

Use of Pesticides and Their Role in Environmental Pollution

Muhammad Jamil Khan, Muhammad Sharif Zia and Muhammad Qasim

Abstract—Insect pests are the major source of crop damage, yield and quality reduction in Pakistan and else where in the world. Cotton crop is the most hit crop in Pakistan followed by rice and the second most important foreign exchange earning crop. A wide variety of staple, horticultural and cash crops grown, reflect serious problems of many types of insect pests. To overcome the insect pest problem, pesticide use in Pakistan has increased substantially which has now been further intensified. Pesticides worth more than billions of rupees are imported every year. This paper reviews the over all pesticide use in Pakistan in relation to pesticide prices, support price of cotton and rice, pesticide use in different provinces of Pakistan on different crops and their impact on crop productivity. The environmental pollution caused by the use of pesticides, contamination of soil and water resources and the danger associated with the disposal of their empty containers is also discussed in detail.

Keywords—Pesticide use, crop productivity, environmental pollution

I. INTRODUCTION

INSECTICIDES and herbicides are known to have played a significant role in the improvement of crop yields all over the world during the last four to five decades. Use of fertilizers along with pesticides, high fertilizer responsive dwarf crop varieties with high yield potential, development of water resources, intensive cropping and best management practices formed an essential part of green revolution of late sixties in Pakistan.

Insect pests are a major source of crop damage and yield reduction in this part of the world. Cotton is worst hit crop in Pakistan. Jassid, whitefly, thrips, boll worms, aphids and spider mites are posing serious threat to this high value cash crop. Therefore, production losses in cotton due to pest attack are reported to have been increasing every year and these losses were found to be 3.1 million bales in 1998-99 [1]. Whitefly, which is a carrier of leaf curl virus, indirectly contributes to additional losses. This is why use of pesticide in cotton crop accounts for about 62% of the total pesticide consumption in Pakistan [2].

Rice is the second most important foreign exchange earning crop of Pakistan grown mostly in Punjab and Sindh. About 70 insect pests are reported to attack paddy crop and cause 20-25 % losses on recurrent basis. The major insect pests that cause significant yield losses are stem borers, white backed plant hopper and leaf folder [3].

The wheat is fortunate found to be free from serious insect attack. The diverse variety of horticultural crops reflects serious problems of many types of insect pests viz, fruit flies, beetles, mealy bugs etc. These insects on many instances practically reduced the food availability by over 50%.

To overcome the insect pest problems, pesticides worth more than billions of rupees are imported every year in Pakistan. In the absence of local formulations and manufacturing facilities this situation will constantly increase the import bill to cope with the rising demand. In spite of all this, pest problem still exists and even the colossal increase in pesticide consumption has not led necessarily to increase the yields of crops [4]. However, as a result of lavish, unplanned and indiscriminate use of pesticides and their mishandling, many other problems such as pesticide residues in agro-ecosystem; development of insect resistance to pesticides and resurgence of target pests; outbreak of secondary pests; destruction of bio-control agents; environmental pollution (soil, water, air); accumulation of pesticide in food chain; health related issues such as human and domestic animal poisoning; damage to wild life and loss to biodiversity have emerged [5,6]. Their indiscriminate use is also showing signs of several serious human ailments, the most common being cancer, liver diseases and hypertension. It is estimated that annually thousands of the farmers and farm workers are poisoned due to pesticide exposure.

Over and misuse of pesticides has led to tremendous economic losses and environmental pollution and in addition, has increased the cost of production, while pest problem still persist. This paper discusses the use of pesticides in agriculture and the causes leading to environmental pollution due to their careless use and mishandling.

II. PESTICIDE USE IN PAKISTAN

Fertilizers and insecticides are extremely important inputs and integral component of crop production system. Both of these inputs are extremely important in bridging the yield gap that exists between the potential yield and the yield realized at the farm level, especially in cotton and rice. During the last 3-4 decades insect pest attack on different crops has been identified as one of the major constraints to exploit crop genetic potential and realizing potential yield and quality of crops. The pest problem increased with the introduction of

M. J. Khan is with the Department of Soil & Environmental Sciences, Gomal University, DIKhan, 29050, KPK., Pakistan. phone: 0092 966 750120; fax: 0092 966 750255; e-mail: shahmir3rd@yahoo.com.

