 e (-90.44)	4.22 cd (-60.85)	0.00 d (-100)
T_5	3.67 d (-77.37)	6.78 b (-37.11)	0.00 d (-100)

*** -** Values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments.

The plantation forests and the secondary degraded forest lands of Bangladesh are being progressively invaded and suppressed by this alien invasive woody shrub *Lantana camara* L. in an alarming rate. The invasion of *Lantana* threatens the natural regeneration and survival of many young plantation species. *Lantana* occurs in diverse site conditions ranging from open, un-shaded conditions such as wastelands, the edges of forests, in agricultural areas, grasslands, scrub/shrub lands, urban areas, wetlands and degraded forests recovering from fire or logging, roadsides, railway tracks and canal banks. In addition, this weed is exerting allelo-chemicals that also inhibit the growth and development of both the common agricultural and forest crops in diverse ecosystems. A strategy and action plan is essential to eradicate and control this noxious weed from further spread in new ecosystems.

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PARASITIC FLOWERING PLANTS ON CULTIVATED PLANTS IN JORDAN-THE PRESENT STATUS AND MANAGEMENT

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ABSTRACT

Parasitic flowering plants are problematic species, posing high concern to farmers, and potential threat to agriculture and forestry in Jordan. Recent field research revealed the occurrence of 8 parasitic genera belonging to 6 plant families in the country. Parasitic plants found belong to the families Orobanchaceae (Orobanche and Cistanche), Cuscutaceae (Cuscuta), Santalaceae (Osyris and Thesium), Cynomoriaceae (Cynomorium), Viscaceae (Viscum) and Loranthaceae (Loranthus). Parasites were found attacking a wide host range of plants of wild herbs, field crops, forage plants, rangeland shrubs and forest and fruit trees. They are spread in different biogeographical regions with clear variations in their ecological tolerance. Many of the hosts recorded and certain parasitic species are reported for the first time. Possible management of these parasites based on recent research findings, some recommendations and experiences of local farmers are discussed.

Keywords: Parasitic plants, host species, problematic weeds, management.

INTRODUCTION

Weeds represent a major threat to agriculture in Jordan and cause great yield losses due to their negative interference with crop plants (Qasem, 2003). Parasitic weeds are one group of high concern to farmers as well as to researchers, and represent a real danger to agriculture. These parasites subset on the root system or aerial vegetative parts of the host species and can lead to severe growth damage, yield failure and in most cases death of host plants under heavy infestation. Parasitic weeds may or may not have chlorophyll pigments and thus may partially or completely depend on host plants for food and/or water (Parker and Riches, 1993).

In Jordan, three families including 3 genera have already been reported to attack 34 wild and cultivated species (Abu-Iramileh, 1979). The danger these parasites exert is mainly due to their difficult

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control with available weed control methods, except by soil fumigation against certain species, which is not economically feasible on a wide scale. In addition the huge number of seeds produced accompanied with long seed viability and adaptability to disseminate by wind (*Orobanche*, *Cistanche*, and *Cynomorium*), animals or birds (*Loranthus*, *Viscum* and *Osyris*), or crop infested seeds (*Cuscuta*, *Orobanche* and *Thesium*) added more complications to control methods. The interrelationship and the way they connect to host plants through the absorptive organs (suckers or haustoria) are another means through which they challenge control measures. Morphological and physiological similarities between these and their hosts and the ability of certain species to develop additional shoots from epicortical roots or embedded haustoria (*Cuscuta* spp.) especially after damage to or removal of the primary shoot (*Viscum* and *Loranthus*) hinder pruning and herbicide use as a common method of control.

The aim of this study was to: (1) survey parasitic flowering plants of cultivated crops in Jordan; (2) familiarize agriculturist with the threat these species exert on agriculture; and (3) quantify the significant changes that have occurred on these species distribution, and hosts.

This paper introduces an update on information and findings on species of parasitic weeds, their hosts and possible management

MATERIALS AND METHODS

Field studies were carried out during the period from 2003 to 2009 at which parasitic flowering species and their hosts were recorded throughout the country. During the survey, parasitic species were identified and recorded with their hosts from cultivated species. Visual estimation was considered to quantify the severity and intensity of infestation on different host species and in the total area surveyed using a scale of light, moderate and high for intensity of infection and another scale of rare, limited, sporadic, common, and very common to indicate prevalence in the total area of the country. All parasitic species were photographed with their hosts.

