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**Pesticide-use and its Impact on Crop
Ecologies: Issues and Options**

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Pesticide-use and its Impact on Crop Ecologies: Issues and Options

Tahir Hasnain

0. Abstract

The pesticides are dominant in Pakistan's plant protection. It is often urged that pesticides have not solved pest problems, nor led to higher crop production besides posing great risks to health and ecology. The current study was initiated to see if pesticides have altered the agro-ecological system and how their use can be minimised by adopting alternatives to pesticides. To obtain an insight into the pesticide situation in Pakistan, data over-time on pesticide-use and its environmental impacts have been collected. The current study, specifically, focuses on the effect of pesticides on the crop ecologies and the need for efforts to develop alternative strategies to manage pest populations and minimise uneconomical pesticide use. Integrated pest management (IPM), which is cost effective and environment friendly, is discussed in detail as the best possible alternative to pesticides.

1. Introduction

Pakistan is an agrarian based economy. Agriculture as the largest single sector of the economy, accounted for 24.6 percent of the total gross domestic product (GDP) in 1997-98 (Finance Division 1998). However, it is a matter of acute concern that each year the country fails to achieve targeted agricultural yields. One of the major constraints to achieving potential yield and quality of crops include a variety of crop pests. To achieve a higher crop output, the use of pesticides was/is perceived to be the most effective method. Thus, there has been a persistent and steady increase in the use of pesticides from 665 tonnes in 1980 to 44,872 tonnes in 1998.

Historically, pesticide use in Pakistan started with the introduction of the Green Revolution (GR) technologies in the early Sixties. The GR introduced high yielding crop varieties (HYV) that require more water and fertilisers. To achieve self-sufficiency in agriculture, HYV were cultivated widely. The HYV proved susceptible to various insect pests. Traditional pest controlling tactics became inadequate to contend with large pest populations. As a result, need for the plant protection measures of a much higher order emerged. Chemical control (pesticide-use) became, thus, the key pest control method in modern agriculture.

Moreover, due to a lack of knowledge and appropriate regulatory agencies, in Pakistan, pesticides have not been used in ways likely to maximise their benefits (Qasmi 1997). The negative impacts associated with pesticide use (such as loss of non-target beneficial organisms, health and environmental hazards) began to emerge overtime, which are alarming at the moment. According to Pimental (1992), pesticides have not solved the pest problems and in addition, increase the cost of production and environmental and health risks. He figured out that despite the use of 2.5 million tons of pesticides worldwide in 1992, approximately 55% of potential crop production is lost to pests. According to a survey conducted by SDPI (1998), pest varieties and their populations in cotton have increased overtime, despite heavy pesticide use. These bursting pest populations are the result of, one, the resistance which pests have developed overtime against commonly used pesticides and,

two, due to elimination of their natural enemy complex¹. Eventually, farmers are required to spray more pesticides with higher concentrations every year to combat these increasing pest populations. No specific detailed research has been conducted so far to study the impact of pesticide-use over-time on crop ecologies in Pakistan. Agricultural researchers, however, are aware and agree that indiscriminate pesticide use erodes agricultural biodiversity, adversely affects the ecology of the region and poses health and environmental risks. Efforts are, thus, being made to monitor problems associated with pesticides and to develop appropriate alternatives.

With an assumption that pesticides have altered the agro-ecosystem, this study was initiated to examine the impact of pesticide-use on crop ecologies. The study aims to explore the use of sustainable agricultural practices for a transition to sustainable development in Pakistan. The conclusions and recommendations will be made after discussing the pesticide situation in Pakistan over-time and analysing the survey-data on environmental impacts of pesticide-use.

2. The Problem

2.1. Menace of Insect Pests

It is obvious that human life is directly dependent on agriculture, as it provides 95 percent of food plus other benefits (Baloch 1995). However, a variety of insect pests also consume agricultural crops, competing with humans. According to one estimate, insect pests cause both quantitative and qualitative loss to agricultural commodities averaging at 30-50 percent either from field crops or in stores after harvest (Baloch 1995). In a world where many people still go hungry, insect pests claim more than their fair share. The tables presented in annex 2 and 3 show how insects affect human's welfare and the damage done to different parts of crop tissues/organs.

According to Baloch (1995), the economic annual loss to crops in Pakistan is estimated at Rs. 130 billion. Cotton alone, which is Pakistan's main cash crop, faces more than 130 pest species, which result into a loss of millions of rupees every year (Ahmad 1996). Baloch (1995) reported that attack of sugarcane *Pyrrilla* and sugarcane borers, in the early 1960s, was so high that it reduced the sugarcane recovery to a minimum low of 5 percent in NWFP. Similarly, rice also receive serious attacks of stem borers, leaf and plant hoppers, leaf rollers, thrips, etc., every year. Major insect pests of important crops in Pakistan are listed commodity-wise in Annex 10. However, this is very arbitrary because the occurrence, population density and distribution vary a lot depending upon availability of principal and alternate host-plant besides the optimum environmental conditions for growth and multiplication.

Some plant feeding insects are important, not so much because they directly reduce crop yield and quality, but because they transmit disease organisms. This is particularly the case with crop virus diseases, many of which can only spread from plant to plant by means of suitable insect vectors. In Pakistan, for example, the whitefly (*Bemisia tabaci* Genn.) is a notorious vector of the cotton leaf curl virus disease.

2.2. Pest Control

The issue of controlling insect pests is as old as the agricultural history. However, pests than the present-one less affected the traditional farmer, because the situation has changed drastically (Box 1). Traditionally, pests were kept under economic damage levels through simple farming practises like crop rotation, trap crops, resistant crop varieties, altering the sowing or harvesting time, etc. The

1. The *natural enemy complex* means presence of parasite/predators of pests in the nature which keep pests under control. If these natural control agents are eliminated, e.g. due to pesticide use, pests appear in outbreaks.

intention behind the pest control programmes was to manage pest populations, not to eliminate/kill the whole pest population.

Today, effective pest control measures are necessary part of farming. Various pest control procedures which fall under a number of headings such as cultural control, biological control, mechanical control, physical control, chemical control, etc (Annex 4). Among these, at present, chemical control method is widely practised. The pests are perceived, nowadays, as an unwanted creature and are eliminated/killed promptly. The traditional pest control procedures and the current approach in this regard are being discussed separately.

Box 1: Reasons how Traditional Farmer was Less Affected by the Pests

- Modern farming has replaced the natural plant cover by a single or few species of cultivated plants. All other plants are regarded as weeds and suppressed as far as possible. These activities have favoured a number of potential pests;
- It is a fundamental principle of ecology that complex communities tend to be stable because they incorporate many checks and balances, and no one species can explode in numbers. The modern farming ecosystems in contrast are simple and hence inherently less stable. Outbreaks of pests are thus more likely to occur.
- Cultivars have been produced/bred for features (higher yield and quality of produce) other than the pest resistance and thus, the crops today bear no resemblance to their original wild ancestors.
- The insect pests have also dispersed globally by human activities itself. Man's travel and trade around the world have provided the means of distribution of many species that would not otherwise occur. Their dispersal has been accidental because they have been able to catch a ride on man's transport or goods. Many species accidentally introduced in this way have become serious pests because they are largely free of natural enemies in the new area.

(Fenemore 1984)

2.2.1. Indigenous or Traditional Methods

Prior to introduction of pesticides, as said earlier, pest populations were managed largely through cultural farming practices. Given below are some common traditional pest controlling tactics practised by the traditional farmers.

- The indigenous (*desi*) crop varieties, resistant to pests and extreme climates, were cultivated. These varieties were non-succulent, stout and hairy, thus, were resistant to insect pests.
- Another key factor, in keeping pests under control, was regular cultural practices at the farm. It provided them cultural control of pests. Some of the examples are quoted below:
 - ◆ Regular weeding and hoeing prevents the spread and breeding of insect pests. In the old agriculture, manual weeding and hoeing were a regular part of farming to keep the soils fertile besides discouraging pests.
 - ◆ It was a common practice that, after a period of year or two, some agricultural lands were left uncultivated to restore their fertility. At the same time, the insect pests were also discouraged due to non-availability of host plants around.
 - ◆ Crop rotation was another common practice to keep crops protected from the insect pests and soils fertile. Due to changing cropping pattern in a planned rotation, the pests were discouraged to breed regularly and emerge in large quantities.
 - ◆ Insect pests can also be avoided by altering the sowing, irrigation and harvest time. The traditional farmers were fully aware of this fact.
 - ◆ The crop residues, after harvest, were treated properly to kill the hibernating pests. For example, the sugarcane residues, just after the harvest, were burnt and all the hibernating larvae of sugarcane borers were destroyed in this way.
 - ◆ The pests were also kept under control by regular manuring and stimulating the growth. Research has shown that healthy and vigorous crop plants are less attacked by pests as compared to the sick or undernourished plants (Atwal 1984).

- ◆ The cultivation of 'trap crops' was another successful tactic to secure the crops from the pests. According to Mohyuddin, et. al. (1994), the infestation of sugarcane borers in the sugarcane crop can be reduced tremendously by growing Clover plants within sugarcane rows and on ridges as trap crop.
- The traditional farmers believed in multi-cropping system growing a variety of crops side by side. This sort of mix-cropping pattern provided a rich and diverse agricultural biodiversity. Scientific research (Bioscience Centre 1997) has proved that a rich biodiversity helps in controlling insect pests in many ways. For example, due to the presence of plenty of natural enemies, pests remain under control. Similarly, presence of limited host plants also check the wide-spread of pests.
- In severe cases, the botanical extracts such as *neem* and tobacco leave extracts were used to deter pests doing economic damage. However, these products were safe and environment friendly.

2.2.2. Modern approach

During the past 40 years, vast advancements have been made in pest control techniques. However, the chemical pest control has become compulsory tool for plant protection in modern agriculture. According to Fenemore (1984), the synthetic pesticide development really began with the discovery of DDT in 1936-37. However, their use spread globally with the introduction of Green Revolution in early Sixties. This was followed by a great expansion of chemical synthesis of organophosphorus compounds. With this breakthrough a series of organochlorines, organophosphates and carbamates were developed and introduced commercially, for the control of insect pests or weeds of economical crops, fruit & vegetables and ornamental plants (Fenemore 1984).

In recent years, pesticides have also been made of substances that influence insect behaviour. For example, chemicals which are attractive to pests, or which induce sterility, are in use. These are insect-growth inhibitors, moulting hormones, juvenile hormones, chemosterilants, chitin inhibitors, attractants, repellents, pheromones, and fumigants.

2.3. Pesticide Use in Pakistan

Prior to the introduction of HYV crops in early Sixties, farmers used to control pests through farming practices (such as tillage and rotation) and the mechanical removal of pests. Thereafter, synthetic pesticides became a regular part of plant protection measures. Much of the research efforts by public institutions in the 1950s and the 1960s were spent perfecting the development and application of pesticides. Initially, in the 1950s when the locust started destroying crops, chemical pesticides were used for the first time to combat the attacks. In 1954, at the initiation of cultivation of HYV's, the government imported formulated pesticides amounting to 254 metric tons (Habib 1996). This was the beginning of the pesticide business in the country. Pesticides and other related services (like aerial spraying) were initially provided to farmers free of cost up to 1965 (Habib 1996). Thereafter, pesticides have been heavily subsidised at different levels to enhance their use in the country. The concept of agricultural self-sufficiency was closely linked to the amount of pesticides used.

Box 2: History of Pesticide Use in Pakistan

Period	Pesticide Usage and Policies
1954	First time import of pesticides amounting 254 tonnes to control locust.
Upto 1965	Introduction of HYVs and free of cost pesticide distribution by the public sector.
1966-74	From a flat rate of Rs. 0.25/litre to 75% subsidised price; distribution by the public sector. First pesticide ordinance was promulgated in 1971.
1970s	A shift in research policy. IPM research projects initiated.
1975-79	50% subsidy on ECs/WPs and 75% subsidy on granules; 25% distribution by the public sector and 75% by the private sector.
1980-85	Complete withdrawal of subsidy except in Balochistan; complete distribution by private sector, except in Balochistan. In 1985, Pakistan adopted the model rules for pesticide registration according to UN FAO's International Code of Conduct on the distribution and use of pesticides.
1986-91	Complete withdrawal of subsidy in all provinces; complete distribution by the private sector.
1991	GOP amended the 1971 Ordinance and made two relaxations in pesticide imports <ul style="list-style-type: none"> i. pesticides can be imported under generic names rather than brand names, ii. if a pesticide is registered in some other country, it can be imported without going through local registration process.
1992-93	Duty and surcharge exemption on herbicides.
1993	Duty exemption on pesticides.
1994	Banning of 21 environmentally hazardous pesticides.
1997	Various sections and clauses of the 1971 Ordinance were amended to strengthen the punishment provisions for pesticide adulterators.

Source: Updated version of Habib (1996).

Policies for regulating the pesticide use also changed over-time (Box 2). To legalise and enhance the use of pesticides in the country, the first pesticide ordinance was promulgated in 1971 and Agriculture Pesticide Rules were framed in 1973. All imports, manufacture, formulation, marketing, distribution and use of pesticides have been controlled under this ordinance. Following this, an Agricultural Pesticide Technical Advisory Committee (APTAC) was established to advise the central government on technical matters related to the administration of this ordinance (Habib 1996).