M. S. Zia., was with Gomal University, DIKhan, 29050, KPK., Pakistan e-mail: drsharifzia@yahoo.com.

M. Qasim was Dean, Faculty of Agriculture, Gomal University, DIKhan, 29050, KPK., Pakistan. e-mail: drqasim02@yahoo.com.

high yielding and fertilizer responsive varieties which prove susceptible to various pests. For example, *Heliothis* and army worm were minor pests of cotton, but introduction of delta pine cotton in Pakistan changed the scenario leading to serious pest situation in cotton. Similarly, cultivation of IR-6 led to introduction of white backed plant hopper [7]. Likewise weed problem has become very serious due to import of Mexican wheat seed in large quantities. Also insect infestation problem has become quite serious in fruits and vegetables, badly affecting the production and the quality of the produce. Consequently use of pesticide in agriculture has become extremely essential.

A. Over all Pesticide Use

The use of pesticide is one of the essential measures of modern agricultural practices in protecting the crops from different pests. Therefore, the pesticide use in Pakistan which started in nineteen fifties with the import of 250 metric tons (mt) has increased steadily and substantially over the years in Pakistan [8, 9]. The data (Table 1) revealed that pesticide consumption increased by 2159% in 2004 over 1982. But after 2004, there is decline in the use of pesticide. This decline is attributed to cultivation of Bt cotton and adoption of integrated pest management (IPM) technology through Farmer Field Schools (The News, 26 August, 2007).

TABLE I
PESTICIDE USE IN PAKISTAN

Year	Pesticide use (000t)	% increase over 1982
1982	5.00	-
1984	9.21	84.2
2000	61.30	1126.0
2004	112.93	2158.6
2006	73.56	1371.2

Source: [2]

Increase in pesticide prices negatively impacted on the pesticide use (Figure 1) in the country. However, increase in support price of seed cotton and rice (Bas 385) positively impacted the pesticide use (Fig. 2 & 3) in the [2].

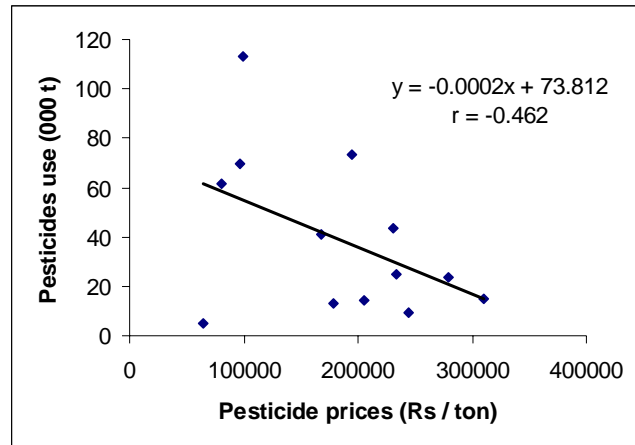


Fig. 1: Pesticide use in relation to pesticide prices for the period 1992-2006

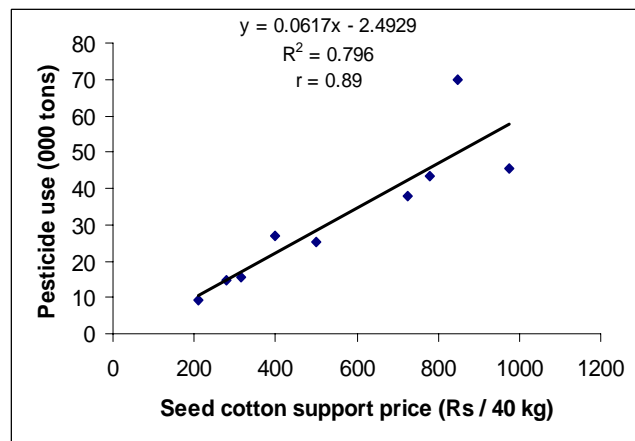


Fig. 2: Effect of support price of seed cotton on pesticide use in cotton during 1990-2006