RESULTS

Prevalence and host status on parasitic weeds in Jordan

Parasitic weeds and their hosts from cultivated species found in different biogeographical regions of Jordan as listed in Table-1. Results showed the presence of 8 genera including *Cuscuta* (6 species) attacking 41 cultivated species of 19 families, *Loranthus* (1 species) attacking 14 species from 8 plant families, *Orobanche* (7 species) parasitizing 55 cultivated plant species belonging to 19 families, *Cistanche* (3 species) attacking 9 species from 8 families, *Viscum* (1 species) attacking 7 cultivated species of 4 plant families, *Osyris* (1 species) attacking 10 cultivated hosts from 8 families, *Thesium* (1 species) attack 2 crop species of monocot plant families and *Cynomorium* (1 species) on 2 cultivated species of the same family. However, many of the reported hosts were attacked by more than one parasitic species. Among the recorded parasitic weeds, it appeared that *Cuscuta* and *Orobanche* were the most common on field crops (mainly vegetables) in different biogeographical regions, while *C. campestris* and *O. ramosa* were most spread species. Results showed that different plant species from cultivated plants of different plant families were attacked by these parasites. There is a great potential for *Cuscuta* and *Orobanche* to infest more agricultural lands due to their wide host range from wild species or common weeds. *Loranthus*, *Viscum*, *Cistanche* and *Osyris* species appeared restricted to shrubs, fruit and forest trees, while certain species of *Orobanche* (*cernua*, *palaestina, ramos*a, and *schultzii*) were found parasitizing fruit trees as well as herbaceous plants. Results revealed that a wide host range of plants of different economic importance are parasitized and infestation on certain hosts is quite severe. It has been also shown that many of the common wild species served as hosts for certain noxious parasites (*Orobanche* and *Cuscuta*) giving these a survival strategy to exist and tolerate control measures.

Table-1. Parasitic flowering plants, their families, host intensity of infectionandprevalence in Jordan for the period 2003-2009.

Parasitic species/host	Family	Intensity of infection	Prevalence*
Cuscutaceae			
Cuscuta			
***Cuscuta campestris* Yuncker**			
Allium cepa L.	Liliaceae	Moderate	Common
Allysum maritima (L.) Desv.	Crucifereae	Moderate	Rare
Beta vulgaris Music	Chenopodiaceae	Moderate	Rare
Cicer arietinum L.	Leguminosae	Moderate	Common
Cichorium inthybus L.	Compositae	Light	Common
Citrullus vulgaris Schrad.	Cucurbitaceae	Light	Rare
Corchorus olitorius L.	Tiliaceae	High	Very common
Coriandrum sativum L	Umbelliferae	High	Common
Cucumis melo L	Cucurbitaceae	Light	Rare
Daucus Carota L.	Umbelliferae	Moderate	Common
Duranta plumieri Jacq	Verbenaceae	Moderate	Rare
Foeniculum vulgare Mill.	Umbelliferae	Light	Common
Fragaria vesca L.	Rosaceae	Light	Rare
Lactuca sativa L.	Compositae	High	Common

Lens esculentus (L.) Moench	Leguminosae	High	Rare
Lycopersicon esculentum Mill	Solanaceae	Moderate	Common
Medicago sativa L.	Leguminosae	High	Very common
Mentha viridis L.	Labiatae	Moderate	Rare
Ocimum basilicum L.	Labiatae	Light	Rare
Olea europea L.	Oleaceae	Light	Rare
Origanum syriacum L.	Labiatae	High	Rare
Pelargonium zonale (L.) Aiton (N)	Geraniaceae	Moderate	Rare
Petroselinum sativum Hoffm.	Umbelliferae	Light	Common
Phaseolus vulgaris L.	Leguminosae	Moderate	Rare
Solanum melongena L	Solanaceae	High	Common
Solanum tuberosum L	Solanaceae	Light	Rare
Thymus syriaca Boiss.	Labiatae	High	Rare
Trifolium alexandrium L.	Leguminosae	High	Very common
Triticum durum Desf.	Graminae	Moderate	Rare
Vigna sinensis (L.) Savi ex Hassk.	Leguminosae	Moderate	Rare
*Vinca major*L. (N)	Apocynaceae	High	Rare
Vitis vinifera L.	Vitaceae	Moderate	Common
***Cuscuta epilinum* Weihe**			None
***Cuscuta epithymum* (L.) L.**			
Nicotiana tabaccum L.	Solanaceae	High	Common
Thymus capitatus (N)	Labiatae	High	Rare
***Cuscuta indecora* Choisy**			None
***Cuscuta monogyna* Vahl**			
Allium cepa L.	Liliaceae	High	Common
Casuarina equisetifolia L.	Casuarinaceae	Light	Rare
Cicer arietinum L.	Leguminosae	High	Common
Citrus maxima Merr.	Rutaceae	Light	Rare
Citrus aurantifolia Swingle	Rutaceae	Moderate	Very common
Citrus deliciosa Ten.	Rutaceae	High	Common
Citrus limon (L.) Burm.	Rutaceae	High	Very common
Citrus paradisi Macf.	Rutaceae	Moderate	Rare
Malus domestica Borkh.	Rosaceae	High	Rare
Olea europea L.	Oleaceae	Light	Common
Origanum syriacum L.	Labiatae	High	Rare
Solanum melongena L	Solanaceae	High	Rare
Triticum durum Desv.	Gramineae	Light	Rare
Vitis vinifera L.	Vitaceae	High	Common
***Cuscuta planiflora* Ten.**			
Amygdalus communis L.	Rosaceae	Light	Rare
Trifolium alexanderinum L.	Leguminosae	Light	Common
Loranthaceae			
Loranthus			
Loranthus acaciae			
Acacia arabica (Lam.) Willd	Leguminosae	Light	Rare