Until 1980, government agencies controlled the import and subsidised distribution of pesticides through national agricultural extension network. Free aerial spraying was also provided to control pest attacks on major crops. In 1981, when the Government of Pakistan allowed the private sector to import, manufacture and market pesticides, it gave a big boost to pesticide use in the country with the result that the sprayed area and pesticide consumption increased manifold. The increasing trend in the use of pesticides is evident from the fact that pesticide consumption increased from 665 tons in 1980, when pesticide subsidies were virtually removed to allow the private sector to step-in, to 43,219 tons, out of which 30,856 tons valuing Rs. 5,272.5 million were imported, in 1996-97 (Table 1).

In 1985, Pakistan adopted the model rules for pesticides registration according to UN FAO's International Code of Conduct on the distribution and use of pesticides. Furthermore, the government amended the 1971 Ordinance in 1991 and allowed pesticide import under generic² names rather than brand names. A large number of companies have since been registered for importing pesticides in large quantities.

Pakistan Agricultural Research Council (PARC) during the early 1980s, initiated the case for de-registering pesticides that were internationally banned/restricted for use in the developed countries. The issue was deliberated thoroughly in various meetings of APTAC with regard to their deleterious effects and economic implications. Ultimately, the import of 21 pesticides either in technical grade material or formulation, was banned via gazette notification of September 19, 1994 (Annex 8). Despite the ban, their use on limited scale still continues due to various reasons including smuggling from Afghanistan, Iran, India and other countries where these pesticides are still used/marketed.

2. It means the same pesticide (active ingredient) can be imported and marketed under different brand names.

Although, the subsidies on pesticides have virtually been removed, indirect subsidy on pesticides is still in practice. The private sector enjoys several subsidies to manufacture, import and market pesticides; for example, i) relaxed policy on duty and surcharge exemption on import of pesticide raw material; ii) subsidies and loans for factory machines and instalments; and iii) free hand for marketing rather than controlled by the state.

2.3.1. Extent of Pesticide Consumption

Plant protection measures in Pakistan, due to the reasons mentioned earlier, are largely limited to the use of pesticides (Annex 5 and 6). According to Qasmi (1997), Pakistan is the second largest pesticide consuming country among the twelve Asia and Pacific regional countries and occupies a disadvantageous place in terms of safe use of pesticides as the bulk of our farmers are illiterate and untrained.

Table 1 shows, chronologically, the pesticides import, production, total consumption and their value overtime. Pesticide's percent growth per year in Pakistan is given in annex 7. Furthermore, insecticides are over 90% of the total pesticides used in Pakistan, while, herbicides, fungicides, acaricides and rodenticides put together account for less than 10% of the total pesticide used (Baloch 1995).

Table 1: Consumption of Pesticides in Pakistan
Quantity in M. Tones and Value in Million Rs.

Year	Quantity			Value
	Imports	Production	Total	
1980	---	---	665	39
1981	---	---	3,677	213
1982	3,552	1,448	5,000	320
1983	4,875	1,713	6,588	629
1984	6,081	3,132	9,213	2,256
1985	8,270	4,260	12,530	2,249
1986	8,834	5,665	14,499	2,978
1987	8,019	6,829	14,848	3,259
1988	6,256	6,816	13,072	2,334
1989	6,869	7,738	14,607	3,642
1990	4,802	9,941	14,742	4,581
1991	6,157	14,056	20,213	5,536
1992	6,619	16,748	23,439	6,554
1993	6,128	14,151	20,279	5,384
1994	10,693	14,176	24,869	5,808
1995	20,134	23,239	43,373	7,273
1996	24,151	19,068	43,219	9,987
1997	31,036	13,836	44,872	9904

Source: MINFAL, 1997.

Under regular registration scheme, 202 active ingredients under different trade names with concentrations/formulations are registered in the name of particular pesticides marketing companies, but under generic scheme 14 active ingredients under 139 products are allowed for marketing (Qasmi 1997).

2.3.2. Role of Private Sector

Although, the government of Pakistan, initially, introduced and managed a subsidised distribution of pesticides to farmers upto 1980, but the real thrust in pesticide use in the country started when the private sector got a free hand in production, import and marketing of pesticides in 1981. The role of the private sector in promoting the production and use of pesticides (for their own benefit) is tremendous. Table 2, shows that pesticide consumption, in 1997 has reached 44,872 metric tons as compared to only 665 metric tons in 1980.

However, the private sector has been very avaricious. Pesticide companies, in order to expand their business, trapped the farmers by giving them several incentives including credit, and succeeded in convincing them. Firstly, the farmers, due to their ignorance and illiteracy, were made to believe that pesticides were vitamins to their crops. Secondly, they adopted pesticides so quickly because it saves their time as well as hard work in the field. The sales representatives of pesticide companies, to fulfil targets fixed by their employers, also induced farmers via hand sell tactics to increase the number of sprays. In cotton areas, farmers are so misled that they are applying precautionary sprays without observing the pest population (SDPI 1998).

Pesticide companies, as they are highly organised, impart extensive campaigning among farmers in the use of pesticides. The companies also maintain a database of their clients and send them information regularly about the damage caused by pests and the use of pesticides. On the other hand, the government departments (Agriculture Extension, Pest Warning and Pesticide Quality Control), though heavily staffed, are extremely weak in extending the requisite services. It is, however, quite unfortunate that these departments become relaxed due to private sector intervention and thereafter, they begin to support them due to the influence of pesticide companies.

Moreover, the private sector also influenced the government policies and took full advantage of government's pesticide oriented policy. The advertisements of their products, especially in electronic media, supports this argument. The aggressive media campaigns do not comply with FAO guidelines for advertising pesticides (Zia 1997).

In Pakistan, out of 19 pesticide manufacturers, seven are the richest multinationals whose products dominate the pesticide sale countrywide. According to Qasmi (1997), Ciba Giegy, Hoechst and ICI alone made a turn over of Rs. 1,587.3 million, Rs. 598.8 million, and Rs. 538.5 million respectively (out of the total value of consumed pesticides amounting Rs. 5536 million) in 1991. Despite this, the pesticide import is increasing at an average rate of 18% per annum in value.

Within the private sector, local importers/manufacturers proved more opportunistic. They started a business of adulterated pesticides, which posed a great loss to the economy as well as the ecology of the country. On the one hand, they took full advantage of the farmer's poor economic conditions and began to sell their adulterated products on relatively low prices to attract farmers. On the other hand, pesticide dealers also preferred to sell these cheaper products, by misleading farmers, because there they have more profit margins than in the case of standard pesticides. Application of cheaper pesticides, thus, became common since the last decade. Eventually, several potential pests have developed resistance against commonly used pesticides, and have become key pests now. In cotton, for example, resistance has been recorded in Cotton Whitefly and American Bollworm.

2.4. *Problems with Pesticide Use*

Although, the chemical pest control approach is much more scientifically based, the negative impacts associated with the pesticide use can not be ignored. It is not always appreciated because we still have rather inadequate understanding of the complex biological systems within which most pest problems occur and are thus unable to predict accurately the outcome of particular actions. Now research has shown that pesticide use in agriculture is a significant source of environmental degradation (Masud 1984). Their impact on crop ecology will be discussed later in detail in section number 3. Problems associated with pesticides can be divided on the basis of quality, environmental affects and health risks.

2.4.1. Quality Problems

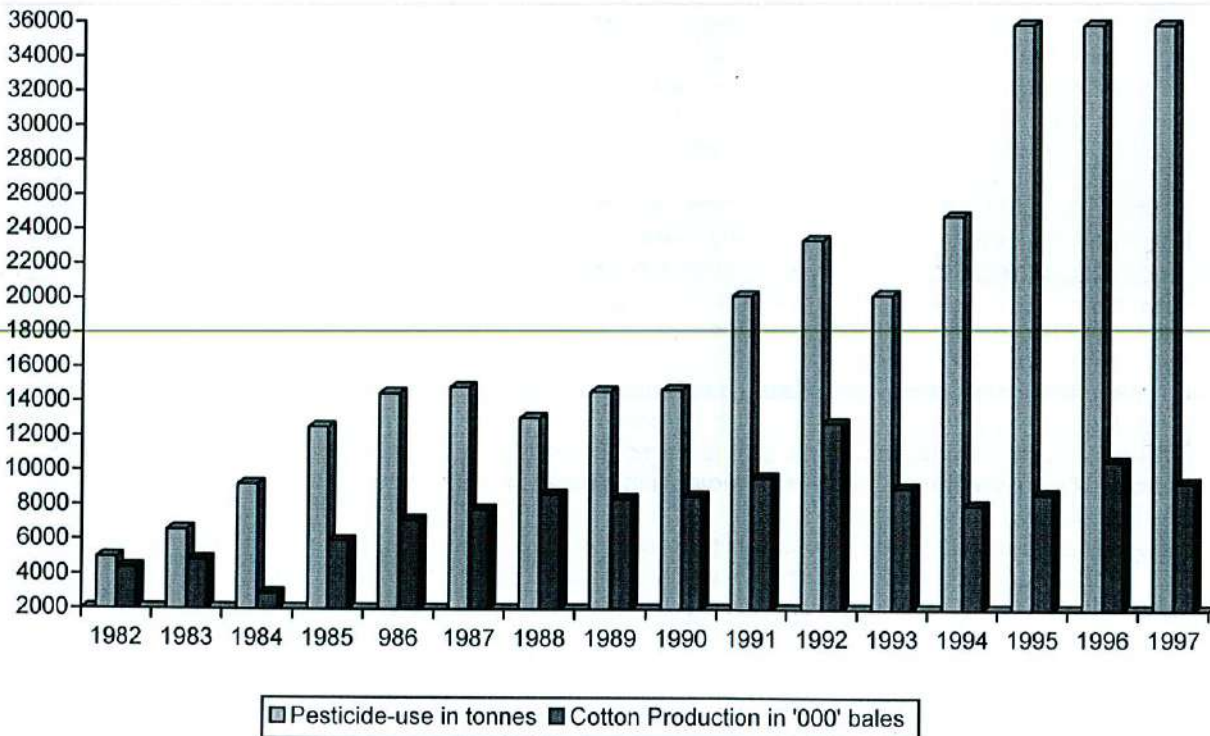
2.4.1.1. Overuse of Pesticides

There are several pesticide-related consequences which have occurred only due to regular overuse of pesticides. Their overuse in the country started due to unwise subsidies on pesticides which the government allowed in the past upto 1985 (Table 1). Farmers have been overusing pesticides because, in the beginning, these were made available to them virtually free of cost. Secondly, they were compelled through the agricultural extensionists to use pesticides, instead of being educated and made aware of toxic effects. As a result, the farmers became so reliant on pesticides that other forms of control became of little or no consideration. For instance, they began to view pesticides as a kind of medicine that their crops needed to grow. What they still believe is that if little is good, more must be better. Farmers need to be sensitised to the potential harmful effects of pesticides.

Since 1981, the private sector is leading the farmers through its sale managers and media campaigns to use pesticides in large quantities. They try constantly to induce farmers to use more pesticides and take full advantage of their ignorance, simplicity and illiteracy. The field observations show that farmer's lack of knowledge about pesticides proved harmful to land and crop productivity in the long runs [SDPI Survey 1997 (1)]. Farmers seem to be trapped in the vicious cycle, and have no choice but that using more and more pesticides every year.

The consequences of the overuse of pesticides are evident in cotton growing areas of Pakistan, where almost 70% of pesticides are being sprayed every year [Inayatullah 1997(1)]. The statistics show that increased use of pesticides has not solved the pest problems or led to higher cotton production. Fig. 1 shows that with the increased use of pesticides, cotton production increased in the beginning, became stagnant after a while, and is declining now for last few years.

Figure 1: Pesticide Use VS Cotton Production Overtime



Source: MINFAL 1997

2.4.1.2. Misuse of Pesticides

Pesticide's misuse, due to farmer's poor knowledge regarding pesticide application, is another serious problem in Pakistan. According to Forrester (1994), in Pakistan, almost 95% of pesticides applied to crops hit the non-target areas. This is partly due to untrained pesticide applicators and partly due to faulty spraying equipments.

Another example of pesticide's misuse is its illegal use in fruit and vegetable wholesale markets and commercial storehouses. Pesticides are also being sold and served in large quantities in urban environments as household insect control and fumigation services [SDPI Survey 1997 (2)].

2.4.1.3. Ineffectiveness of Pesticides

One of the serious issues related to pesticides in Pakistan is the use of ineffective pesticides, especially, in cotton growing areas of Pakistan. In fact, several major pests have developed resistance against the commonly used pesticides. Unfortunately, these products are still in use in the country.

Cotton Research Institute, Multan, has conducted studies on the development of resistance in American bollworm and whitefly. According to Ahmad (1995), American bollworm has developed a high level of resistance against *cypermethrin* and *monocrotophos*. Likewise, whitefly has developed resistance against *methamidofos*. This is a natural phenomenon as these compounds have been over-used against cotton pests.