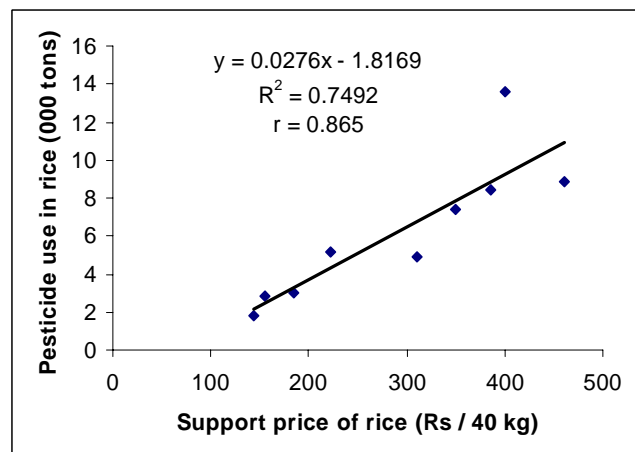


Fig. 3: Impact of support price of rice (Bas 385) on pesticide use in rice during 1990-2006

B. Pesticide used in different provinces on different crops

Out of total pesticide use in Pakistan, 88.3% is used in Punjab province, followed by Sindh (8.2%) and NWFP 2.8%). Pesticide use on fruits and vegetable is very high in Balochistan and NWFP (Table 2).

Major pesticide use in Pakistan is on cotton crop (61.92%) followed by on fruits and vegetables (11.9%), rice (11.86%), sugarcane (6.14%), maize (4.83%) and oilseeds (2.21%). Though the use of herbicides is increasing on wheat yet its share is negligible (Table 3).

TABLE II
PESTICIDE USE IN DIFFERENT PROVINCES OF PAKISTAN

Area	Punjab	Sindh	NWFP	Balochistan	Total
Covered (ha)	20570	1906	645	177	23298
% of total	88.3	8.2	2.8	0.76	-

Source: [2]

TABLE III
DATA ON PESTICIDE USE ON DIFFERENT CROPS IN PAKISTAN

Area	Paddy	Cotton	S. cane	Maize	Wheat	O. Seed	Tobacco	Fruit s/ Veg
Covered (ha)	2763	14426	1431	1125	109	514	159	2770
% of total	11.86	61.92	6.14	4.83	0.47	2.21	0.68	11.9

Source: [2]

In Sindh and Punjab, maximum use of pesticide is on cotton and rice followed by fruits and vegetables. In NWFP and Balochistan, major use of pesticides is on fruits and vegetables followed by maize in NWFP and rice and cotton in Balochistan (Table 4). Out of the total pesticide use in the country, insecticides comprised of 90%, herbicide 7%, fungicides, 3% and others (acaricides, fumigants) 0.2%.

TABLE IV
SHARE OF PROVINCE WISE PESTICIDE USE ON IMPORTANT CROPS

Crop	Province wise share (%)			
	Punjab	Sindh	NWFP	Balochistan
Cotton	63.7	67.7	0.3	16.1
Rice	11.1	20.5	4.7	27.2
Sugarcane	6.7	0.3	7.8	-
Fruits/Vegetables	10.3	6.0	62.8	55.9
Maize	5.2	-	8.1	0.3
Oilseeds	2.4	-	2.3	-

Source: [2]

C. Impact of Pesticide Use on Crop Productivity

Pesticides are used to overcome the pest problem in various crops. When the pest problem is managed at the proper time it helps to improve the crop productivity. Therefore, pesticide use definitely helps in improving the crop productivity and quality if right type of pesticide is used at right time with right dose. The productivity of two major crops (cotton and rice) will be discussed here as these crops were badly affected by pest problem.

Pesticide use in cotton has positively impacted the cotton production in Pakistan (Fig. 4). And there is linear relationship between the pesticide use and cotton production.

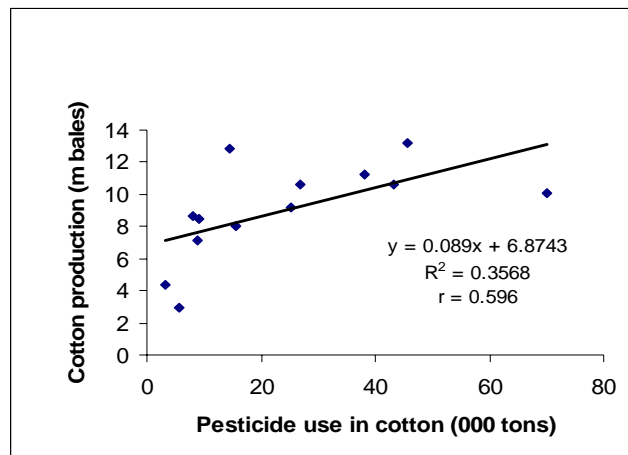


Fig. 4: Impact of pesticide use in cotton production during the period 1982-2006

Elahi [10] studied the effect of 33 qualitative and quantitative factors on cotton productivity. Better pesticide use along with quality seed, better fertilizer and agronomic practices (proper moisture at sowing, rotation, planting time etc) has shown significant contribution. Ahmad et al., [11] concluded that pesticide use significantly contributed towards higher cotton yield. Javid [12] reported that pesticide use is most important variable that makes maximum contribution in the yield gap, which exists between the potential yields realized at the farm level.