Acacia asak (Forssk.) Willd.	Leguminosae	Light	Rare
Acacia cyanophylla L.	Leguminosae	Light	Rare
Acacia farnesiana (L.) Willd.	Leguminosae	Moderate	Common
Casuarina equisetifolia L. ex J.R. & G. Forst	Casuarinaceae	High	Very common
Ficus carica L.	Moraceae	Moderate	Common
Juglans regia L.	Juglandaceae	Light	Rare
Melia azedarach L.	Meliaceae	High	Rare
Parkinsonia aculeata L.	Leguminosae	Moderate	Common
Pistacia vera L.	Anacardiaceae	Light	Rare
Poinciana gilliesii Wallich ex Hook.	Leguminosae	High	Common
Punica granatum L.	Punicaceae	Moderate	common
Retama raetam (Forssk.) Webb & Berthel	Leguminosae	High	Very common
Zizyphus jujuba Mill.	Rhamnaceae	High	Common
Viscaceae			
Viscum			
Viscum cruciatum			
Amygdalus communis L.	Rosaceae	High	Very common
Olea europaea L.	Oleaceae	High	Very common
Prunus armeniaca L.	Rosaceae	Light	Rare
Prunus cerasifera Ehrh.	Rosaceae	Light	Rare
Prunus domestica L.	Rosaceae	Light	Rare
Punica granatum L.	Punicaceae	High	Very common
Retama raetam (Forssk.) Webb & Berthel	Leguminosae	High	Common
Orobanchaceae			
Orobanche			
***Orobanche ramosa* L.**			
Allium cepa L.	Liliaceae	Light	Rare
Anethum graveolens L.	Umbelliferae	Light	GH
Apium graveolense L.	Umbelliferae	Moderate	GH
Brassica oleracea L. var. *botrytis*	Cruciferae	Light	Limited
Brassica oleracea L. var. *Capitata*	Cruciferae	Light	Limited
Brassica oleracea L. var. *Caulorapa*	Cruciferae	Moderate	GH
Calendula officinalis L.	Compositae	High	Rare
Capsicum annum L.	Solanaceae	Moderate	Sporadic
Capsicum fruitisence L.	Solanaceae	Moderate	Limited
Carthamus tinctorius L.	Compositae	Moderate	Rare
Citrullus vulgaris Schrad.	Cucurbitaceae	Light	Rare
Coleous blumei Benth.	Labiatae	Light	Rare
Coriandrum sativum L.	Umbelliferae	Light	Sporadic
Cucumis melo L.	Cucurbitaceae	Light	Limited
Cucumis melo L.var. *flexosus*	Cucurbitaceae	Light	Rare

Cucumis sativus L.	Cucurbitaceae	Light	Common
Cucurbita pepo L.	Cucurbitaceae	High	Very common††
Dahlia pinnata Cav.	Compositae	Light	Rare
Daucus carota L.	Umbelliferae	Light	Limited
Dianthus caryophyllus L.	Caryophyllaceae	Light	Rare
Eriobotrya japonoca Lindl.	Rosaceae	Moderate	Rare
Foeniculum vulgare Mill.	Umbelliferae	High	Common
Gazania splendens Kiss. Mix.	Compositae	Moderate	Rare
Lactuca sativa L.	Compositae	High	Common
Lens culinaris Medik.	Leguminosae	High	Limited
Lepidium sativum L.	Cruciferae	Light	Limited
Linum usitatissimum L.	Linaceae	Light	GH
Lycopersicon esculentum Mill.	Solanaceae	High	Very common
Matthiola annua (L.) Sweet	Cruciferae	Moderate	GH
Medicago sativa L.	Leguminosae	Light	Rare
Mesebryanthemum sp.	Aizoaceae	Light	GH
Nicotiana tabaccum L.	Solanaceae	Light	Limited
Ocimum basilicum L.	Labiatae	Light	Sporadic
Pelargonium grandiflorum (Andrews) Willd.	Geraniaceae	Light	Rare
Pelargonium zonale (L.) Aiton	Geraniaceae	Moderate	GH
Petonia hybrida Vilm	Solanaceae	Moderate	GH
Punica granatum L.	Punicaceae	Light	GH
Rosa damascena Mill.	Rosaceae	Light	GH
Salvia splendens Sellow ex Roem. & Schult	Labiatae	Moderate	GH
Solanum melongena L.	Solanaceae	High	Common
Solanum tuberosum L.	Solanaceae	Moderate	Common
Thunbergia alata Bojer ex Sims	Acanthaceae	Moderate	GH
Thymus syriaca Boiss.	Labiatae	Moderate	GH
Trifolium pratense L.	Leguminosae	Moderate	Common
Tropaeolum majus L.	Tropaeolaceae	Moderate	GH
Vicia faba L.	Leguminosae	High	Very common
***Orobanche aegyptiaca* Pers.**			
Brassica oleracea L. var.*capitata*	Cruciferae	Moderate	Limited
Lactuca sativa L.	Compositae	High	Common
Lycopersicon esculentum Mill.	Solanaceae	High	Very common
Pelargonium grandiflorum L.	Geraniaceae	Light	GH
Prunus persica (L.) Batsch	Rosaceae	Light	Sporadic
Solanum melongyna L.	Solanaceae	High	Common
Solanum tuberosum L.	Solanaceae	High	Limited

