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A survey of rice farmers' farming practices posing threats to insect biodiversity of rice crop in the Punjab, Pakistan

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During a survey and through face to face interviews of rice farmers, their attitudes and substandard farming practices were investigated as threats to insect biodiversity associated with rice crop agroecosystem. Excessive and increasing use of agrochemicals (78.7%) and rice straw burning (68%) along with animal grazing were explored as major threats. Rational use of agrochemicals and legislation about bans of rice straw burning and cattle grazing in harvested rice fields were proposed.

Key words: Insect biodiversity, rice farmers, straw burning, animal grazing.

INTRODUCION

Rice is the second major cereal food and cash crop of Pakistan after wheat (Siddiqui et al., 2007). It is grown on an area of 2 million hectares chiefly in the Punjab and Sindh followed by Khyber Pukhtoon Khwa (KPK) and Balochistan (Anonymous, 2003, 2007). In the province of the Punjab, there is a special rice area called "Kallar tract" well known all over the world for fine aromatic "Basmati" rice production. In this area, biodiversity associated with agro ecosystem is reported to be declining (Ahmad and Iram, 2006).

According to the biodiversity productivity hypothesis, the biologically diverse systems are more productive, functional and sustainable (Fernandez, 2005). In order to achieve sustainability in agriculture through integrated farming systems, there is a need to maintain and conserve biodiversity. Although, the practices like poor management of natural resources, grazing, fire, mono-culture, extensive use of pesticides, inappropriate farming practices, ecological degradation and socio-economic status are the main threats to biodiversity (Anonymous, 2001a, 2012; MFSC, 2000).

Farmers are the custodians of biodiversity and their management and farming practices can help to estimate the health and diversity of a farming system (Anonymous, 2001b; Wood and Lenne, 1999).

Therefore, the present study was undertaken in the traditional rice growing area of Kallar tract to investigate the rice farmers' practices which are potential threats to the insect biodiversity associated with this system.

MATERIALS AND METHODS

The survey was conducted in the Kallar tract spreading over the boundaries of three districts: Sialkot, Gujranwala and Sheikhupura Figure 1. A preliminary survey was made by meeting with farmers to develop a questionnaire with suitable information about farming practices.

During the survey, face-to-face interviews of 150 farmers,

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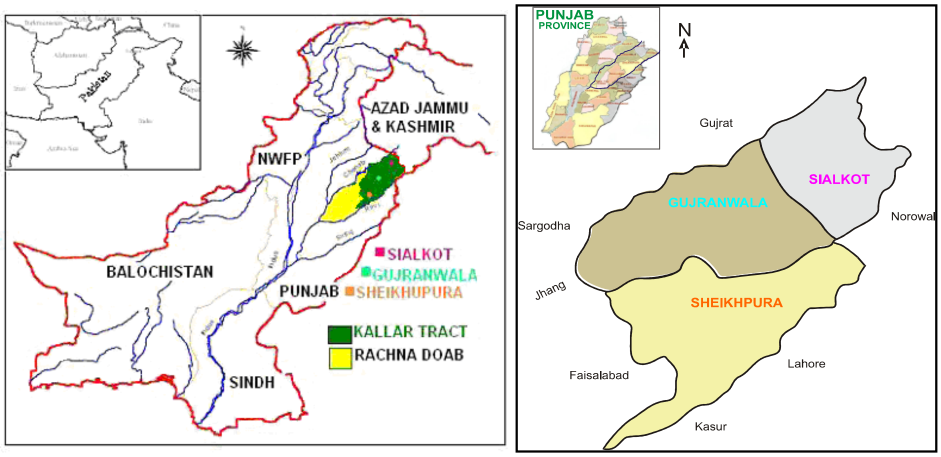

Figure 1. Maps (a) Kallar tract (b) Research localities in the Kallar tract. Source: Suhail et al. (2007)

Table 1. Educational level and age groups of the farmers in sampled area.

Educational level of the farmers			Different age groups of the farmers		
Educational level	**Frequency**	**Percentage**	**Age groups**	**Frequency**	**Percentage**
Illiterate	53	35.3	Young (up to 30 years)	22	14.7
Up to Middle (8 years)	74	49.3	Middle aged (30-45 years old)	48	32.0
Matriculation and higher (10 years or more)	23	15.3	Old (above 45 years)	80	53.3

choosen at random, were conducted in co-operation with Agricultural Extension and Plant Protection officers in each district. All interviews were conducted in the afternoon when farmers were mostly available at their farm houses or in their rice fields.