Similarly, pesticide use in rice has positive impact on rice production (Fig. 5). Rice production is linearly correlated with pesticide use in rice. Contribution of insect control in the yield gap of basmati rice with the use of insecticide has been found to be 18 % ([13]; Fig. 6). In another study, application of Padan increased the paddy yield of Basmati 385 by 42.6 to 54.5 % over control and cost benefit ratio of 1:7 to 1:14 was obtained (Table 5). Here it looks that pesticide use is economically feasible. In a similar study on Super Basmati application of Roll up 7.2G and Padan 3G increased rice yields by 93.4% and 83.3%, respectively (Table 6). Thus judicious use of pesticide in crop production is highly rewarding in terms of increasing crop productivity.

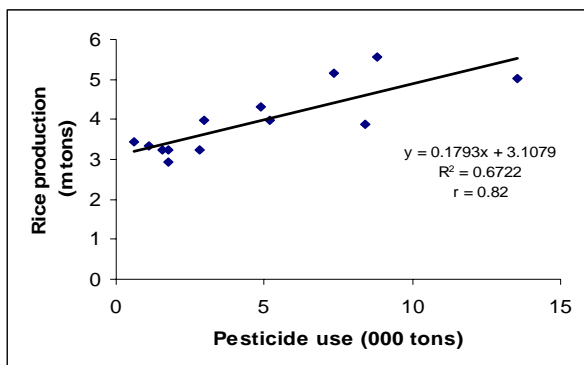


Fig. 5: Effect of pesticide use on rice production during 1992-2006

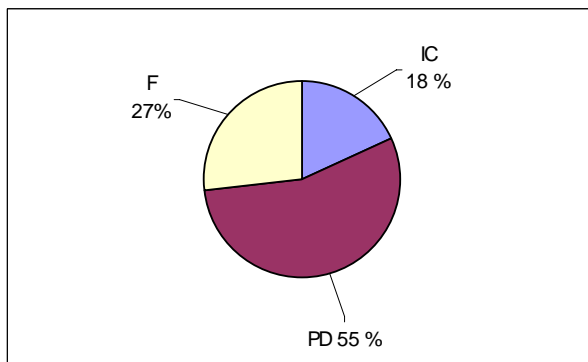


Fig. 6: Contribution of Insect control (IC), Fertilizer (F) and Plant density (PD) in rice (Bas 370) yield gap

TABLE V
EFFECT OF PADAN ON PRODUCTIVITY OF RICE (BAS 385)

Treatment	Yield (t ha ⁻¹)	Increase over control (%)	Gross income (Rs ha ⁻¹)	Incremental cost (Rs ha ⁻¹)	Increase over control (Rs ha ⁻¹)	Cost: Benefit
Control	3.04	-	14440	-	-	-
Padan 95 SP @ 625g ha ⁻¹	4.34	42.6	20596	776	5380	1:7
Padan 95 SP @ 375g ha ⁻¹	4.70	54.5	22306	526	7340	1:14

Source: [14]

TABLE VI
EFFECT OF DIFFERENT INSECTICIDES ON PADDY YIELD OF SUPER BASMATI

Insecticide	Dose (kg ha ⁻¹)	Paddy yield (t ha ⁻¹)	Increase over control (%)
Control	-	1.98	-
Padan 4G	17	3.63	83.3
Rollup 7.2G	15	3.83	93.3

Source: [15]

III. CAUSES OF ENVIRONMENTAL POLLUTION DUE TO PESTICIDES

Though the use of pesticide is not very high in Pakistan as compared to many Asian countries, misuse of pesticide is very common which leads to tremendous environmental problems. Incorrect or improper use of pesticide is quite evident among the farming community [16]. Followings are the different ways farmers misuse the pesticides.