Similarly, a government laboratory in Hyderabad, Sindh, declared about 46 pesticides ineffective during 1992-93 (Aziz, et.al. 1994) (Annex 9). Despite these research results, *cypermethrin* is still being sold under 27 trade names, *methamidofos* under 32 trade names and *monocrotophos* under 11 trade names. These compounds are also sold under generic names and in mixtures with *chlorpyrifos* and *endosulfan*. Of the total pesticide active ingredient used in the country, about 54 percent is *cypermethrin*, *monocrotophos* or *methamidofos* in one or the other form [Inayatullah 1997(1)].

2.4.1.4. Adulteration in Pesticides

Besides ineffectiveness, adulteration of pesticides is also quite common in the country. According to a press release which appeared in Business Recorder (1996), adulteration occurs in various ways. One is import related as the large quantity of pesticides is adulterated after shipment to Karachi. Importers dealing in pesticides mix a variety of cheap chemicals available in the market to increase their margins of profit. Another practice is related to the manufacturing stage. Pesticides are adulterated by the pesticide producing industries in the country. Also, 40-45 percent of the pesticides are adulterated by wholesale dealers and agents. Moreover, some of the retailers further dilute them and also sell the self-packed pesticides in small quantities.

The adulteration problem really rose after the introduction of the generic scheme in early 1990s, which allowed a large number of local investors to enter into this business. The adulteration has reached to the extent that most of the pesticides, having 50 percent a.i. (active ingredient) labels, were found with less than 3 percent a.i. This under-dosing, on the one hand, resulted in the failure of plant protection and, on the other hand, generated pest resistance. It will be difficult, thus, to control these pests even with higher doses of pesticides. Adulteration in pesticides is a serious issue, and the farmers often complain of poor quality pesticides. Under Agricultural Pesticide Rules, 1973 (amended), the fine in this regard was imposed ranging from Rs. 500-3,000. However, according the Agricultural Pesticides (Amendment) Ordinance, 1997, the adulterator can be imprisoned for three years and fined Rs. one million.

2.4.2 Environmental Consequences

We tend to associate the pollution problem with industrial activity, but agriculture, too, is a great polluter. Pesticides are seldom selective and application methods are often indiscriminating. Therefore, they can create pollution of soil, water and air. For instance, pesticides used to protect the crops from pests also harm non-target organisms considerably. The extermination of several species in the agro-ecosystem due to excessive pesticide use creates ecological gaps. Eventually, the whole agricultural ecology of the region is adversely affected besides health risks posed to workers involved in pesticide handling and application.

Pesticides harm the environment in many phases: firstly, in the process of manufacturing; secondly, when they are transported; thirdly, when applied to the crops; and fourthly, during their post-application period. There are many problems associated with pesticide use some of which are discussed in more detail in the next section.

2.4.3. Health Risks

Pesticides used in pest control programmes are also toxic to human beings, with degree of hazards differing from product to product. The World Health Organisation (WHO) has reported that exposure to pesticides is probably carcinogenic as well as toxic (WHO 1979). Some pesticides leave persistent residues in soil, ground water, and the food chain, thus, exposing human population to slow and cumulative poisoning. About 20,000 deaths and 37,000 cases of cancer, round the globe, are linked to pesticides annually, while, more than half of the injuries and about three quarters of deaths occur in developing countries. According to an estimate, 25 million agricultural workers, in the developing countries, suffer pesticide poisoning every year (PAN Asia 1995).

Box 3: DDT Poisoning in Zimbabwe

Two decades after Zimbabwe decided to ignore the ban imposed on DDT, its adverse effects on people and the ecological balance are beginning to show. Perhaps most disturbing have been the findings of a study conducted by the Kariba District Hospital where traces of DDT have been found in the milk of women living in Nyamhunga, a densely populated suburb in Kariba.

Zimbabwe has been using DDT to control its mosquito and tsetse-fly population since the late 1960s. The total use of DDT to control malaria has increased in the country, growing from 10 tons in 1980 to a staggering 300 tons in 1990, demonstrating that despite increased use of DDT, Zimbabwe has been unable to solve the problem at hand. The use of DDT has also taken its toll on flora, fauna and aquatic life. DDT has caused a thinning of egg shells among birds of prey, causing reproductive failure and reducing their population substantially. The health of the fish population in lakes and streams has also been adversely affected.

Also considered to be a cause of cancer and a number of other medical disorders, DDT is still freely used and available, due to its black marketing in Pakistan. Perhaps it's time we get up and took notice.

(IUCN 1997)

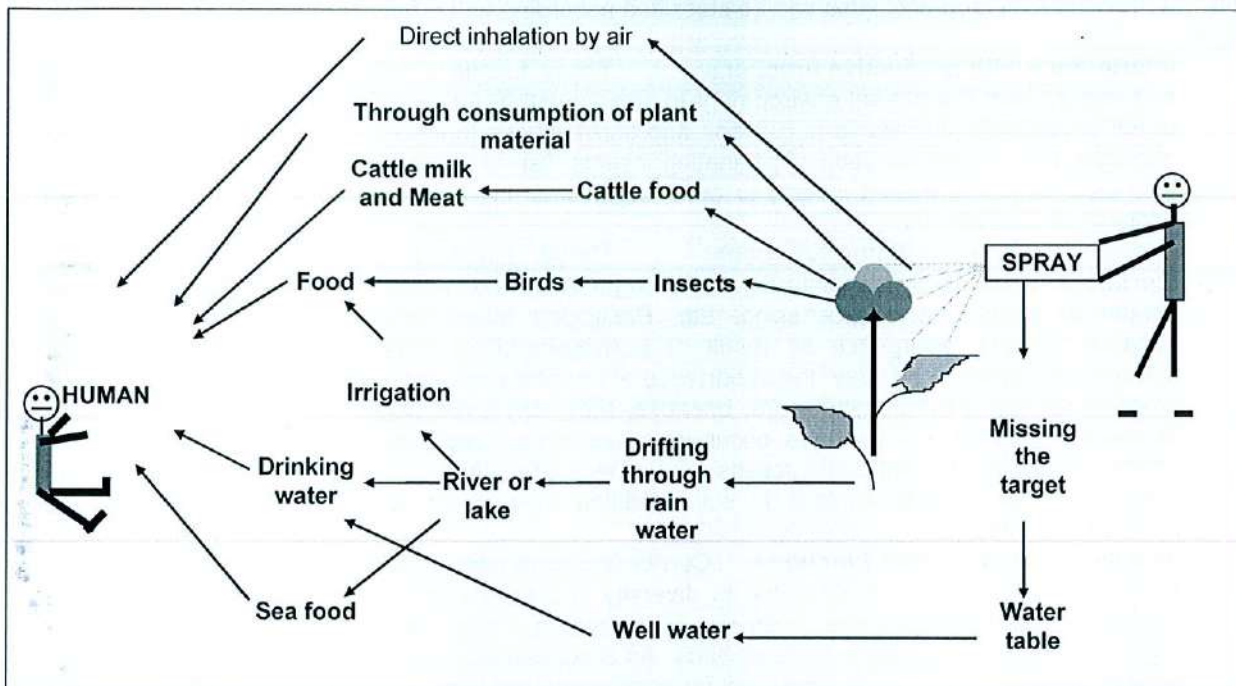
In general, pesticide-related illnesses became serious due to the earlier organochlorines (most notably DDT) (also see box 3). At the moment, organophosphates are even more toxic than DDT. Typical poisoning symptoms include, stomach cramps, dizziness, vomiting, and heavy sweating. Agricultural workers in pesticide applied areas face direct health risks. In Pakistan, cotton is picked up by women. While doing so they are exposed to pesticide residues. A study conducted in 1992 at Multan revealed that out of a total of 88 female cotton pickers, only 1% could be termed as out of danger (SDPI 1994).

Excessive use of pesticides has also given birth to the problem of pesticide residues in the food chain, which is a big threat to human health. Organochlorine pesticides, in particular, can persist in food stuffs for a considerable period. Similarly, if crops are sprayed just prior to harvest without an appropriate waiting period, even organophosphate residues may persist until the food is in hands of consumers. According to

PAN Asia (1995), pesticides found in rainfall, soil and ground water, contaminate our drinking water, and find their way through the food chain into our food, breast-milk, cow's milk, meat, vegetables and fruits. Fig. 2 shows various routes of pesticide intake into the human body.

In Pakistan, occurrence of pesticide residues in human milk, cotton-seed, and drinking water has been documented (PARC 1996). The use of highly toxic and persistent pesticides for the control of pests in edible crops, including vegetables, poses a serious health risk to consumers and the environment. The quality of life is deteriorating day by day. It is, therefore, necessary to reduce the use of pesticides and search for some other sources to protect crops.

Figure 2: Routes of Pesticide Intake into Human Body



3. Impact of Pesticide use on Crop Ecologies

Although, pesticides help control harmful insect pests, they disturb the agro-ecosystem in several ways. Pesticides, during their application in crops to control target pests, kill the non-target and environment friendly organisms such as soil fauna, pollinators, parasites, predators, and birds, directly. Moreover, pesticides also leave residues in soil and groundwater, which again lead to poisoning soil fauna and aquatic biodiversity.

Disturbance in an agro-ecosystem leads to new pest problems through resurgence and resistance processes in the naturally occurring pest populations. According to DeShazo and Theodore (1993), pesticides, when used in large quantities, lead to outbreaks of pests. Looking at the history of pest damage, 7% of crops were estimated destroyed by pests in the late 1950s; the crop-loss has almost doubled in the 1990s; while, pesticide-use has increased twelve-fold (PAN Asia 1995). All these facts show that the long term negative impacts of pesticides are far more serious than the visible consequences.

Most problems associated with pesticide-use arise from the fact that its use against a crop pest does not simply involve action of the chemical on the pest alone. The simple interaction can be represented by the notation:

Pesticide → Pest

In fact the interaction is between the pesticide and a complex biological system of which the pest is only one component. This interaction is more truly depicted by:

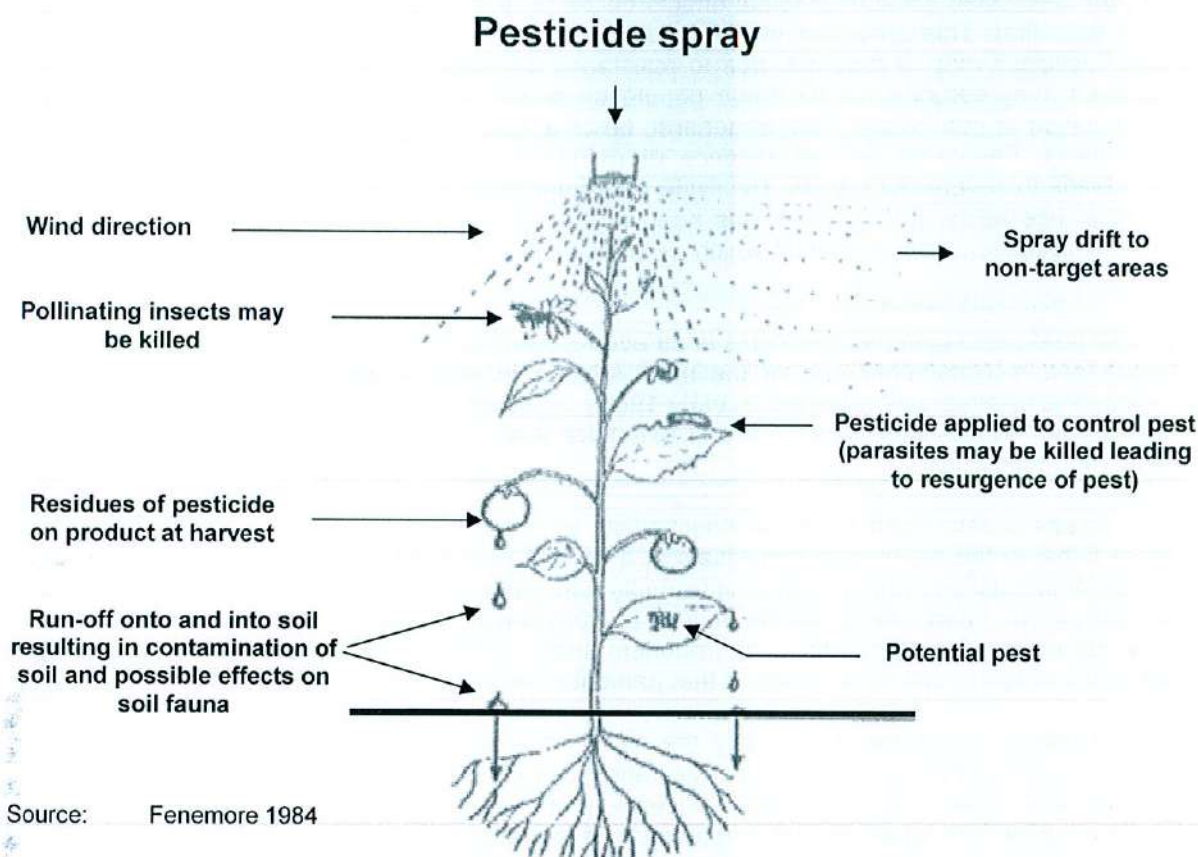
Pesticide ↔ Ecosystem in which the pest occurs

Impact of Pesticides on crop ecologies can be classified according to the functions of an agro-ecosystem, such as:

- a. **Interference with productive functions:** These functions refer to the supply of material and energy from the natural environment to society, either for direct survival (e.g. food, oxygen) or for construction and textile (e.g. wood and fibre). These functions, through pesticide use, are damaged due to extermination of pollinating insects; fish in contaminated lakes and rivers; birds who prey on contaminated insects or other organisms; livestock and other animals feeding on contaminated plants; etc.
- b. **Interference with regulating functions:** These functions comprise those ecological processes which annihilate disturbances brought about by human activities, such as, natural control of pests, waste processing, etc. Pesticides affect various regulatory functions of ecosystem. Pest resurgence as result of parasite/predator extermination appears to be a common phenomenon. Today, the importance of the pest's natural enemy complex in agricultural crops is recognised more and more, because, they may exert considerable natural regulation. Similarly, micro-climatic changes occur in cases where pesticides are used indiscriminately without following the right instructions and where the plant cover is altered by the use of herbicides. Subsequent changes in soil condition may cause soil degradation, erosion and decreased water retention capacity of soils.
- c. **Interference with Carrier functions:** Carrier functions refer to the ecosystem as substrate for human activities, e.g. recreation due to diversity in the ecosystem. The introduction of certain applications of pesticides has given rise to a serious impact on populations of various living organisms in the ecosystem, such as birds. As a consequence many habitats lose their natural attractiveness and recreational potential for people who like to enjoy the natural amenities.
- d. **Interference with information functions:** These functions indicate both information derived from the natural ecosystem for research and education as well as the potential information with resource value such as genetic sources of useful plants and animals. It is a matter of acute concern connected with the information functions that due to pesticide use, plants and animal species may be exterminated, which have resource value for future generations. The diversity of fauna and flora is decreasing in many countries and contribution by pesticides can not be excluded.