Vicia faba L.	Leguminosae	Light	Limited
***Orobanche cernua* Loefl.**			
Amygdalus communis L.	Rosaceae	High	Limited
Cucumis melo L.	Cucurbitaceae	Moderate	Limited
Daucus carota L.	Umbelliferae	Moderate	Common
Ficus carica L.	Moraceae	Moderate	Limited
Helianthus annuus L.	Compositae	Light	Rare
Lycopersicon esculentum Mill.	Solanaceae	High	Very common
Nicotiana tabaccum L.	Solanaceae	High	Very common
Olea europaea L.	Oleaceae	Light	Limited
Petunia hybrida Vilm	Solanaceae	Light	GH
Prunus armeniaca L.	Rosaceae	Moderate	Rare
Prunus persica (L.) Batsch	Rosaceae	Light	Sporadic
Punica granatum L.	Punicaceae	Light	GH
Quercus coccefera L.	Fagaceae	Light	Limited
Solanum melongyna L.	Solanaceae	High	Limited
Solanum tuberosum L.	Solanaceae	Light	Common
Salvia splendens	Labiatae	High	GH
Vicia faba L.	Leguminosae	Light	Common
***Orobanche crenata* Forskl.**			
Daucus carota L.	Umbelliferae	High	Very common
Lycopersicon esculentum Mill.	Solanaceae	High	Very common
Pisum sativum L.	Leguminosae	High	Limited
Vica faba L.	Leguminosae	High	Very common
***Orobanche palaestina* Reut.**			
Amygdalus communis L.	Rosaceae	Moderate	Sporadic
Daucus carota L.	Umbelliferae	Light	Rare
Olea europaea L.	Oleaceae	High	Rare
***Orobanche minor* Sm.**			
Daucus carota L.	Umbelliferae	Moderate	Very common
Vicia faba L.	Leguminosae	Moderate	Common
***Orobanche schultzii* Mutel**			
Amygdalus communis L.	Rosaceae	Moderate	Limited
Olea europaea L.	Oleaceae	High	Limited
Prunus armeniaca L.	Rosaceae	High	Limited
Prunus cerasifera Ehrh.	Rosaceae	High	Limited
Cistanche			
Cistanche lutea (Desf.) Hoffmanns and Link			
Haloxylon persicum	Chenopodiaceae	Moderate	Limited
Cistanche tubulosa (Schrenk) Hook			
Acacia cyanophylla L. (NC)	Leguminosae	Light	Rare
Casuarina equisetifolia L. ex J.R. and G. Forst	Casuarinaceae	Light	Limited

Eucalyptus camaldulensis Dehnh. (NC)	Myrtaceae	Moderate	Rare
Olea europaea L. (NC)	Oleaceae	Light	Rare
Opuntia ficus-carieca L. (NC)	Cactaceae	Moderate	Rare
Pinus sp. (NC)	Pinaceae	Moderate	Rare
Punica granatum L.	Punicaceae	Light	Rare
Trifolium pratense L.	Leguminosae	Light	Common
***Cistanche salsa* (C.A. Mey.) Benth. et Hook.**			
Haloxylon persicum	Chenopodiaceae	Moderate	Limited
Santalaceae			
Osyris			
Osyris alba			
Acacia cyanophylla Lindl.	Leguminosae	Moderate	Limited
Amygdalus communis L.	Rosaceae	High	Moderate
Casuarina equisetifolia L.**	Casuarinaceae	Moderate	Rare
Cupressus sempervirens L. *var. horizontalis* (Miller) Gordon	Cupressaceae	High	Sporadic
Cupressus sempervirens L. *var. pyramidalis* Nyman	Cupressaceae	High	Sporadic
Ficus cariaca L.	Moraceae	Moderate	Rare
Olea europaea L.	Oleaceae	High	Sporadic
Pinus halepensis Mill.	Pinaceae	Light	Sporadic
Prunus domestica L.	Rosaceae	Moderate	Limited
Retama raetam (Forskal) Webb & Berth	Leguminosae	Moderate	Rare
Vitis vinifera L.	Vitaceae	High	Moderate
6. Cynomoriaceae			
Cynomorium			
Cynomorium coccineum			
Atriplex leucoclada	Chenopodiaceae		High
Haloxylon persicum	Chenopodiaceae	Moderate	Limited