A. Farmer's know how about pesticide application

Majority of the farmers are not properly educated and lack know how regarding the use of pesticides. Farmers mostly apply pesticide without knowing the population of insect pests, natural enemies and crop condition. They just apply on calendar basis. Our surveys revealed that farmers' attitude towards pesticide use is very optimistic. They consider pesticides as medicine rather than a source of poison. Over dose or under dose may cause disturbance in the ecosystem. The overuse of pesticide started due to government's relaxed policies given on pesticide import, manufacturing and distribution [5]. The consequences of the overuse of pesticide are quite evident in cotton growing areas where 62% of pesticides are being consumed every year. It is the need of the time that farmers must be made aware of the potential hazardous effects of pesticides.

Because of the farmer's poor knowledge regarding pesticide application, misuse of pesticides is another serious problem in Pakistan. A large proportion of pesticides applied to crops hit the non-target areas because of the untrained pesticide applicators and faulty spray equipment [5]. Other reports revealed that over dosing can kill non-target organisms, which could give rise to resurgence of insect pests [17]. Due to misuse of pesticides in cotton, various insect pests (Heliothis, whitefly, etc) have developed resistance to insecticides [16, 18]. Resultantly, farmers have to repeat pesticide application several times for the control of insect pests without getting the desired results.

Due to lack of knowledge or negligence on the part of the farmers, they select improper insecticide. For example, farmers some times use left over pesticides on vegetables, which are actually recommended for cotton. These pesticides persist longer and cause contamination of vegetables with high residue limits (MRL). On the other hand, resource limiting conditions of farmers force them to purchase

pesticides not of their choice rather trader's / middleman's choice.

B. Use pesticide at improper time and field conditions

It has also been observed many times that majority of the farmers do not monitor their fields regularly. Thus they apply pesticides when the damage has already been done and the symptoms have become quite visible i.e. after the appearance of 'dead hearts' or 'whiteheads' due to stem borers attack, rolling of leaves by leaffolder or 'hopperburn' due to heavy infestation of white backed plant hopper in rice [16]. This is just wastages of resources on one hand and cause of environmental pollution on the other hand.

It has been observed that farmer not apply pesticides according to recommended moisture in the field, particularly in rice they broadcast granular insecticides when the field is just moist and there is no standing water in it or they apply insecticide when the field is in highly flooded conditions. Some times they also go for spraying the pesticides when fast wind is blowing or apply the microbial insecticides when temperature is low than the required temperature. Some farmers also apply insecticides when pests are in inactive stage, viz. when there are no adults present in the field and insects are in pupal or full grown larval stage.

IV. FACTORS ATTRIBUTING TO PESTICIDES ASSOCIATED PROBLEMS

A. Lack of awareness about IPM

Pesticides represent the most popular approach to control insect pests in Pakistan. Majority of the farmers ask which insecticide should they use to control a particular insect. They never asked how these insects can be controlled. Or what other methods are there to control insects. This indicates the dominance of insecticides over other control measures. Various reports have revealed that farmers consider that pesticides are the only solution of their problem. They were made to believe that pesticides are the only remedy to their crops [9]. They have no knowledge about IPM. Even the extension workers do not consider IPM as workable technology. Moreover, pesticides are easy to apply and no hard work is involved and the job is accomplished efficiently. Therefore IPM, technology is not preferred by extension staff because of hard work involved in it. Moreover, the extension system is not fully equipped to handle updated IPM research, which needs long term commitment.

B. Govt. pesticide oriented policies

The government took various steps from time to time to popularize the use of insecticides> these policies are:

- Subsidies on pesticides are totally removed but imports have been exempted from duty. The government is helping the farmers by provision of spraying equipment on subsidized rates.
- Free advisory service by pesticide companies is being provided.
- Strong private sector and their vested interest have gone a big way in this direction.

- Aggressive media campaigns have also significantly.

C. Improper storage and manhandling of pesticides

Farmers generally store pesticides in separate room (80%), animal room (5%) and sitting room (1 %) [19]. More over, the pesticides are being sold with other general store items. Pesticide leakage is also a big issue which mostly occurs during transportation, field application and during storage. Persons engaged in spraying pesticides do not use protective clothing and masks as and when required. It is evident from reports that 50% of the farmers use precautionary measures during pesticide spray. The measures used most frequently include avoid eating and drinking during spray, covering body and washing hand and face after finishing spray (Table 7). The farmers have little understanding about the hazardous effects of inhaling pesticides and precautions required under harsh climatic conditions. Reports indicate that 19% farmers got training about pesticide handling and spraying (Figure 6) [19]. Awareness of farmers, spray men, and personal handling pesticide is highly essential. Even at formulations places contamination of soil with pesticides has been observed due to leakage of containers. Leakage of products can cause localized contamination within storage or some times surrounding areas.