Each interview took about 30 to 60 min. The theme of interviewswas to obtain a clear picture of the farmers' farming practices in their rice crop.

The questions were asked in local (Punjabi) language in simple words and the answers were then translated into English and finally the questionnaire was completed accordingly.

Data analysis

The coded data obtained from the filled questionnaires was entered into Microsoft EXCEL worksheet and analyzed to find out frequencies and percentages of farmers' responses.

RESULS AND DISCUSSION

Socio-economic conditions of the farmers

Socio-economic conditions included educational level, age and land holding of the farmers. They have a strong influence on farmers' perceptions of pests, pesticides and other management practices (Rola and Pingali, 1993). Actually, these conditions are the driving forces leading to the general trends in land use, biodiversity and environmental management. Some important aspects of socio-economic conditions of farmers of the Kallar tract are discussed below.

Educational level of the farmers

Out of the 150 farmers, 35.3% had no formal education, 49.3% had attained education to the middle school level, and 15.3% had undergone matriculation or higher education (Table 1). Previous survey studies also showed similar trend of lower level of education among rice farmers (Mironga, 2005; Sheikh et al., 2006; Heong et al., 2008; Shegun et al., 2002).

As most of the farmers in the study area were either illiterate or had average literacy level, therefore during making policies regarding future of agriculture and farmers training on pest management this factor should be given due importance. This is because it is very difficult to relate ecofriendly pest management techniques to uneducated farmers because illiteracy increases communication barriers. The evidences have also proved strong links between education and agricultural output (Weir, 1999).

Different age groups of the farmers

Among the 150 farmers interviewed, 14.7% were of young

Table 2. Land holding of the surveyed farmers.

Farm size	Frequency	Percentage
Small (< 5 ha)	110	73.3
Medium (5-15 ha)	26	17.3
Big (> 15 ha)	14	9.3

age (up to 30 years), 32.0% were of middle ages (30-45 years old), while 53.3% were older (above 45 years old) (Table 1).

It is clear that most (85.3%) of the farmers in the present survey were above the age of 30 years, which showed that a large number of farmers belonged to middle or old age groups. These results are similar to those of Mironga (2005) and Heong et al. (2008).

These results indicate increasing ages of farmers and the trend of declining number of young and able bodied people towards land farming which is very alarming for the future of agriculture of Pakistan, an agricultural based country. Therefore a new policy for agriculture in Pakistan must address the increasing average age of farmers and discover ways to persuade and encourage young people to choose farming as an occupation (Anonymous, 2002).

Land holding

Most (73.3%) of the farmers had small land holdings (less than 5 hectares), while 17.3% were those having land from 5-15 hectares and 9.3% of the farmers belonged to big land owner category having land more than 15 hectares (Table 2).

These results are similar to those of Mironga (2005) who stated that land holding of the farmers in the study area ranged from 0.5 to 1.5 hectares. However, the results are different from those of Sheikh et al. (2006) who reported that average operational land holdings of the farmers in their study was more than 10 hectares.

To maintain social status, the farmers having big land holding are more careful about plant protection measures and yield losses which ultimately lead to excessive use of agrochemicals (Mukherjee et al., 2006). The present study showed that a sufficient number of the farmers were of medium and big land owners. Therefore, a vigorous pesticides and fertilizers use tendency among them could be expected.

Farmers' attitude and practices of pest management

In this section, average number of application of various pesticides, change in pesticides usage, increase in usage of pesticides, and preference for aerial spray against rice pest insects are reported.

Average number of application of various pesticides

The frequency of insecticides used by the farmers only once was 54.0%, while 45.3% farmers used insecticides twice in single rice crop season. The number of farmers using herbicides once in rice was 88.0 and 6.7% farmers used herbicides either two times or used two types of herbicides at the same time by mixing them or one after the other. The frequency of fungicides used once was found to be 30.7%, while 4.7% farmers used fungicides twice. On the other hand, 0.7, 5.3 and 64.7% of the farmers were those not using insecticides, herbicides and fungicides, respectively, in rice crop (Table 3).

It is evident that the use of pesticides especially of insecticides and herbicides among the rice farmers was very high. This is because the farmers always choose those pest management options which appear best to meet their pest control desires (Rola and Pingali, 1993). Therefore, they mostly rely on pesticides leading to their misuse and overuse (Berg, 2001; Bandong et al., 2002).