* Rare: only on few plants in 1-2 sites of a biogeographical region; Sporadic: few plants infected in one or more biogeographical regions; Limited: on many plants localized in certain locations of 1 or 2 biogeographical regions; Common: on certain plant species in > one biogeographical regions; Very common: on many plant species in different locations of different biogeographical regions; GH: in glasshouses; NC: attachment was not confirmed.

Managements of Parasitic Flowering Plants in Jordan

Surveys of control management methods of parasitic flowering plants in Jordan are generally traditional/primitive or absent for certain parasitic genera. However, farmers' practices in controlling these parasites are shown in Table-2. For most species hand removal is widely practiced in different locations. A combination of more than one method of control is commonly followed against certain genera (e.g. *Orobanche* and *Cuscuta*), while hand removal and pruning are both used for mistletoes control. In contrast, hand pulling is the only operation practiced against *C. coccineum* while farmers are not familiers with *O. alba* as a parasitic species. Application of soil solarization followed by plastic mulching of the solarized soil and application of chicken manure and\or ammonium sulphate or urea fertilizers are common practices in the Jordan Valley location and may be in other regions. These practices have effectively restricted the infestation and abundance of *Orobanche* spp. and to a less extent *Cuscuta* infestation to vegetable crops. However, soil plastic mulching can be also applied in certain fruit tree orchards. This however, is under experimentation at present while the application of animal manure and straw mulch is a common traditional practice followed by farmers in different regions which may lower infestation by certain root parasitic species (mainly *Orobanche).*

Control of other parasitic species is still at infancy. Mistletoes are usually pruned at later stages and hand removed at earlier phase of infestation. However, the second practice is not effective in most cases since these parasites can revegetate from the inserted suckers inside their hosts and difficult to adopt against *Loranthus* because of many epicortical roots extended on the host stem surface. Herbicide application for control of these parasites is completely absent. *O. alba* control is not practiced by any mean except removal through tillage or by the hoe without any previous knowledge of the farmers on this parasite.

Control of *Cynomorium* and *Cistanche* spp. is mainly practiced through hand-removal of both parasites in different regions while farmers are not enough concerned on losses resulted from these parasites since they mostly attack forage plants and wild shrubs in the desert.

Natural enemies of some parasites may play an important role in their control although no studies on these were conducted under local conditions. The present survey revealed that some of the parasites are attacked by different insects. The larvae of *Thrips* sp. was found in seed capsule (*C. tubulosa*), in the stem of *O. schultzii*, or on leaves and branches of *V. cruciatum* (*Ceroplastes rusci*). Al-Khesraji *et al.* (1987) reported that different natural enemies attacked *Cynomorium* and *Cistanche* spp. in southern desert of Iraq including *Tropinota squalida* attacking species of both genera, *Aphis gossypii* on *Cistanche* spp., larvae of *Eumerus* spp. and those of Lepidoptera (Fam. Sesiidae) on both genera and the larvae was found very effective on *Cynomorium*. *Phytomyza orobanchia* Kaltenbach [Diptera: Agrornyzidae] was also found in the capsules of certain *Orobanche* species. In addition, the same parasitic species were found attacked by different fungi.