TABLE VII
PERCENT FARMERS USING PRECAUTIONARY MEASURES DURING PESTICIDE SPRAY

Precautionary measures	Yes	No
Observe precautionary measures while spraying	52	48
While spraying use gloves	100	-
While spraying use mask	19	81
While spraying use eye glasses	15	85
While spraying cover head	41	59
While spraying use boots	15	85
While spraying cover body	85	15
Avoid smoking while spraying	44	56
Avoid eating while spraying	63	37
Avoid drinking while spraying	67	33
Spray in wind direction	58	42
Wash hands and mouth after spraying	93	7

Source: [19]

D. Disposal of empty containers

Most of the time it has been observed that farmers throw empty containers in water channel, canals or near by their houses in the courtyard rather than burying them in the soil. Sometime empty containers are also being used by farmers for keeping edible oil, drinking water or milk. Empty containers may be hazardous to children, may contaminate the environment or may be lethal to wildlife [18].

E. Disposal of obsolete pesticides

The objective of pesticide disposal is that the chemical becomes permanently harmless to all of us. No enough preventive measures are taken to dispose of or decompose such poisonous materials. These compounds are washed down into the underground water, contaminating the surrounding environment and endangering the lives of humans as well as animals. During 2004, there was sudden mass fish killing in Rawal Lake in Islamabad, the main source of municipal water provision to Rawalpindi Cantonment area. This was believed to be due to throwing of out dated pesticides by some pesticide traders [20].

F. Banned pesticides still in use

The persistent carcinogenic most toxic chemicals like ADT and chlorinated hydrocarbons are still in use in Pakistan. Nasir [21] reported their 10 fold increase in 1986-87 over 1981-82. This is not restricted to Pakistan, India also faces this situation. According to Metha [22] in USA, only one in hundred cities does not care DDT in their body. This is thus a serious issue, which needs careful consideration.

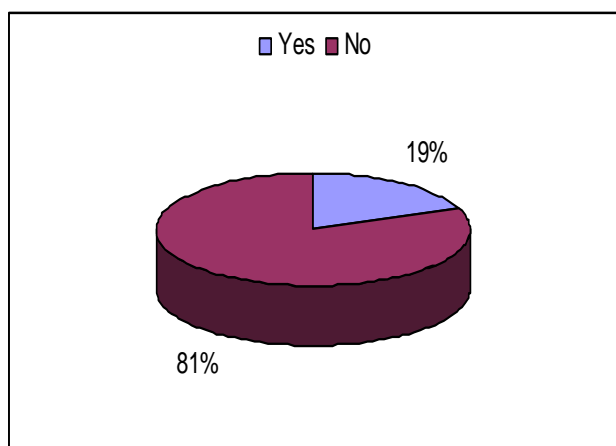


Fig. 7: Percent farmers got training in pesticide handling and spraying

V. CONCLUSIONS

Foregoing review on the subject indicates that pesticide use is an important and integral component of crop production system. Its use is essential measures of agricultural practices in protecting the crops from different pests. Pesticide use in Pakistan increased substantially over the years. Pesticide consumption increased by 2159 % in 2004 over 1982, but now there is declining trend in their use. Pesticide prices negatively impacted the pesticide use in the country, where as the ncrease in the support prices of cotton and rice were positively correlated with the pesticide use. Major pesticide use (62 %) is on cotton, followed by rice (11.9 %), fruits and vegetables (11.9 %), sugarcane (6.1 %) and oilseeds (2.21 %). On wheat pesticide use is negligible. Pesticide use has positive impact on the productivity of cotton and rice. Farmer's poor knowledge about pesticide application, lack of awareness about integrated pest management (IPM), popularized and indiscriminate use of pesticide as a result of government pesticide oriented policies, use of obsolete and banned pesticides, improper storage and reuse of empty pesticide

containers for purposes other than pesticides have been regarded as the main causes of pesticide pollution in agro-ecosystem.

ACKNOWLEDGEMENT

The authors are extremely thankful to the Higher Education Commission (HEC), Islamabad, Pakistan for the financial support.