The application of fungicides was low as compared to insecticides and herbicides (Table 3). This was probably due to the difficulties associated with their applications. Because at the time of disease incidence, the rice crop usually has nearly reached maturity, it is difficult for a sprayer to work on them, which ultimately encumbers even the need for fungicides.

Change in pesticides usage

The farmers were asked about any change in pesticide usage during the last five years. A large segment (78.7%) of the farmers answered that there was an increase in pesticide usage during this period. On the other hand, 2.7% of farmers claimed that there was decrease, while 4.7% claimed no change in pesticide usage. However, 14.0% farmers did not answer this question (Table 4).

One of the most important findings from this survey is that many farmers increased their use of pesticides. This could be attributed to the farmers' dependence on pesticides as main pest control tactics. Thus, pesticides have dominated the pest management practices of rice farmers. The results of present study are in accordance with those of Berg (2001).

This increasing use of pesticides is very alarming to health of farmers, environment and biodiversity associated with rice crop ecosystem (Berg, 2001; Anonymous, 2012). The education and training in improvement of pest management related information through extension services could be helpful to reduce the farmers' risk aversion and ultimately to reduce their pesticide use.

Increasing use of pesticides

Out of 150 farmers interviewed, 60.7% declared that

Table 3. Average number of applications of various pesticides in rice crop.

Name of pesticide	Once		Two times		Not used	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Insecticides	81	54.0	68	45.3	1	0.7
Herbicides	132	88.0	10	6.7	8	5.3
Fungicides	46	30.7	7	4.7	97	64.7

Table 4. Change in pesticides' usage during the last five years.

Change in use of pesticides			Increased use of pesticides		
Farmer's view	Frequency	Percentage	Name of pesticide	Frequency	Percentage
Increased	118	78.7	Insecticides	91	60.7
Decreased	4	2.7	Herbicides	24	16.0
No change	7	4.7	Fungicides	21	14.0
No response	21	14.0	No response	14	9.3

Table 5. Farmers' preference for aerial spray against rice crop pest insects.

Farmers' response	Frequency	Percentage
Yes	122	81.3
No	8	5.3
No response	20	13.3

there was an increase in insecticide usage. It was followed by increased use of herbicides (16.0%) and fungicide (14.0%) while 9.3% of the interviewed farmers did not respond (Table 4).

The findings are similar to those of Berg (2001) and Dawe (2008). The overall impact from this changed insecticide use patterns is difficult to assess. However, these will most likely have a large impact on shaping the future of rice farming systems (Berg, 2001).

Preference for aerial spray against pest insects of rice crop

A large portion (81.3%) of farmers favoured aerial sprays of insecticides for control of rice pest insects, while only 5.3% of the farmers were against such type of spray programs (Table 5). However, 13.3% farmers did not answer this question.

Chemical applications do pose negative impacts on the populations of beneficial insects, humans and other life forms along with unwanted side effects to the environment (Akhtar et al., 2009; Thomson, 2012). But it is evident that a majority of the farmers were unaware of harmful effects of insecticides to the environment and non-target organisms through aerial sprays.

Substandard farming practices

Besides the above described threats to insect biodiversity, the others as identified during survey were: improper use of fertilizers, undesirable practices of insecticide application, rice straw burning and rice monoculture.

Improper/imbalance use of fertilizers

Among 150 farmers, the farmers not using urea, diammonium phosphate (DAP) and potash were 3.3, 16.7 and 73.3%, respectively (Table 6). The farmers using urea, DAP and potash up to 1 bag/acre were 36.7, 68.0 and 26.7%, respectively. It is also clear that a big segment of the farmers (57.3%) used urea fertilizers @ up to 2 bags/acre. The farmers using DAP @ 2 bags/acre were 15.3%. There was a small portion (1.7%) of the farmers using Urea @ more than 2 bags/acre. However, none of the farmers interviewed was using potash @ 2 or more than two bags per acre.

It is evident that among the other reasons of high attack of diseases and insects, the imbalance use of fertilizers is of utmost important, especially the excessive use of nitrogenous fertilizers, that is, urea and DAP (Table 6).

The high nitrogen application, to get higher yields for more profits and due to more food demands, has increased pest intensities, which demands more pesticides (Heong et al., 1995) which ultimately deteriorates ecosystems. It is estimated that about 60% of fertilizers applied are left behind as residues and pollute the underground water, rivers, lakes and modify soil microbial ecology, by affecting the diversity of soil microflora and fauna (Heong and Escalada, 2005).