Pesticides effect the basic agriculture by altering the physiological processes of crops resulting in diminishing food quality and destroying soil biota (Sultan 1997). These consequences emerge due to the fact that a large amount of pesticide goes wasted and cause environmental degradation. The more understandable consequences of pesticide-use are summarized diagrammatically in Fig. 3. It shows how a major portion of pesticide applied to a plant hits the non-target areas of agro-ecosystem. The possible parts of an agro-ecosystem which might be affected by the pesticide spray are: beneficial insects/animals, non-target plants, wild life (animals, birds, fish, etc.), soil, water sources, air, and human life. All of these parts of an agro-ecosystem are inter-linked with each other, if any part is damaged, it may lead to a fatal disturbance in the agro-ecosystem and eventually, the pest may reappear in outbreaks.

Figure 3: Consequences of pesticide use for pest control



The ecology of an agricultural region comprises: diversity of crop plants; weeds; pests; natural enemies of pests; domestic and wild animals; human beings; soil; water; and air as its biotic and abiotic components³. Pesticides affect all these components, directly or indirectly. Given below are some visible ecological effects of pesticides.

i. Toxicological and Ecological Effects

Pesticides degrade the environment in many ways, but basically two types of side effects can be distinguished: the toxicological and ecological effects. Toxic side effects represent the result of toxicity of a pesticide for a certain non-target species. Direct toxic effects occur particularly with broad-spectrum pesticides, and gives rise to both acute, lethal effects and chronic, sub-lethal effects. While the indirect toxic effects are those which occur in the form of poisoning at a higher trophic level, in which organisms of lower trophic levels act as intermediaries or food.

The ecological side effects, on the other hand, refer to non-toxic effects on organisms. These effects take place indirectly, via food or habitat changes, or changes in competitor or predator species within a habitat. The food change means that organisms at higher trophic levels are affected by population extermination of their prey. The other ecological effects include resurgence of pests due to loss of their natural enemies, emergence of secondary pests, and development of pesticide resistance in pests.

3. Biotic components mean all living organisms in an ecosystem, whereas, abiotic components include all the non-living things.

ii. *Resurgence in Pests*

As long as the pesticides show their lethal effects on pests, the natural enemies of pest also suffer much more than that. This reduction in the natural enemy complex favours recovery of the pest population. Pesticides may or may not, due to resistance developed by pests, help in reducing the pest population, they certainly kill the large population of parasites/predators and other beneficial insects. Population of natural enemies, in general, takes a longer time to recover from the pesticide effect than pests. Eventually, in the absence of natural enemies, pests breed faster and their resurgence leads to severe out breaks. Pesticide treatment to control the Plant Hopper (*Nilaparvata lugens* Stal) in rice fields, for instance, has been known to result in an 800-fold increase in pest density, due to reduced spider predators which were also killed off (Kenmore 1991).

iii. *Development of Resistance*

Resistance of pest populations to pesticides is an ever-growing source of concern. It is a world-wide phenomenon and is considered one of the most serious threats to agriculture. The problem of development of resistance was recorded in early 1900s, however, it became widespread only during the last 40 years, following the discovery and extensive use of synthetic organic insecticides and acaricides (Georghiou 1986).

Resistance means a developed ability in insect pests to tolerate doses of certain pesticide which would prove lethal to the majority of individuals in a normal population of the same species. It is a characteristic of populations rather than of individuals and within population, some strains may show a natural tolerance to a particular pesticide. If such a strain constitute, say, 10% of the population it is that 10% which will survive after a pesticide treatment and go on to multiply. It means a much higher proportion of the offspring will be resistant to that particular pesticide.

The intensive use of pesticides is probably the most important reason for increased resistance. Heavy use of a single pesticide encourages the rapid emergence of resistant species because the only one that survive are those that acquire resistance. Repeated applications can also cause resistance to develop through an accelerated process of tolerance.

In Pakistan, resistance has been detected in Cotton whitefly and American Bollworm against commonly used pesticides. There is no information available about other cotton pests, like, jassid, aphid, pink bollworm, spotted bollworm and mites. Furthermore, the distribution of resistant population in the entire cotton ecosystem and its level of resistance is not known.

The impact of resistance development is multifold, firstly, the population of pests flare up, causing more damage to the crop; secondly, the money spent on ineffective pesticides is wasted; and thirdly, the pesticides are put into the environment without achieving any purpose with subsequent effects on parasites, predators and pollinators in the area. The most important economic impact of pesticide resistance is that the natural resistance in a crop variety breaks down due to the development of overwhelming insect populations, thus, valuable genes in a variety are lost and years of varietal research and development work is wasted. Furthermore, the insect may develop resistance to the compounds of other classes as well which may make the insect control even more difficult.

iv. *Loss of agricultural Biodiversity*

The agricultural biodiversity can not be conserved in an environment with hazardous pesticides. Some of the target and non-target organisms are affected directly, while most of the life present in the treated agro-ecosystem and in the downstream suffers for longer time. The non-target organisms may be parasites, predators, pollinators of crops, birds, livestock, rodents, reptiles, fish and other aquatic life. Toxic chemicals move through water and air, into soil, plants and animals. For instance, there are several predacious birds which feed on insects. Spraying of pesticides on an extensive area has definitely affected these birds by feeding the poisoned insects.

The extermination of pollinators, which play a vital roll in pollination, leads to lower crop yields. For example, in the cotton growing area of Punjab, where pesticides are sprayed 5-9 times per year (fig. 5), the yield of cross-pollinated crops, such as oilseed crops (toria, sarsoon, raya, taramera), sunflower, cabbage, cauliflower, radish, onion, guava, citrus, phalsa, etc. declines. Latif, et. al. (1960) reported that the honey bee, (*Apis cerana indica*) is the most important pollinator of 'toria' (*Brassica campestris*), and yields of toria increases by 60%, if pollinated by the honey bees.

v. *Residues in Soil and Water*

Pesticides used for pest control, eventually, ends up as residues in soil and water. Soil can be contaminated either through 'fall out' after crop spraying or through direct soil treatment with pesticides. The persistence or break down of these chemicals depends on the kind of chemical bonds in their compounds. Similarly, contamination of water by pesticide-affected soil residues is to a large extent a function of water solubility of a particular pesticide. Jabbar *et al.* (1993) reported that the soil and shallow water, in cotton areas of Sumundari, were contaminated with pesticide residues. Similarly, outdated pesticides, dumped in about 1900 sites of Pakistan, are a constant source of soil and ground water contamination (Box 4).

Box 4: Dumps of Banned Pesticides in Pakistan

Use of persistent organic pesticides began in the 1950s when the GOP began importing DDT and BHC for malaria control. In the late 1970s, Pakistan imported pesticides in far greater quantities than actually required and were stocked for future. Reasons for accumulation of stockpiled pesticides are: a) excessive, inappropriate and late arrival of donations; b) leftovers from the former east Pakistan's stocks; and c) improper and prolonged storage of products with short shelf-life. Moreover, an agreement between the GOP and pesticide corporations prevented further distribution of these stocks (Greenpeace 1998). In 1987, the World Environment Centre (WEC) estimated that a stockpile of about 5,000 metric tons of expired pesticides were stored at about 1900 sites all over Pakistan. Of these outdated pesticides, about 3,000 metric tons are dumped in Punjab and Sindh, while, 1,855 metric tons are dumped in Peshawar, NWFP (EPA/GTZ, 1998).

There is evidence that the pesticides which have seeped out of the drums and bags have found their way into the groundwater. Studies conducted at HEJ Research Institute of Chemistry, Karachi, have shown that, in groundwater around Malir, a number of pesticides and residual compounds are present.

Likewise, in Sahiwal, the soil around the pesticide warehouse is contaminated with pesticides. According to a USDA report, about 70 tons of various pesticides have been lost through leakage and container deterioration. Besides constant threat to the environment, these stores act as the major source of banned pesticides which are available in the black-market.

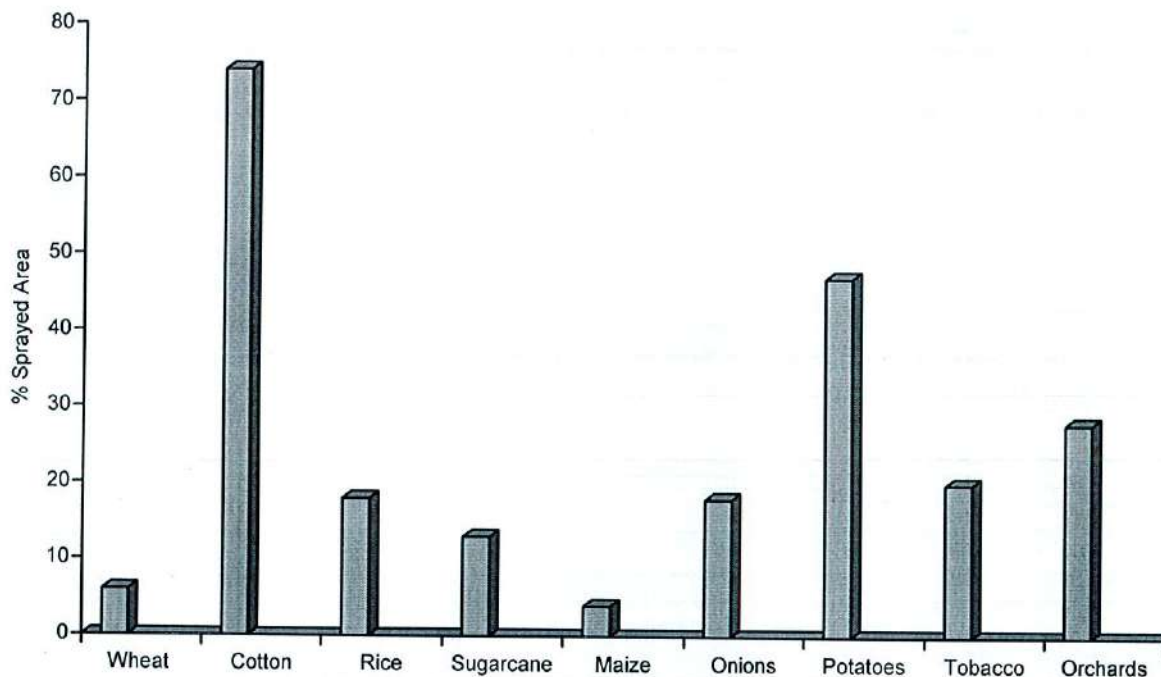
(SDPI/WWF, 1998).

3.1. Case of Pakistan's Cotton Crop Ecology and Pesticides

Cotton is the most important cash crop cultivated in Pakistan. It is the country's main source of foreign exchange earnings. Pesticide use on cotton has increased drastically since last decade and more pesticides are applied to cotton than to any other single crop. Figure 4, is about the use of pesticides on important crops (% of total cropped area), which shows that cotton receives maximum pesticides as compared to other crops. According to SDPI (1996), almost 70% of pesticides are used for cotton pest control, annually, in a period of only four months (June-September).

The increased and indiscriminate pesticide-use has damaged the whole ecology of the cotton growing areas in many ways. On the one hand, farmers lost the natural control agents at their farms (parasites/predators of pests), while, on the other hand, pest populations and their variety have also increased.