Managements of Parasitic Weeds in other Parts of the World

Managements of parasitic species reported from different parts of the world are many and varied but these are still limited in effetivenes and magnitude. However, most recent reported methods are summarized below and for different parasitic genera (Qasem, 2006), viz. (i) the use of natural enemies including *Fusarium* and *Trichoderma, Phytomyza* for *Orobanche*; *Smicronyx* sp. and fungal species for *Cuscuta;* (ii) use of herbicides mainly glyphosate for *Orobanche* control in fababean and different sulfonylurea herbicides for other species (e.g. *O. aegyptiaca* and *O. ramosa* in tomato); (iii) soil solarization and plastic mulch for *Orobanche* and *Cuscuta* species; (iv) plant residue and natural products allelopathy (e.g. for *Orobanche*, root extracts (sunflower), Plant oils (gingelly, groundnuts, palm, sunflower, safflower, castorbean, linseed, neem, coconut or tobacco seed oils, niger (*Guizotia abyssiniaca*), and mustard oils, orobanchol and alectrol germination stimulants, Different strains of *Streptomyces,* certain fungal metabolites including cotylenins and fusicoccins; (v) trap and catch species in crop rotation or intercropping; (vi) genetically engineered crops (herbicide resistant); (vii) plastic mulch with fertilizers (chicken manure, urea, ammonium sulphate); (viii) resistant cultivars for different crop species and screening studies on tolerant/resistant crop lines; (ix) mowing and general contact herbicides for *Osyris* and *Cuscuta* (early infestation in perennial field crops) species control; (x) pruning and shading for mistletoes control; (xi) selective application of MCPA and 2, 4-D for mistletoes control,; and (xii) integrated control

DISCUSSION

Parasitic flowering plants or parasitic weeds represent a real threat and challenge to farmers worldwide (Riches and Parker, 1993) mainly because of difficult control and poor management under field conditions. Difficulty in controlling these species is mainly due to the huge number of seeds they produce, the extended seed longevity of certain species (e.g. *Orobanche*), the wide host range they attack from both cultivated and wild grown species (Qasem, 2006; Qasem and Foy, 2007) the ease of seeds and/or fruits dispersal by different means of specialized or non-specialized agents. In addition, the nature of physiological, anatomical and/or morphological interrelations between parasitic species and their hosts that allows their germination and growth at different time and place and make the control job more difficult and sometimes far reaching. The absence of any suitable and effective method of control including selective and effective herbicides is another obstacle should be added to the problems that these species have in cultivated lands.

Table-2. Managements of parasitic weed control by local farmers in Jordan.

Method of control	*Cuscuta* spp.	*C. coccineum*	*O. alba*	*V. cruciatum*	*L. acaciae*	*Cistanche* spp.	*Orobanche* spp.	*C. coccineum*	*O. alba*
Hand pulling/removal	+	+	-	+	+	+	+	+	-
Hoeing	+	-	-	-	-	+	+	-	-
Soil solarization	+	-	-	-	-	-	+	-	-
Planting date	+	-	-	-	-	-	+	-	-
Root-stocks/Grafting	-	-	-	-	-	-	+	-	-
Plastic mulch	+	-	-	-	-	-	+	-	-
[(N-fertilizers) NH_4 $2SO_4$, Urea, Chicken manure]	+	-	-	-	-	-	+	-	-
Intercropping	-	-	-	-	-	-	+	-	-
Pruning	-	-	-	+	+	-	-	-	-
Soil applied herbicides	≈	-	-	-	-	-	≈	-	-
Foliage applied herbicides	-	-	-	-	-	-	-	-	-

+ = Effective, - = Ineffective

The present survey showed that the main and serious well known destructive parasitic species are available in Jordan, and there is a huge number of host species accommodate their parasitism and spread. While certain parasitic species appeared highly confined to fruit or forest trees, others infest field crops, herbs as well as fruit and forest species. This high variability in host range reflects high physiological tolerance of these species to different hosts. In the other hand, certain species require host stimulants (e.g. *Orobanche*) appeared with a wide host range reflecting their ability to stimulate seed germination and to break parasites seed dormancy. This however, may have an ecological implication in any control program of these parasites. Overall situation, it appears that all kind of vegetation in Jordan are under threat of different parasitic species and there is a great potential for these to spread and invade new regions in the country in absence of any attempt to stop or restrict their hosts and agents. During the survey it was found that many of the wild plant species were attacked by one or more parasitic species emphasizing the role these have in disseminating parasitic plants and the importance of weed control in any well managed control program. It is also shown that certain species attack fruit trees are confined to high lands (e.g. *Osyris alba*) while others (*Loranthus* and *Viscum*) are spreading in different biogeographical regions, which may indicate the role of environmental conditions in distribution and prevalence of these species in different regions and the differences in their ecological tolerance.

Parasitic species are different in the number of host plants they attack which is normal since certain species are highly specific while others are not. However, it is clearly shown that certain strategic crops such as olives, almonds and grapes are highly threaten by different parasitic genera. In addition certain parasites require stimulants for germination while this is not required for other species. It is well documented that chemical, physiological, anatomical and probably other factors are important factors in the compatibility between parasites and their host, in addition environmental factors are another constrain limiting factor of their distribution. It is worth indicating that this survey although covered most of the country area but probably more species of more or less importance are available. However, there is clear trend toward great potential of parasitic species to spread and to infest new areas and new hosts in absence of any awareness of the local farmers with the problem or the complete absence of any control measures and the situation deserve more studies and attention.