Table 6. Fertilizers used by rice farmers.

Amount of fertilizer used @ kg/acre	Urea		DAP		Potash	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
No use	5	3.3	25	16.7	110	73.3
0-50 (1 bag)	55	36.7	102	68.0	40	26.7
51-100 (up to 2 bags)	86	57.3	23	15.3	0	0.0
101-150 (>than 2 bags)	4	1.7	0	0.0	0	0.0

Table 7. Practices of insecticides application.

Farmers' views	Frequency	Percentage
Not use insecticides	1	0.7
After looking pest	70	46.7
After looking damage	20	13.3
After consulting Agriculture Department	14	9.3
Following the neighbour	40	26.7
Routine wise	55	36.7
At ETL	1	0.7

Undesirable practices of insecticide applications

For a better pest control program, the proper timing of application of pesticides is of utmost important. This practice could reduce the costs of pesticides and their application as well as save the environment from these poisons by their inept and heavy-handed applications at improper times. It is clear (Table 7) that only a small fraction (0.7%) of farmers were not using insecticides. But a majority (46.7%) of the farmers applied insecticide just after looking for pests and 13.3% after looking for their symptoms of damage. Only 9.3% farmers consulted the Agriculture Department before using insecticides, while 26.7% were those who applied insecticide after seeing their neighbours doing so or hearing from people that the attack of a certain pest insect has started. The frequency of the farmers using insecticides on calendar/crop-stage base or routine wise schedules was somewhat high (36.7%). Only 0.7% farmers out of 150 were using insecticides at economic threshold level (ETL). Multiple responses were allowed

As farmers mostly remain conscious about yield losses, which could occur as a result of pest insect attack, they applied unnecessary insecticides by just looking for insect pest/damage or on a routine basis which is in agreement with the findings of Heong et al. (1995). The farmers observed these pest insects or their damage not by proper pest scouting methods but by monitoring them during weeding, irrigation and fertilizer application, bund cleaning or while walking along pathways on rice field's bunds.

Many farmers applied insecticides when their neighbour did so. These findings are in accordance with those of Bandong et al. (2002).

A majority of the farmers also applied insecticides just by looking for insects or their damage and ignored ETLs. Actually, farmers had set their own ETLs for rice pest insects (Rajasekaran, 1993) that is, just observing the moths of stem borers and leaf folders or their damage symptoms in rice fields (Bandong et al., 2002; Heong and Escalada, 2005).

The important thing was that the farmers' self made ETLs were always lower than those recommended by researchers. Hence, in most of the cases they applied control measure when it was not needed (Bandong et al., 2002). It means insecticide used among rice farmers was based on perceived needs and perhaps fear, rather than real need and economics of the situation (Mumford and Norton, 1984).

A large proportion of farmers used insecticides on routine wise/calendar base/crop stage basis because farmers innately prefer the simpler crop stage-based insecticide approach. This finding is in accordance with that of Berg (2001).

The results indicate that the insecticides were misused to a greater extent in the Kallar tract. These were the leaf or plant damage symptoms that stimulated the farmers to use insecticides. They believed that this leaf damage could cause yield losses and thus immediate action should be taken to control it, a loss aversion behavior.

This misuse of pesticides is common and may lead to secondary pest problem and can severely affect human health beside deteriorating quality of environment and threatening the biodiversity of the system (Rola and Pingali, 1993). So, there is a dire need to educate farmers about sustainable pest management strategies which are socially acceptable, effective against the target pests only, friendly to environment and economic conditions of the farmers and to motivate the farmers to adopt a 'wait and see' approach.

Rice straw burning

A large number (68.0%) of the farmers burnt rice straw in harvested rice fields, 4.7% ploughed it in the field, 1.3% sold it out to market, while 52.7% feed it to cattle (Table 8). Multiple responses were allowed.

Table 8. Rice straw burning.

Action taken	Frequency	Percentage
Burn	102	68.0
Plough in the field	7	4.7
Sale	2	1.3
Feed to cattle	79	52.7

A large number of rice farmers disposed of rice straw by burning because, after harvesting with combine harvesters, it was difficult for them to collect half cut and scattered straw from the field. Thus, they did the easier job of rice straw burning irrespective of its harmful effects to the environment and insect biodiversity (Punia et al., 2008)

Due to the difficulties faced during ploughing only a small portion of farmers incorporated rice straw into the rice field.