Figure 4: Use of Pesticides on Important Crops



SDPI has initiated the current study with an assumption that pesticides have modified the cotton ecology in the area negatively. A survey has been conducted in Multan and Faisalabad to investigate the history of pesticide use on cotton, change in cotton pest and parasite/predator complex, and the development of IPM technologies overtime. For this purpose, a number of research scientists, farmers and pesticide company officials were interviewed (Annex 12) using a structured questionnaire (Annex 13). The findings of the survey are summarised below:

3.1.1. Pesticide-use and Cotton Pest Complex in Pakistan
 3.1.1.1. Situation before 1980s

Till 1960, there was almost no pesticide use in agriculture and farmers were not aware of the synthetic pesticides. On cotton, during this period, only the Cotton Jassid (*Amrasca devastans* Distant; Hemiptera; Cicadellidae) was a major pest in most of the regions. While, in some areas, near thick vegetations or forests, the Cotton Leaf Roller (*Sylepta derogata* Fab.; Lepidoptera; Pyraustidae) was also a major pest. However, in early 1970s, with the development of hairy varieties, resistant to Cotton Jassid, solved the jassid problem to a great extent. To reduce the incidence of Cotton Leaf Roller, practices like land development, crop rotation, altering time of sowing and harvest, and trap crops, were adopted.

Although, the GOP started importing pesticides during the early Sixties, they were not used for the cotton crop. Even by 1980, pesticide use in cotton was limited to only few big cotton growers and generally, the rest of cotton growers were able to produce their crop without spraying pesticides.

Till 1980, as mentioned earlier, the government agencies controlled the import, and subsidised distribution of pesticides, which were used, mainly, against mosquitoes, desert locust, and fruit and vegetable pests.

3.1.1.2. Situation after 1980s

After 1980, when the private sector was allowed to step-in for pesticide production, import and its marketing, total pesticide consumption increased manifold (from 665 tons in 1980 to 3,677 tons in 1981), whereas, cotton became major target-crop for the pesticide business. As already mentioned above, Cotton Jassid was the only key pest at that time, while, Cotton Pink Bollworm (*Pectinophora gossypiella* Saunders; *Lepidoptera*; *Gelechiidae*), Cotton Spotted Bollworm (*Earias insulana* Bois. and *Earias vitella* Fab.; *Lepidoptera*; *Noctuidae*), American Bollworm (*Heliothis armigera* Hubner; *Lepidoptera*; *Noctuidae*), Cotton Aphid (*Aphis gossypii* Glover; *Hemiptera*; *Aphididae*) and Cotton Whitefly (*Bemisia tabaci* Genn.; *Hemiptera*; *Aleyrodidae*) were of no more importance.

The American Bollworm appeared, for the first time, in the form of a major pest with the introduction of deltapine varieties of cotton in early 1980s⁴. Pesticides gained large scale popularity since then. Also, in 1982-83, the cotton crop, due to rains and favourable climatic conditions, faced a severe pest attack and the crop failed to produce the economical production except in those cotton farms where pesticides were sprayed against pests on large scale (Table 1). Farmers got convinced of the efficacy of pesticides and adopted pesticides as

necessary input for cotton production. Since that time, the Pyrethroid pesticides, besides organo-phosphatic pesticides, became very popular and are still used on a large scale.

Eventually, the extensive use of pesticides since 1982, further changed the pest complex. The Cotton Pink Bollworm, Cotton Spotted Bollworm, Cotton Whitefly and American Bollworm, began to appear as major pests after the 'resurgence' process besides Cotton Jassid. During this stage, the population of Red Spider Mite (*Tetranychus cinnabrinus* Boid.; *Tetranychidae*; *Acarina*) also increased and was introduced as a new cotton pest. However, until 1988, a quarter of smallholder (less than 5 hectare) cotton farmers were producing their crop without using any pesticide (Bioscience Centre 1998).

In 1988, resistance in Cotton Whitefly was detected at CCRI, for the first time. Cotton Leaf Curl Virus (CLCV), (which is transmitted by the Cotton Whitefly) started spreading in 1988, especially, in S-12 cotton variety, a renowned susceptible variety to Cotton Whitefly. Since then CLCV has become a key problem for the cotton crop. The area affected and production loss due to CLCV in the Punjab, from 1988 to 1997, is given in Table 2.

Table 2: Area Affected and Production loss due to CLCV in the Punjab (1988-1997)

Year	Affected Area (000 Hectares)			Loss in Production (000 bales)	Percent Loss in Production
	Partial	Complete	Total		
1988-89	--	0.06	0.06	0.3	0.001
1989-90	--	0.20	0.20	1.0	0.013
1990-91	--	0.80	0.80	4.0	0.047
1991-92	11.3	2.80	14.10	20.0	0.047
1992-93	364.0	121.00	485.00	750.0	0.175
1993-94	607.0	282.00	889.00	1880.0	28.821
1994-95	407.0	notavailable	407.00	221.0	2.982
1995-96	882.0	notavailable	882.00	447.0	5.126
1996-97	1623.9	137.40	17621.30	2100.0	29.563

Source: Survey Data, Cotton Commissioner Office, MINFAL 1998.

In early 1990s, the Government of Pakistan allowed the import of pesticides under the generic scheme in the country, which encouraged various local investors to enter into this business. Although, the scheme stabilised

4. Deltapine varieties mean the American varieties introduced by an American multi-national seed company called DELTA.

the pesticide prices, but unluckily, the adulteration problem in the pesticides became common. Eventually, Cotton Whitefly and bollworms developed resistance against the ineffective chemicals (Table 3). The Cotton Whitefly became a key damaging pest since then. The dramatic increase in pesticide use since early 1990s has been aimed at three main pests in cotton: the Cotton whitefly, Cotton Jassid and three bollworms.

Table 3: Level of Resistance in Different Pests Against Pesticides

Pesticides	Resistance in	
	Whitefly	American Bollworm
Cypermethrin	300 fold	26-168 fold
Monocrotophos	20-139 fold	19-720 fold
Methamidophos	40-492 fold	Not known
Chloropyrifos	Not known	2-8 fold
Endosulfan	22 fold	16-36 fold
Profenofos	56 fold	9-13 fold
Cyfluthrin Thiodicarb	2000 fold Not known	Not known 3-14 fold

Source: Inayatullah 1997 (1).

For the last five consecutive years, Cotton Whitefly, and consequently the Cotton Leaf Curl Virus, are appearing in outbreak forms. In addition, cotton aphid also appears in outbreak form, but late in the season. Although, the latter pest does not inflict much loss in yield at that time, it makes cotton lint black and covered with honey dew on which sooty mould fungus grows, thus affecting the quality of fibre.

All these facts show that, with the introduction of pesticides in cotton, pest problems have increased. More than a dozen insignificant pests have attained a status of major pests. Moreover, residues of pesticides in soil and water are also affecting the ecology of the cotton growing areas.

3.1.2. Pesticide-use and Cotton Natural Enemy Complex

One of the major reasons of enhanced pest complex in cotton is the non-availability of natural enemies of pests. Indiscriminate pesticide-use overtime has destroyed the population of natural enemies. A rich agricultural biodiversity ensures presence of plenty of parasites and predators of pests, which provide natural/biological pest control. Pesticides, when used irrationally, destroy the natural enemy complex far more than the target pests. Since pesticides are biocides, they are intrinsically dangerous for other non-target and environment friendly species, and, therefore, have unwanted and unanticipated side effects. Eventually, pests breed faster in the absence of its natural enemies and emerge in outbreaks.

According to Forrester (1994), pesticides help little but destroy far more, because, almost 95% of pesticides applied to crops hit the non-target areas. Similarly, PAN Asia (1995), has reported that less than 10 percent of sprayed pesticides reach their target crops; and less than 1% reach target pests. The rest of the pesticide contaminates soil and water (Fig 3).

In Pakistan, no work has been done on pesticide's impact on the population of various natural enemies of crop pests. The information we collected during the current survey is reported below.

Prior to 1980s, when the pesticide-use in cotton was not common, various parasites and predators were found in plenty. According to Bioscience Centre (1984), following important parasites/parasitoids⁵ and predators of important insect pests of cotton were identified in the field during 1980:

- a. **Parasites/Parasitoids:** *Apantelese angaleti* Mues., *Apantelese syleptae* Ferr., *Apantelese significans* Wlk., *Chelonus* sp., *Habrobracon hebetor* Say., *Phanertoma hendecasisella* Cam., *Bracon gelechia* Ashm., *Bracon greeni* Ashm., *Bracon hebetor* Say., *Rogas testaceus spinola* and *Rogas*

5. A parasite is an organism which lives inside its host for generations and does not need to pass any of its life stage outside the host. While, a parasitoid is usually much smaller than the host and necessarily passes one of its life stages outside the host.

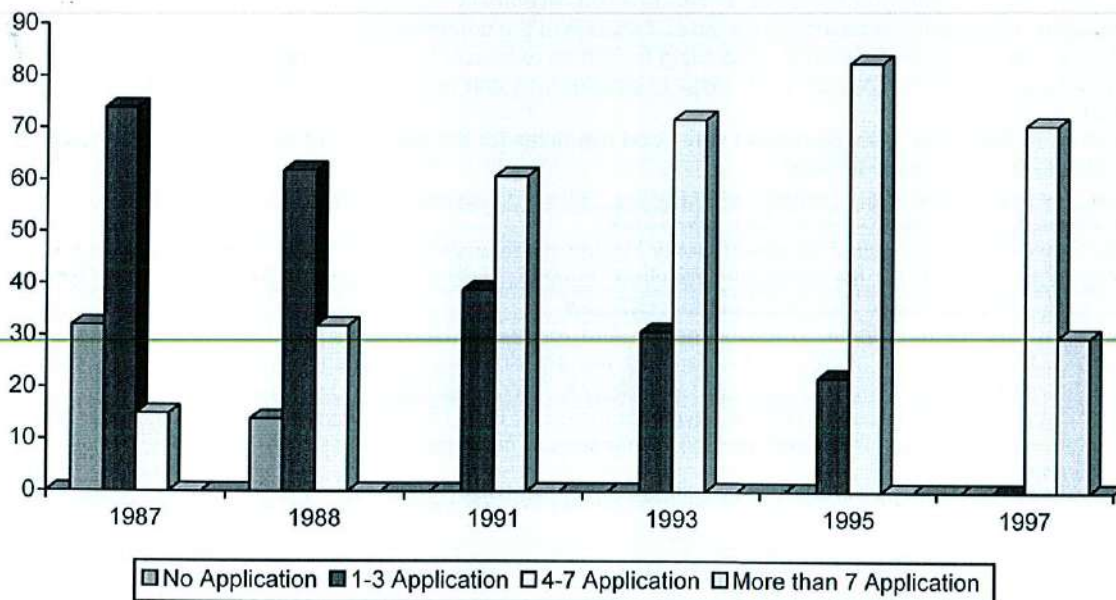
aligarhensis Qadri (Braconidae); *Gnizus* sp. (Bethyidae); *Elasmus johnstoni* Ferr. (Elasmidae); *Goryphus mursei* Cam., *Netelia ocellaris* (Thom.), *Campoletis chlorideae* Uch., and *Xanthopimpla punctata* (F.) (Ichneumonidae); *Trichogramma chilonis* Ishii and *Trichogramma brasiliensis* Gir. (Trichogrammatidae); *Eurytoma syleptae* Ferr. (Eurytomidae); *Exorista xanthaspis* Wied. (Techinidae); *Encarsia* sp., *Encarsia tricolor* Fores, *Eretmocerus corni* Hald., *Eretmocerus mundus* Merc., *Prospaltella flava* Sha., *Prospaltella lutea* Masi, Parasitic mite, fungus *Paecilomyces* sp.

- b. **Predators:** Lacewing *Chrysoperla carnea* Steph. (Chrysopidae); *Orius albidipennis* Reut. And *Formicormis caesuleipennis* Laf. (Anthocoridae); *Geocoris tricolor* (F.) (Lygacidae); *Coranus spiniscutis* Reut. And *Rhynocoris fuscipes* F. (Reduviidae); *Paederus fuscipes* Curt. (Staphylinidae); *Laius malleifer* Cham. (Malachiidae); ladybird beetle *Coccinella* spp. (Coccinellidae); spiders, big eyed bug, pirate bug, rove beetle, carabid beetle, predatory mite, assassin bug, and ants.

In an interview with Mr. Rafiq Ramay, a senior Entomologist at CCRI, the population of natural enemies has declined by 80-90 percent in the last ten years and is still declining. Similarly, Dr. Ashraf Poswal, Scientist-in-Charge, Biosciences Centre, mentioned that an important parasitoid *Encarsia* spp. is now not available in the cotton growing areas. According to the same source, no scientific study has been conducted in Pakistan directly on the impact of pesticides on the population dynamics of natural enemies of important pests and the ecology around. According to him, such a study is very needed to understand the rate of deteriorating ecology of the region due to pesticide use.

Since the last three decades, Bioscience Centre has mass-multiplied and augmented various local and imported parasitoids/predators in cotton areas. Though they have recovered the augmented parasites/predators establishing in the cotton fields, however, these never survived for long periods due to extensive use of pesticides in surrounding areas. The rate of pesticide use can be seen in the Fig 5, which shows that farmers are applying 5 to 9 sprays on cotton each year.

Figure 5: Frequency of Application of Pesticides by Cotton Farmers (1987-97)



Source: Biosciences Centre 1998

4. Alternatives to Pesticides

Governments, environmental action groups, farmers, and consumers across the globe are taking great interest in monitoring the environmental and human health risks associated with pesticides. Thus, the trend now is to develop/practise alternatives to pesticides or use selective and safe pesticides. In fact, the technological solutions that promise a more sustainable and environment friendly control of pests do exist, but never practised on a sufficiently large scale. These solutions range from such techniques as plant resistance; cultural, mechanical, physical, chemical, biological pest control; and pest quarantine; to integrated pest management (IPM), which requires farmer's hard work and a cultural change.