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WEED FLORA OF *Curcuma longa* FIELDS OF DISTRICT KASUR, PAKISTAN

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ABSTRACT

District Kasur, Punjab, Pakistan shares more than 80% of turmeric production. Survey of fields from twenty six localities of the district were undertaken during two successive years to study the distribution of weed species in turmeric (Curcuma longa L.) fields. A total of fourteen weed species belonging to 8 angiosperm families, were recorded in the fields of turmeric. Sonchus aspera L., Chenopodium album L., Rumex dentatus L., Ageratum conyzoides L. Convolvulus arvensis L., Cynodon dactylon (L.) Pers., Oxalis corniculata L., Malva parviflora L., Malvastrum coromandelianum L., Trifolium resupinatum L., Euphorbia prostarta L. and Phalaris minor Retz., were found to be the most prevalent weed species occurring in 90% or more studied areas during one or the other growing season. The frequently occurring weeds with absolute frequency of above 80% were C. album L., M. cromandlianum L. and C. dactylon. Other densely populated weed species with higher absolute density were A. conyzoides, C. arvensis, E. prostrata and C. dactylon. The study highlighted the need to manage weed in order to realize higher turmeric yields.

Key words: Turmeric (*Curcuma longa*), weeds, Kasur, Pakistan, survey.

INTRODUCTION

Turmeric is a root crop of Zingiberaceae propagated by rhizomes. It is one of the most important medicinal plants due to its antioxidant properties and protective powers for our health (Majeed *et al.,* 1995). Curcumin and volatile oils in the rhizome of turmeric are known to prevent cancer diseases, tumors and the production of free radicals, and to improve liver and kidney functions (Hermann and Martin, 1991) found antibacterial activities of essential oils in *Curcuma longa* L. It has been used for a long time in Bangladesh, India, Myanmar, Pakistan, Sri Lanka and Thailand as a spice, cosmetic and medicine. Recently, it is used worldwide as a spice and natural medicine (Hermann and Martin, 1991).

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Studies on emergence pattern, growth and development of a plant species as influenced by edaphic factors are important for better production (Hossain, 1999; Ghorbani *et al*., 1999). It is essential to plant a root crop at the proper planting depth to obtain a higher yield, because soil type, bulk density and soil ecological factors affect the growth and development of rhizomes and tubers (Aoi, 1988; Hossain, 1999; Peng, 1984)

Agriculture plays an important role in the economy of Pakistan. It contributes up to 25% in the national GDP (Anonymous, 2007.). Agriculture sector is mainly confined to the cultivation of major crops as wheat, rice, cotton and sugar cane. The presence of weeds in the fields and their impact on the crop production and environment has been well documented (Morse *et al.,* 1995; Randall, 1996; Fröhlich *et al.,* 2000; Hassan and Marwat, 2001)

Weeds are the main problem with turmeric (*Curcuma longa* L.) cultivation where herbicides are not used. This is because herbicides cause water contamination, air pollution, soil microorganism hazards, health hazards, and food risks. Considering turmeric's medicinal value and the environmental problems caused by herbicides, various agronomic practices have been evaluated for non-chemical weed control in turmeric (Hossain, 2005).

Weed surveys are useful for determining the occurrence and importance of weed species in crop production systems (Frick and Thomas, 1992). Documenting the kinds of weed species and its relative distribution facilitates the establishment of priorities for research and extension services (McClosky *et al.,* 1998). A survey was conducted in Lahore district to highlight the distribution of different weed species in Gladiolus fields (Riaz *et al.,* 2007).

MATERIALS AND METHODS

Field Surveys

Field surveys of different turmeric growing areas in district Kasur Pakistan were conducted during the growing season of December 2009-January 2010. Twenty six localities in district Kasur were selected i.e. Atari Karm Singh, BakerKe, Usmanwala, Jajjar, Akkike, Kanganpur, Lande, Saresar, MoujeKe, Bahigiwal, Dhatte, Muqam village, Macchina, Mustuwal, Arzani Pur, Atri Wirk, Khuddian Khas, Muhammadi Pur, Laddi, Wiram, Wan Khara, Sham Kot Nuth, Wirk Nau, Burj Ran Singh, Singh Wala and Biya for study of weed distribution. Sampling was done randomly using 1×1 m^2 quadrat. Data regarding prevalence, absolute and relative frequency, and absolute and relative density of weeds were recorded by applying the following formulae (Riaz *et al.,* 2007).

$$\text{Absolute frequency (AF) (\%)} = \frac{\text{Number of quadrates in which species occurs}}{\text{Total number of quadrates}} \times 100$$

$$\text{Relative frequency (RF) (\%)} = \frac{\text{Absolute frequency value for a species}}{\text{Total absolute frequency values for all species}} \times 100$$

$$\text{Absolute density (AD)} = \frac{\text{Total number of individuals of all species in all quadrates}}{\text{Total number of quadrates}}$$

$$\text{Relative density (RD) (\%)} = \frac{\text{Absolute density for a species}}{\text{Total absolute density for all species}} \times 100$$

RESULTS AND DISCUSSION

In the present study fourteen weed species belonging to eight angiosperm families were found growing in turmeric fields of District Kasur, belonging to family Asteraceae, Poaceae Chenopodiaceae, Euphorbiaceae, Ranunculaceae. Brassicaceae, Malvaceae and Solanaceae contained one species each.