REFERENCES

- [1] I. Ahmad and A. Poswal, "Cotton integrated pest management in Pakistan: Current status. Country report presented in cotton IPM planning and curriculum workshop" organized by FAO, Bangkok, Thailand, February 28-march 2, 2000.
- [2] MINFAL, "Agricultural Statistics of Pakistan. Ministry of Food, Agriculture and Livestock. Government of Pakistan, Islamabad, 2006.
- [3] M. Salim, S. A. Masud and M. Ramzan, "Integrated Insect pest management of Basmati rice in Pakistan," PP: 149-162. In: *Specificity Rices of The Word: Breeding, Production and Marketing/Tech. Eds. Ram C. Chaudhary, D. V. Tran; editor, R. Duffy; FAO, Rome, Italy PP: 358. 2001.*
- [4] M. A. Poswal and S. Williamson, "Stepping of the cotton pesticide treadmill: Preliminary finding from a farmers' participatory cotton IPM training project in Pakistan," CABI Bioscience Centre, Rawalpindi, 1998.
- [5] A. Rehman, M. H. Soomro and I. Ahmad, "Rational use of pesticides," *The News*, Islamabad, June 5, 2000.
- [6] M. Sharif Zia, M. Jamil, M. Qasim and A. Rahman, "Pesticide residue in the food chain and human body inside Pakistan," *Journal of Chemical Society*, Pakistan, 31 (2), April, 2009.
- [7] S. I. Chaudhry, "Plant Protection: Paper presented at the 2nd Agricultural research Conference," PARC, Islamabad, October 24-27, 1981.
- [8] N. Habib, "Invisible farmers: a case study on the role of women in agriculture and the impact of pesticides on them," *Khoj Research and Publications Centre*, Lahore, Pakistan, pp 129. 1996.
- [9] A. Rehman, "Plant Protection Problems and Pesticide Use Policy of Pakistan," *PAK/99/002, UNDP/FAO/GOP*, Islamabad, Pakistan. pp 82, 2001.
- [10] M. Elahi, "An economic analysis of main factors contributing to the high productivity of cotton: A case study in District Jhang," *M.Sc Thesis. University of Agriculture*, Faisalabad. 1998.
- [11] M. Ahmad, B. Ahmad, M. Hussain and M. Iqbal, "Economics of plant protection," *The case of cotton. Pak. Entomol.* Vol. 18, pp. 25-31. 1996.
- [12] M. Javed, "A study of productivity differential between progressive and non-progressive farmers in cotton crop," *A case study of Bahawalpur District*. 1989.
- [13] M. S. Zia, "Soil Fertility evaluation and management of low land rice soils of Pakistan. Doctor of Agriculture Dissertation," *Faculty of Agriculture*, Kyoto University, Japan. 1990.
- [14] Rice Annual Report, "Effect of Padan on productivity of rice (Basmati 385)," *Annual Report of Rice Program, NARC*, Islamabad, 1993.
- [15] Rice Annual Report, "Effect of different insecticides on paddy yield of Super basmati," *Annual Report of Rice Program, NARC*, Islamabad, 2004.
- [16] M. Salim, "Misuse of insecticides," *The Nation*, Islamabad. January, 3, 1999.
- [17] T. Hasnain, "Pesticide use and its impact on crop ecologies: issues and options," *SDPI working paper series # 42. SDPI*, Islamabad, pp73. 1999.
- [18] M. Irshad, "Disposal of pesticides," *The Nation*, Lahore, June 20, 1999.
- [19] FAO, "Policy and strategy for rational use of pesticides in Pakistan. Food and Agriculture Organization/Global IPM Facility," *United Nations development Programme*, Govt of Pakistan, 2001.
- [20] K. Ahad, A. Mohammad, F. Mehboob, A. Sattar, and I. Ahmad, "Pesticide residues in rawal lake, Islamabad, Pakistan," *Bull. Environ. Contam. Toxicol.* Vol. 76, pp. 463-470. 2006.
- [21] Nisar, M., M. Mumtaz and M. M. Baig, "Contamination of paddy ecosystem with aerielly sprayed DDT formulation. In: *Proc. World*

Environment Day," Dept. Zool. Univ. Kar. June 6. Special supplement.
Pakistan Journ. Ent. Soc. Karachi, 1987.

- [22] K. Mehta, "Sustainable Agriculture-Can it Provide Enough Quality Food to Our People? Proceedings of the national seminar on sustainable Agricultural Development," *Voluntary Health Association of India*," New Delhi, pp72-78. 1991.