Several measures in different countries have been taken to reduce the use of pesticides (Box 5). In Pakistan, unfortunately, farmers have not been able to develop alternatives to chemical pest control, largely because of government's pesticide oriented agricultural policies. Similarly, the research work regarding alternatives to pesticide or IPM is still limited to agricultural scientists, research stations, experimental plots and research reports. Farmers, however, do not have any choice against pesticide use at the moment.

Box 5: Parameters Adopted by Various Countries to Cut Down the Pesticide Use

Several measures in different countries have been taken to reduce the use of pesticides. For example Netherlands, the world's 2nd largest agriculture exporter, has cut down the pesticide use by 35% surprisingly. Similarly Denmark, Sweden and Canada has been very successful to reduce the pesticide use by an average of 30-40% respectively using the following parameters:

1. **Agriculture Extension Training and Research:** In Sweden a comprehensive three days 'Spray Training' is provided so that pesticides may not be wasted during application.
2. **Legislation, Regulation & Taxation:** Certain legislation and regulation has been implemented which allows the use of only permissible pesticides. Certain taxes have also been introduced to reduce the pesticide use. For example, in Sweden a tax of \$1.5/kg of active ingredient generates \$3.5 million per year to finance research and extension work in agriculture and forestry. Another tax of \$8.5/ha. has been levied to control the dosage of pesticides. The taxation, eventually, resulted into i) development of new technologies; ii) reduction in pesticide use; and iii) change in the cropping pattern.
3. **Land Use and Set-aside Schemes:** According to Danish research, farmers can agree to follow specific land management plans, many of which restrict pesticide use and receive compensation for fulfilling the contract.
4. **Incentives to Farmers:** Canada has set very good examples for the reduction of pesticide use by giving incentives to farmers. These include:
 - a) **Income Tax Concessions:** Farmers undertaking certain conservation practices, e.g. reduction in pesticide use, could be eligible to pay less income tax.
 - b) **Capital Cost Incentives:** Just as governments include other businesses to adopt certain practices by allowing faster write-off for the machinery required, farmers could be offered an accelerated write-off capital equipment purchased as a substitute for pesticides.
 - c) **Conversion Grants/Incentives:** One-time grants and /or compensations for the lost income, over a period of years, could be offered to the farmers making dramatic reduction in pesticide use. Such incentives could stimulate investment in new technology to further reduce pesticide use.
 - d) **Income Support:** Farmers can be offered payments based on units of area where specified management conditions have been met. This could provide a measure of financial security for the transition to lower pesticide use.
 - e) **Equipment Maintenance Subsidies:** The cost of testing pesticide application equipment could be offset with grant/subsidy.

(Qasmi 1997)

According to Fenemore (1984), good plant protection practices can attain an effective control of pests and ensure better yields. The basic steps of good plant protection are: a) be able to identify the pests; b) know of the beneficial insects present; c) know economic threshold levels; d) do pest scouting; e) choose the right pest control tactic/procedure at the right time; f) give preference to non-chemical pest control measures; g) if a pesticide's application is necessary, choose the right pesticide (to maintain natural

balance in agro-ecosystem, a pesticide should only be applied if it is really necessary); h) use recommended dose of the pesticide; and i) use correct pesticide application method.

4.1. *Potential Pesticide-alternatives*

Discussed below are various potential alternatives to pesticides, which can be employed individually or in a mix way. At the end, principles of safe pesticide-use, and pesticide-reduction through institutional collaborative efforts, are also discussed.

4.1.1. Biological Control

Biological Control (controlling pests either by introducing, augmenting or conserving their natural enemies) is very successful as an alternative to pesticides (Waage 1991). This sustainable method of controlling pests is non-polluting, species specific and its effects are cumulative and long lasting in reducing pest populations. Biological agents may be predators, parasitoids, pathogens or competitors of the target pests (including animal, weed, and disease pests). Many other valuable pest control tactics, such as the use of pheromones or host plant resistance, are often included in agents of biological control.

A few years ago, it could be said that biological control was only an interesting subject of largely research scientists in universities and government research institutions. Today, it is increasingly the interest of government policy makers, aid organizations, agricultural extension services, local community groups and non-government organizations, farmers, foresters, grazers and the environmentally-conscious food consuming public in many countries. Much of this rapid expansion of interest can be attributed to the problems perceived with chemical pesticides, on the one hand, and the search for sustainable and natural pesticide-alternatives, on the other hand, which the biological control can provide.

Where the natural enemies, present in an agro-ecosystem, are insufficient for effective pest control, the augmentation of natural enemies is the best possibility to control pests without harming the environment. A range of natural enemies can be mass produced and released into crops at a synchronised time. In Pakistan, for example, an egg parasitoid *Trichogramma chilois* and a larval parasitoid *Apanteles flavipis* have been mass produced by the Bioscience Centre and were augmented, successfully, against stem-boring moths and bollworms in sugarcane, maize and cotton crops (Bioscience Centre 1984). Today, augmentative methods are also being focused on the pathogens of pests. Virulent pathogens, so-called bio-pesticides, that attack pests, can also be mass produced in the laboratory and applied as a pesticide.

In Pakistan, the Bioscience Centre-Pakistan, (with its head quarter in UK), is a specialised international institution of biological control, working since the creation of Pakistan. It is dedicated to promote biological means of pest control and their integration into sustainable pest management systems through co-operative research, training and information, according to the needs of the country. The institute has mass reared several indigenous species of parasites/predators and augmented these through its well trained technical staff through out the country. The centre has also introduced several useful natural enemies of important pests from other regions of Pakistan and foreign countries. The Bioscience Centre claim a higher level of success in the field of biological control. Today, biological control is a main component of their IPM programmes which are being run successfully.

4.1.2. Botanical Pesticides

In contrast to synthetic pesticides, the plant kingdom is full of the most-efficient 'natural factory' of pest controlling compounds (Anonymous 1992). Numerous plant ingredients are highly toxic to a wide spectrum of pests, but most of them are less toxic or non-toxic to mammals and vertebrates.

The seriousness of the pesticide problems led some scientists to develop non-chemical, plant-derived, pesticides. As a result, some plant derivatives are now available in the market which are safer health-wise

and environment friendly than the synthetic pesticides, for example, Parathroids, Morgosam, Juliflorin, Fenaremol, Triarimol, and Nimboli. However, these are not used widely, perhaps, due to their limited availability, unawareness, and its slow action as compared to synthetic pesticides.

The use of plant pesticides is not a new idea. Some pesticides of plant origin have been in use for a long time; for instance, pyrethrum, obtained from heads of *Chrysanthemum* sp., was known during the time of the Persian King Darius in 486-521 B.C. (Schmutterer 1995). Nicotine and derris (rotenone) were used in previous centuries and some others are still in use, although on a limited scale. *Neem*, for example, has long been used due to its pesticidal qualities, to prevent crops and stored food products from pests. It is a tropical, evergreen tree of mahogany family, and is indigenous to the subcontinent (Pakistan and India). *Neem* contains *Azadirachtin*, one of the most powerful insect repellents ever discovered.

It seems that this new generation of 'soft' pesticides that allow people to protect crops through sound ways will provide the best alternatives to chemical pesticides. The tabulated outcome of USC Canada-Nepal project on 'Integrated Community Development Programme for Natural Pesticide Development' in Nepal is reported in annex 11. It has the usage and results/impacts of using pesticides extracted from various plants. All these natural pesticides are being used in USC project Areas. The results are very encouraging on a variety of crops.

4.1.3. Organic Farming

The concept of ecological farming has existed in the literature since the 1970s. Initially, it referred to forms of agriculture whose production-technology was adapted to the soil and climatic conditions at the farming location. Later, the concept was broadened to include social and economic aspects. For some years now, the concept of organic farming has also been gaining ground world wide (Hoesle 1997).

Organic farming is based on traditional agricultural methods of a region, which can be practised using inputs available on the farm. Preference is given to local material cycles. Natural accessory agents such as green manure in crop rotation and *neem* plant extracts for crop protection, can be used. The principle behind organic crop protection is to organise the whole cultivation system so as to favour its own natural powers of self-regulation. If these are not sufficient, natural accessory agents must be used. However, as a matter of principle, organic farming excludes the use of artificial production inputs such as mineral fertilizers and synthetic pesticides, including genetically engineered organisms. This applies to both the production process as well as to any further processing of products.

For the cotton crop in Pakistan, for example, an organic farming model can be as follows:

- Soil fertility can be maintained through application of organic manures such as farm yard, green and compost manure; poultry excreta; crop residues; and through encouragement of effective micro-organisms in the soil.
- Similarly, for proper plant protection, biological control based IPM can be applied by encouraging natural enemies and augmentative releases of parasitoids/predators to control different pests.
- In addition, cultural practices such as proper thinning, weeding, crop rotation, destroying the left over bolls, altering the time of sowing and harvesting, removal of alternate host plants of serious pests, can be carried out to manage pests and increase the fertility of soil.
- Currently grown varieties can also be evaluated for resistance against pests.
- In case of severe pest attack, indigenous botanical pesticides, especially *neem* extracts, can be applied to control pests instead of synthetic pesticides.

4.1.4. Integrated Pest Management

No single method alone can control all the pests or even single pest under all situations (Salim 1998). It is therefore, essential to adopt integrated approach for effective and economical pest control. The Integrated Pest Management (IPM), one of the best alternatives to pesticides, is a common-sense method that farmers have used for centuries. It relies on a complementary mix of tactics, including biological control; growing resistant varieties; altering the time of sowing and harvest; careful planting; crop rotation; agricultural practices like hoeing, removing crop residues; and if needed, the selective use of both synthetic pesticides or naturally occurring botanical pesticides. IPM is fundamentally different from other approaches to pest control as it aims: i) to utilise several pest control techniques together in an integrated fashion, ii) to make maximum use of natural mortality factors, and iii) to apply specific control procedures only as and where necessary.

IPM may be defined as "the use of all appropriate techniques of controlling pests in a compatible manner that enhances, rather than destroys, natural control and maintains pest populations at levels below those causing economic injury". Pesticides, if part of the IPM programme, must be applied only in a way to provide a safe food supply, a clean and healthy environment, and a productive and profitable agriculture. Pesticides should also be used selectively so as not to interfere with natural enemies.

Historically, the IPM, first termed as 'integrated control', was developed and introduced as a concept in California in the late 1950s (Fenimore 1984). Integrated control was developed to bring together chemical and biological control. The concept was based on the premise that pesticides, if applied at the correct time and at the correct pest population level, could have a minimum impact on the natural enemies of the pest. Although the name was changed from integrated control to IPM, the integration of chemical and biological control remained the major theme of IPM throughout the 1970s. As secondary effects, particularly the negative effects relating to human safety and the environment, created greater public concern and as pesticide resistance became more prevalent, IPM became more balanced in this approach. The focus of IPM began to shift to non-pesticidal tactics in the 1980s, including expanded use of cultural controls, pest-resistant plants, and biological control (Fenimore 1984). Although pesticides still play a major role in modern agriculture and are likely to continue to do so in the future, the clear trend is that their use is being moderated through IPM (Box 6).

Box 6: Successful Stories of IPM around the Globe

Cotton IPM has been successful in several countries, e.g., USA, China, Australia, Mexico, Colombia, Nicaragua and Brazil. Using a mix of chemicals, biopesticides (BT), pheromones and natural predators and parasites, these countries have arrested the growth of pests. In China, pesticide use on cotton has declined by 34% and yields have increased. The Chinese strategy included: planting of sorghum between cotton plants to attract natural enemies of cotton pests, changing tillage practices and selectively applying chemicals in the lowest effective doses. In Mississippi, because of the use of IPM, the increase in net returns was \$ 122/ha (state-wide return \$ 29.68 million) whereas it was \$ 282/ha in Texas (state-wide return \$215.83 million). Pesticide use in USA has dropped by 75% (6.63 kg/ha in 1971 and 1.68 kg/ha in 1982) because of strict adherence to the IPM policy.