Only one species (*Chenopodium album*) found in all the twenty six fields showing 100% prevalence, *Rumex dentatus* and *Sonchus aspera* species were found in 90% prevalence. Three species namely *Euphorbia prostrata, Phalaris minor, Ageratum conyzoides* and *Malvastrum coromandelianum* exhibited 80% prevalence each (Table-1).

Rumex dentatus with 60% absolute frequency (AF) and 7.5% relative frequency (RF) was found to be the most frequently occurring weed followed by *Anagallis arvensis* and *Trifolium resupinatum* with 50 % AF and 6.25 % RF each. Other frequently occurring species were *Convolvulus arvensis, Malva parviflora, Cirsium arvense, Oxalis corniculata* were also found. The least frequently occurring species with AF of 20% was *Parthenium hysterophorus* (Table-1).

Weed emergence and interference are not affected by planting depth, seed size, planting pattern, planting space, ridge spacing, and the row number of turmeric until 60days after planting. This is because turmeric cannot develop a canopy structure until then. Thereafter, weed infestation reduces similarly and significantly when turmeric is planted at depths of 8, 12, and 16cm, compared to shallower depths. The yield of turmeric at these depths is statistically the same, but the yield for the 16cm depth is difficult to harvest and it tends to decrease. Turmeric grown from seed rhizomes (daughter rhizomes) weighing 30-40g reduces weed infestation significantly (Hossain, 2005). Since this is the first report of weed distribution in turmeric fields in Pakistan so the quality and yield losses in turmeric due to infestation of these weeds are not known. However, the frequently occurring species viz. *R. dentatus*, *A. arvensis, M.*

coromandelianum, *C. arvensis* and *M. parviflora* are also found in other crops especially in wheat where they are known to cause heavy yield losses due to competition for nutrients, water, and space and sometimes through the release of allelochemicals (Rabbani and Bajwa, 2001). In the present study *P. hysterophorus* was found only with 20% AF and 2.5 % RF (Table-1). However being an invasive weed, it is most likely that in future this aggressive alien weed may become one of the problematic weed due to its high reproductive potential, fast growth rate and allelopathic nature (Dagar *et al.,* 1976; Navie *et al.,* 1996; Singh *et al*., 2005) and suitable field conditions as turmeric is cultivated on ridges with sufficient plant to plant distance.

A. conyzodies and M. coromandelianum were found to be the most densely populated weed with 1.33 plants m^{-2} and a relative density (RD) of 10 (Table-1). These are also of major concern in various crops of economic importance including wheat in India and Pakistan (Chhokar *et al.,* 2007; Anjum and Bajwa, 2007; Mehmood *et al.,* 2007).

The present study reveals that turmeric fields are infested with many well known problematic weed species especially *C. album, C. arvensis, P. hysterophorus, C. arvensis, M. coromandelianum and R. dentatus* which are well known for their adverse impacts on crop growth and productivity as well as quality of the produce. There is an urgent need to take necessary intervention to create awareness among the farmers for adopting integrated weed management strategies to improve and maintain the quality and yield of turmeric.

Table-1. Absolute frequency (AF), Relative frequency (RF), Absolute density (AD) and Relative density (RD) of weeds in turmeric fields in District Lahore, Pakistan.

Weeds	A.F %	R.F %	A.D	R.D%
Sonchus aspera	70	8.75	0.7	7.95
Chenopodium album	80	10	0.7	7.95
Rumex dentatus	60	7.5	0.6	6.8
Ageratum conyzoides	80	10	0.8	9.09
Convolvulus arvensis	70	8.75	0.7	7.95
Cynodon dactylon	80	10	---	---
Oxalis corniculata	60	7.5	0.6	6.8
Malva parviflora	70	7.5	0.7	7.95
Malvestrum cromandlianum	80	10	0.8	9.09
Euphorbia prostarta	80	10	0.8	9.09
Anagallis arvensis	50	6.25	0.5	5.68
Trifolium resupinatum	50	6.25	0.5	5.68
Phalaris minor	70	8.75	0.7	7.95
Cirsium arvense	60	7.5	0.8	9.09
Parthenium hysterophorous	20	2.5	0.2	2.8

A.F % = Absolute Frequency %, R.F % = Relative Frequency %
A.D. = Absolute Density, R.D. % = Relative Density %

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