The small percentage of the farmers' selling rice straw to the market could be those who harvested their rice crop manually, mainly because of their small land holdings and poor livelihood. The farmers were feeding rice straw to their cattle either after collecting from fields or by grazing animals in harvested field (Praweenwongwuthi et al., 2010). However, these farmers were also setting fire to rice stubbles remaining in fields after cattle grazing.

Certain problems are taking their births with the adoption of high-mechanized rice farming (Punia et al., 2008). As agricultural labor is expensive and also not available at needed times, almost all the farmers, instead of manual harvesting, used combine harvesters to harvest their crops. In case of manual harvesting, the straw is bailed out and used as cattle's fodder or sold out in the market. But in the case of harvesting with machines, straw is burnt in the fields as farmers think it is an 'easy solution' to get rid of it. Due to burning despite the large losses of nutrients (up to 80% of N, 25% of P and 21% of K and 40-60% of S), this practice not only deprives soils of organic matter but also causes significant air pollution. The residues when burnt instantly generate as much as 13t of CO_2 per ha, thus contaminating the air, besides killing the biocontrol agents and other soil inhabiting insects (Akhtar et al., 2009). The overall effect of such malpractices is that the world is becoming increasingly species poorer and more homogenous in its insect fauna (Samways, 1996; Ijaz, 2008).

In Pakistan, there is a need for implementing better environmental polices and a better system of monitoring and implementing the laws in rural areas. Due to variability and complexity of invertebrate assemblages and their responses to fire, a much more rigorous approach to methodology must be adopted if optimal fire policies for invertebrate conservation in various habitat types are to be devised.

Area (acres) were different rice varieties are sown

It is quite clear from Table 9 that about 80.4% area of the surveyed farmers was under Super basmati followed by 14.5% under 386 and 3.5% under super fine. An area of 1.0% was under IRRI types (Irri-6 and NIAB Irri-9), 0.4% under Basmati-385, 0.2% under Basmati-2000 and only 0.03% was under hybrid rice. All the Basmati rice varieties collectively contributed to 81.0% of total surveyed area under rice crop. The results are in accordance with those of Mann and Meisner (2002).

The coverage of large area by a single variety or by a few varieties of the same crop adversely affects the biodiversity (Ahmad and Iram, 2006). This has resulted in increased problems related to plant health, rapid multiplication of rice pest and diseases and loss of soil quality besides having serious implications for yield and long term sustainability of rice ecosystem (Borromeo and Deb, 2006). According to Heong et al. (1995) mixtures of varieties can provide functional diversity that limits pathogens and pests' expansion which will indirectly reduce the pesticide usage. As the pesticides are directly toxic to organisms so a reduction in their use will ultimately protect the biodiversity.

Conclusion and recommendations

Most of the farmers were of low educational level, belonged to middle or old age groups and had small land holdings of less than five hectares. The Agriculture Extension Department should take into account the socio-economic conditions of the farmers for any extension-training program and to target only a specific category of people in extension work to obtain desired results.

Even though insecticides are problematic for the health of farmers, an increasing trend in their use was found. The farmers must be internalized of pesticide use and assured that a wide gap exists between visible and actual damage. Farmers' awareness of the pesticides' hazards to the environment, animal and human health should be included in the local extension activities.

Most of the farmers did not follow the recommendations by the Department of Agriculture or by experts in the case of agrochemical usages. The increasing use of pesticides, improper uses of fertilizers, rice straw burning and coverage of large area by a single variety were of major importance. Hence, more conducive and concrete policies, regulations and enforcement systems are required in this regard, especially for pesticides and rice straw burning.

Lastly, it is suggested that there must be a positive change in attitude and philosophy among decision-makers, scientists and others stakeholder to acknowledge

Table 9. Area (acres) sown under different rice varieties.

Rice variety	Basmati-Super	Basmati- 385	Basmati- 2000	IRRI type	Hybrid Rice	386	Super fine
Frequency	2913	13	6	36	1	526	127
Percentage	80.4	0.4	0.2	1.0	0.03	14.5	3.5

alternatives. So that, while formulating policies and extension training programs regarding agriculture, hazards of pesticides, increasing average age of farmers and encouraging young people to choose farming as a profession, promoting a sense of pride in farmers, making farming both environmentally and economically sustainable, food security and conservation of biodiversity should be addressed. This research will, however, open the doors to analyze the existing farming practices in deep and the ultimate results will be helpful in changing methods and materials in extension and farmer training and in modifying those management practices and approaches of farmers which are harming the insect biodiversity.

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