(Inayatullah 1995)

4.1.4.1. IPM in Pakistan

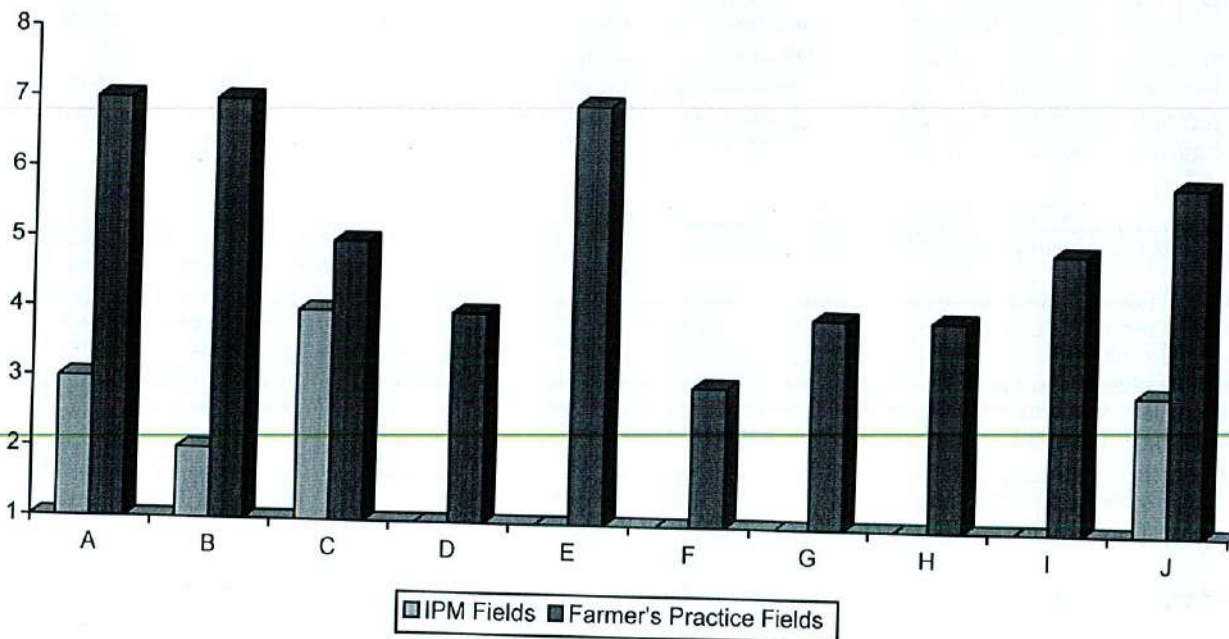
In Pakistan, research on IPM was initiated in 1971 by the Pakistan Agricultural Research Council (PARC), in collaboration with PARC-IIBC Station, Rawalpindi (now called Bioscience Centre-Pakistan). A seven-year PL-480 funded project on cotton bollworms, a three-year PL-480 project on cotton whitefly, and an institutional three-year support project on IPM, funded by the Asian Development Bank, were the first IPM projects. Similarly, other IPM programmes like introduction of natural enemies of sugarcane pyrilla in Sindh and NWFP; cultural control of Gurdaspur borer in the sugarcane; pheromones (methyl eugenol) for controlling fruit fly; and effective and environment friendly use of pesticides against cotton pests, were also carried out by these two research organisations.

The National Agricultural Research Centre (NARC), Islamabad, is also involved in developing IPM technologies for major crops. According to Salim (1998), IPM techniques for managing rice pests, for example, has been developed at NARC. It is mix of cultural control practises, varietal resistance, biological control, microbial control and chemical control.

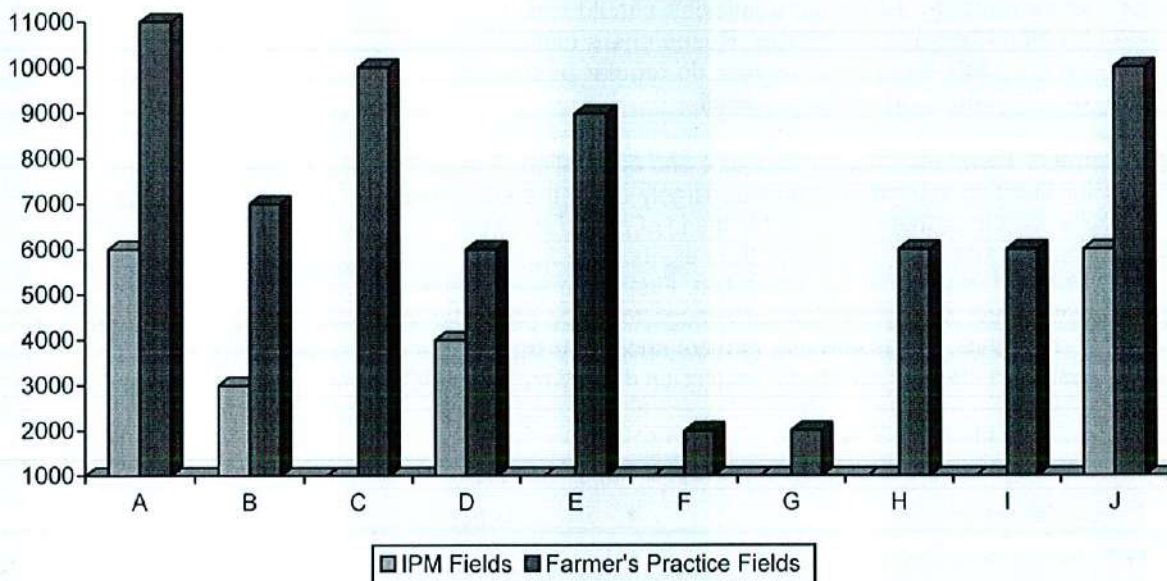
The private sector IPM programmes have got more success than the public sector. Among these, the Bioscience Centre-Pakistan, Rawalpindi, has developed IPM technologies for cotton, sugarcane, maize, fruits and vegetables, which are named 'biological control based IPM technology' and claim its transfer to farmers in their project areas. At present, the centre is running several IPM projects on cotton, sugarcane and fruits, successfully.

Very recently, the Bioscience Centre-Pakistan, has carried out a project, funded by the Asian Development Bank, on 'Cotton IPM Implementation through Trainings of Trainers (TOT) and Farmer Field Schools (FFS)' at Vehari District. Farmer's practice (FP) and IPM fields of at least 0.5 ha were set up in each of the ten FFS sites. No pesticide applications were made on IPM fields, allowing natural enemy populations to build up. In contrast FP fields had already received 3-7 sprays over the same period. Rich complexes of natural enemies were found in all IPM plots and the absence of pesticides allowed these natural enemies to exert effective control over whitefly, jassid and bollworm pests. Seven of IPM plots yielded higher than the FP plots (Fig 6). These yield figures provide a resounding confirmation of the ability of natural enemies to keep cotton pests in check and convincing farmers to reduce pesticide-use in cotton. Moreover, IPM practices also help reduce input cost (figure 7). The profit margins of the FFS groups involved in IPM practices also increased. The IPM plots holders spent an average Rs. 1,974 per hectare on pesticides (range 0-5,725) compared with Rs. 6,066 on FP (range 2,051-9,958); a reduction of 67% (Bioscience Centre 1998).

Figure 6: Cotton Yields in IPM Vs Farmer's Practice Fields



Source: Bioscience Centre 1998

Figure 7: Cost of Pesticides Used on IPM Vs Farmer's Practice Fields

Source: Bioscience Centre 1998

The Ciba-Geigy Pakistan (now called NOVARTIS, Pakistan) is also developing IPM technologies and transferring it to farmers. The technology is called 'chemical control based IPM'. Ciba claims that being one of the biggest, standardised and progressive pesticide company in Pakistan, they spend about one million rupees every year, to develop chemical control based IPM and environment-friendly use of pesticides (SDPI 1998). Ciba, through its Ciba-IPM laboratory in Multan, has developed several chemical control based IPM programmes in collaboration with farmers at their fields, especially for cotton and vegetables. Since the initiation of Ciba-IPM laboratory in 1991, it is still actively engaged in chemical control based IPM activities and also desires to expand research on other important crops (Ciba-Geigy 1997).

However, it is a matter of high concern that all these projects have not had a serious impact on pesticide-reduction at large. Inayatullah (1995) has listed several major reasons for this failure, such as: i) the limited nature of the project and no efforts to mainstream it in the functioning of major research institutions; ii) the extension system is not equipped to handle updated IPM research, since there are hardly any avenues for training extension staff regarding IPM; iii) agricultural educational institutions do not provide training or specialisation in IPM, to ensure a steady stream of experts for staffing research, education and extension departments; and iv) different views advocated by different experts. At the moment, IPM has different meaning at different forums. It is very difficult to develop an effective IPM programme under such a situation.

4.1.5. Pesticide-reduction through Environment Friendly Use of Pesticides

Farmers, in the beginning of the pest attack, can select non-chemical pest control procedures such as: cultural, physical and biological control. A safe and selective pesticide may be selected if the pest attack becomes severe, touching the economic threshold level⁶. The threshold levels can be monitored from time to time through the assistance of a local Agricultural Officers. Since, pesticides are of various

6. Economic threshold level is the pest density at which pesticides should be applied to prevent an increasing pest population/infestation from reaching economic injury level, which represents the lowest pest population that causes economic loss.

types, however, plant derivatives or soft pesticides and synthetic chemical pesticides are quite common. It is needed that farmers should be motivated to use non-toxic soft pesticides such as *neem* and tobacco leave extracts. Chemical pesticides should only be used in extreme conditions when all other control methods become ineffective. Researchers claim that if resistant crop varieties are sown; farmers can identify pests and useful insects; do regular pest scouting; and apply IPM strategies; there would be no need for chemical pesticides at all.

In Pakistan, farmers' knowledge regarding choice and application of pesticides is very weak (Forrester 1994). The baseline for deciding a pesticide depends largely on: i) the sharpness of the sales man of a pesticide company to convince the farmers to select his brand of pesticide; ii) the feedback which they receive from the print and electronic media; and iii) copying the neighbouring farmers. One of the most important causes of pesticide misuse is defective pesticide application. Firstly, the spray equipment are faulty, and secondly, the applicators/operators are, mostly, not trained enough to apply pesticides effectively and in an environment-friendly manner. It is, thus, suggested that farmers should be trained, particularly in selecting, handling and application of pesticides through government extension departments and NGOs/private sector.

Box 7: Pesticide Classifications

Pesticide products are grouped according to the type of pest they control, such as:

- Insecticides (for insects);
- Miticides (for mites and ticks);
- Nematicide (for nematodes);
- Fungicide (for fungi, moulds);
- Herbicide (for weeds);
- Molluscicide (for snail, slugs);
- Rodenticide (for rats, mice, squirrels);
- Bactericide (for bacteria).

Pesticides have also been grouped according to their mode of action, such as:

1. Stomach poisons (which enter into the body of pest through mouth during feeding);
2. Contact poisons (which enter through the skin when pests move onto treated areas);
3. Fumigants (which are poisonous gases inhaled by breathing); and
4. Systemic poisons (which are applied as granules to the roots of a plant with irrigation water, the poison spreads throughout the plants and kills the pests feeding on it).

Pesticides can also be differentiated according to their chemical structure, such as:

- Organophosphates
- Pyrethroids
- Plant Derivatives
- Fumigants
- Chlorinated Hydrocarbons
- Carbamates
- Aerosols
- Growth regulators.

4.1.6. Pesticide-reduction through Public and Private Sector Collaboration

In Pakistan, serious research on pest forecasting is lacking. Public sector, in fact, sponsors and conducts all agricultural research and extension, where several problems such as financial, political, parochial and lobbying exist in many institutions which ultimately affect the efficiency of these departments. Despite heavy funding from national and international agencies for projects on cotton pest management (since 1970s), IPM of cotton pests is non-existent.

On the other hand, as mentioned before, few NGOs and international agencies are doing some practical research regarding IPM and environment friendly pesticide-use in Pakistan. NGOs and private firms like SDPI, PATTAN, KHOJ, OXFAM, SUNGI, Farmer Associates, Asianics, IPM Consultants and SCOPE; and international agencies like the CABI Bioscience Centre, Ciba-IPM Laboratories, WWF-Pakistan, IUCN-Pakistan, UNDP and FAO are also agitating, in this regard and addressing both farmers and policy makers through their research and advocacy campaigns. Moreover, other NGOs, interested in improved agricultural production and environment friendly agriculture, have great potential to play a significant role in promoting environment friendly agriculture.

Public and private sector collaboration, therefore, can help to get rid of the menace of pesticides in the country. There are growers and farmers associations that need to be sensitised and mobilised to monitor on-farm IPM and judicious use of pesticides.

5. Conclusions and Recommendations

For the last decade, farmers have behaved compulsive about pesticide use. Firstly, because, crop varieties, which farmers grow, are highly susceptible to pests. Secondly, most of pests, now, have developed some level of resistance, forcing farmers to spray more pesticides every year. Thirdly, farmers do not have appropriate alternatives to pesticides. Moreover, natural pest regulatory system has also been ravaged due to extermination of the natural enemy complex. It is, therefore, high time to rectify the situation, help farmers to escape from this vicious cycle and conserve the agricultural biodiversity through traditional farming practices for a sustainable agriculture in Pakistan.

Due to the cultivation of HYV, susceptible to pests, and the current system of pest management, which relies mainly on the use of pesticides, is responsible for the negative impact on the agro-ecosystem. Crop ecologies have been altered due to pesticide use over-time. The consequences of pesticides are visible in cotton growing areas where pests have increased and the natural enemy complex has been destroyed besides other environmental and health problems. The ratio of pesticide consumption is increasing over-time. Consequently, pest problems will increase if more pesticides are used which in turn will keep on altering the pest and natural enemy complex. The best solution seems to be IPM, with a long-term planning and a multi-crop farming system, instead of monoculture.

Before selecting an appropriate control measure, the pest should first be properly identified. Assistance from nearby agricultural departments may help for proper identification and professional advice. The farmers should be able to differentiate between crop pests and beneficial insects. Against a pest problem, efforts should be made to manage the pest populations through non-chemical control tactics, such as cultural, physical, mechanical, biological controls and IPM. These measures would help keep pest populations below damaging levels. Pesticides may be used as part of IPM, when all these efforts fail. This approach will help reduce pesticide-use drastically; conserve agricultural biodiversity; minimise environmental and health risks; improve natural balance and the whole ecology; reduce chances of pest resurgences and outbreaks; and increase agricultural productivity to achieve stability and sustainability in the agriculture.

At the end, in the light of this report, it is recommended that:

- As new HYV are known for the susceptibility to pests, indigenous crop varieties resistant to pests and extreme climatic conditions, should be re-introduced.
- A cotton pest, american bollworm, has developed high level of resistance against *cypermethrin* and *monocrotopos*. The cotton whitefly has also developed resistance against *methamidofos*. Similarly, in a government laboratory in Hyderabad, during 1992-93, about 46 pesticides were declared ineffective. It is, therefore, recommended that sale of all those pesticides against which resistance has been developed should immediately be banned.
- To monitor the pesticide resistance in future, a Pesticide Resistance Monitoring Working Group should be established in the Ministry of Food and Agriculture, with 50% membership from farmers, NGOs and other groups.
- Due to faulty spray equipments and untrained operators, more than 95 percent of pesticides applied to crops hit the non-target areas and degrade the crop ecology. To avoid this pesticide wastage, certified and annually tested spray equipments should be used. Secondly, well trained applicators/operators or registered technicians should only be allowed to handle and apply

pesticides. For this purpose, farmers should be trained through public and private sector collaboration.

- A national on-farm project on *Technology Transfer for Ecological/non-chemical Farming System* should be launched in which all sustainable non-chemical pest controlling procedures should be experimented in important crops. Screened-out results may be transferred to farmers through trainings and on-farm demonstration plots at a large scale. Farmers should learn techniques that reduce pesticide-use without any significant reduction in crop production. It is urged that the current menace of pesticides-use can only be avoided if farmers are involved and convinced. If they are encouraged/ assisted in this way, the developed IPM technologies would automatically be transferred to other farmers and the beneficial cycle will continue.

6. Bibliography

- Ahmad, Z. 1995. *Development of Resistance in American Bollworm and Whitefly*. Journal of Economic Entomology. Vol. 88: 771-776, 1995.
- Anonymous. 1992. *Neem: A Tree for Solving Global Problems*. Report of the Science and Technology for International Development National Research Council, Washington. National Academy Press, Washington, D.C.
- Atwal, A. S. 1984. *Agricultural Pests of India and South-East Asia*. A monograph published by Kalyani Publishers, 23 Darya Ganj, New Delhi.
- Aziz, A. Sajid, and Masud. 1994. *Poisoning the crop, the multinational style*. Daily The News, December 30, 1994.
- Baloch, U. K. 1995. *Pesticide Monitoring Programme*. Paper prepared for WWF-Pakistan, Lahore.
- Bioscience Centre, 1984. *25 Years of Service to Agriculture in Pakistan*. Annual report 1984, CABI Biosciences Centre, Rawalpindi.
- Biosciences Centre, 1998. *Stepping Off the Cotton Pesticide Treadmill: Preliminary findings from a farmer participatory cotton IPM training project in Pakistan*. A report of CABI Bioscience Centre, Rawalpindi.
- Business Recorder 1996. *Campaign against Sale of Adulterated Pesticides*. Press release appeared on July 23, 1996.
- Ciba-Geigy, 1997. *Annual report of Ciba-IPM 1997*. Ciba-Geigy Pakistan, Multan.
- Crop-protection Association of Pakistan (CAP). 1996. *National Directory of Crop Protection, Pakistan*, Published by CAP, PARC, Islamabad.
- Deshazo, J.R. and P. Theodore. 1993. *A Case Study of Pesticide Subsidies and Integrated Pest Control*. Harvard Institute for International Development, U.S.A.
- EPA/GTZ, 1998. *Hange Begets Change*. A profile of Improvement of Urban-Industrial Environment Project (UIEP), by EPA (NWFP) and GTZ, Peshawar.
- Fenemore, G. P. 1984. *Plant Pests and their Control*. Reader in Entomology, Department of Horticulture and Plant Health, Massey University, Palmerston North, New Zealand.
- Finance Division. 1998. *Economic Survey 1997-98*, Economic Advisor's Wing, Islamabad.
- Forrester, N. W. 1994. *Management of Key Cotton Pests in Pakistan*. FAO consultancy report no. TCP/PAK/2357.
- Georghiou, G.P. 1986. *The Magnitude of the Resistance Problem*. National Research Council, Washinton. D.C.
- Greenpeace. 1998. *Toxic Legacies; Poisoned Futures: Persistent Organic Pollutants in Asia*. Greenpeace International, Amsterdam, the Netherlands.
- Habib, N. 1996. *Invisible Farmers: a study on the role of women in agriculture and the impact of pesticides on them*. A monograph published by Khoj-Research and Publication Centre, Lahore.
- Hashmi, A.I. and K.A. Hassall . 1989. *Pests and Pesticides in Pakistan*. PARC, Islamabad.
- Hoesle H., 1997. *Site-appropriate and Organic Farming: Similarities and Differences*. Agriculture and rural development. Agriculture and Rural Development. No. 1/1997. Germany.

- Inayatullah, C. 1995. *IPM for Ever-Green Revolution*. SDPI, Islamabad.
- Inayatullah, C. 1997 (1). *Cotton Pesticide link*. Food and Agriculture. Pakistan Agricultural Book-1997. Press Corporation of Pakistan. Karachi.
- Inayatullah, C. 1997 (2). *Biodiversity: Its Conservation and Sustainable Use*. SDPI Working Paper, SDPI, Islamabad.
- IUCN, 1997. Pakistan Environment and Development Quarterly 'The Way Ahead'. Vol. 4, Issue 1, August, 1997.
- Jabbar A., S.Z. Masud, Z. Parveen and M. Ali .1993. *Pesticides Residues in Cropland Soils and Shallow groundwater in Punjab, Pakistan*. Bulletin of Environmental Contamination & Toxicology 51: 268-273.
- Jabbar A. and M. Seeme .1994. *Pesticides and Environment Situation in Pakistan*. SDPI working series paper. SDPI Islamabad.
- Kenmore, P.E. 1991. *Population Regulation of the Rice Plant Hopper (*Nilaparvata lugens* Stal)*, Within Rice Field in Philippines. International Rice Research Institute, Philippines.
- Latif, A., A. Qayyum and M. Abbas. 1960. *The role of *Apis indica* in the pollination of 'toria' and 'sarsoon' (*Brassica campestris* vs. *toria* and *dichtoma*)*. Bee World 41: 283-286.
- Masud, S.Z. 1984. *Pesticide residues in food stuffs*. Pakistan Journal of Scientific and Industrial Research 27:94-95.
- MINFAL. 1996. *Agricultural Statistics of Pakistan 1995-96*, Ministry of Food, Agriculture and Livestock, Economic wing, Islamabad.
- MINFAL. 1997. *Agricultural Statistics of Pakistan 1996-97*, Ministry of Food, Agriculture and Livestock, Economic wing, Islamabad.
- MINFAL. 1998. Survey Data, Cotton Commissioner Office, Ministry of Food, Agriculture and Livestock, Islamabad.
- Mohyuddin, A. I., A. Hamid and A. Mohammad. 1994. *Integrated Pest Management of Sugarcane Borers in the NWFP*. Pakistan Agricultural Research Council, Islamabad.
- PAN Asia. 1995. *Mist of Death*. A poster developed by Pesticide Action Network Asia and Pacific (PAN Asia), Malaysia.
- PAPA. 1997. *Pesticides in the Biosphere of Pakistan: a review*. Pakistan Agricultural Pesticides Association (PAPA) Bulletin, June 1997. Karachi.
- PARC. 1996. Annual report 1995-96. Pakistan Agricultural Research Council, Islamabad.
- Pimental. 1992. *Assessment of Environmental and Economic Impacts of Pesticide Use*. A paper appeared in the monograph 'The Pesticide Question: Environment, Economics and Ethics. Chapman and Hall, New York.
- Qasmi, F. 1997. *Pesticides and Existing Policies in Pakistan*. A paper presented during workshop on 'Environment Friendly Use of Pesticides' organised by the Environment Protection Department (EPD), Govt. of Punjab, on March 29, 1997 at Lahore.
- Salim, M. 1998. *Integrated Pest Management in Rice*. Article appeared in The News on August 03, 1998.
- SDPI. 1994. *Environmental Examination of the Textile Industry in Pakistan*. Project report of Technology Transfer for Sustainable Industrial Development (TTSID), SDPI, Islamabad.
- SDPI. 1996. *Cotton File 1995-96*. Pakistan Environment Digest: A Selection of Clippings on Cotton, SDPI, Islamabad.
- SDPI Survey. 1997 (1). A survey conducted in cotton growing areas on *Cotton and Textiles in Pakistan*, as part of the UNEP project 'Global Product Chains: Northern Consumers, Southern Producers, and Sustainability'. SDPI, Islamabad.
- SDPI Survey. 1997 (2). A survey conducted in Islamabad and Rawalpindi for a project on *Pesticide Consumption in Urban Environments*. SDPI, Islamabad.
- SDPI Survey. 1998. A survey conducted in cotton growing areas on *Pesticide Use Overtime and Change in Pest and Natural Enemy Complex in Cotton*, as part of the study on 'Pesticide Use and its Impact on Crop Ecologies'.
- SDPI/WWF. 1998. *Sustainable Cotton Production, Trade and Environmental Impact: Policy Issues and Options for Pakistan*. An SDPI study developed for WWF-Pakistan.

Pesticide-use and its Impact on Crop Ecologies: Issues and Options

- Schmutterer, H. 1995. *The Neem Tree: Source of Unique Natural Products for IPM*. Monograph published by VCH Verlagsgesellschaft, Weinheim, Germany.
- Statistics Division. 1990. Pakistan Census of Agriculture 1990, Agricultural Census Organisation, GOP, Gulberg-III, Lahore.
- Sultan, A. I. 1997. *Vermicology: The Biology of Earthworms*. A monograph published by Orient Longman Limited, 3-6-272 Himayatnagar, Hyderabad 500 029 (A.P), India.
- USC. 1990. USC Canada-Nepal Annual Report, Unitarian Service Committee of Canada.
- Waage, J.K. 1991. Biodiversity as a Resource for Biological Control. Proceeding of the First Workshop on Biodiversity: Its Role in Sustainable Agriculture. CAB International. CASAFA Report Series No. 4.
- WHO. 1979. World Health Organization, Technical Report Series No. 634.
- Zia, S.M. 1997. Brief for Pesticide Policy. Policy brief series No 1. SDPI, Islamabad.

Annex 1

Acronyms and Abbreviations

ADB	Asian Development Bank
APCOM	Agricultural Prices Commission
APTAC	Agricultural Pesticides Technical Advisory Committee
APTMA	All Pakistan Textile Mills Association
CABI	Commonwealth Agriculture Bureaux International, UK
CCRI	Central Cotton Research Institute
CLCV	Cotton Leaf Curl Virus
CRI	Cotton Research Institute
EC	Emulsifiable Concentrate
EPA	Environment Protection Agency
EPB	Export Promotion Bureau
EPD	Environmental Protection Department, Lahore
FAO	Food and Agricultural Organisation
GDP	Gross Domestic Product
GOP	Government of Pakistan
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
ha.	hectare
HYV	High yielding Variety
IIBC	International Institute of Biological control
IPM	Integrated Pest Management
MINFAL	Ministry of Food, Agriculture and Livestock
NGO	Non-Government Organisation
NEQS	National Environmental Quality Standards
NIBGE	Nuclear Institute of Biology and Genetic Engineering
NWFP	North West Frontier Province
PAN Asia	Pesticide Action Network, Asia
PAPA	Pakistan Agricultural Pesticides Association
PARC	Pakistan Agricultural Research Council
PCCC	Pakistan Central Cotton Committee
PIDE	Pakistan Institute of Development Economics
PMRC	Pakistan Medical Research Council
R & D	Research and Development
SDPI	Sustainable Development Policy Institute
UK	United Kingdom
UN	United Nation
USC Canada	Unitarian Service Committee of Canada
USA	United States of America
USDA	United States Development Aid
WEC	World Environment Centre
wp	Wetable Powder
WHO	World Health Organisation
WTO	World Trade Organisation
WWF	World Wide Fund for Nature

Annex 2

Insect Activities in Relation to Human's Welfare

Activity	Type of activity	Effects
Harmful	<ul style="list-style-type: none"> • Pests of cultivated plants. • Pests of farm animals. • Pests of stored produce. • Pests of timber and wood products. • Pests of medical and public health importance. • Pests in households and industrial premises. 	<ul style="list-style-type: none"> • Reduction in yield and quality of produce. Transmission of plant diseases. • Discomfort. Reduction in vigour and growth rate. Lowered production (dairy stock). Damaged skins and hides. Transmission of diseases. • Accelerated deterioration. Reduction in quality and nutritional value. Aesthetically offensive. • Accelerated deterioration resulting eventually in structural failure. • Discomfort and ill health. Reduction in vigour. Transmission of diseases. • Aesthetically offensive. Damaging to stored food and other produce, e.g., wool and woollen goods. Unhygienic.
Beneficial	<ul style="list-style-type: none"> • Natural enemies of pests. • Pollinators of cultivated plants. • Producers of useful materials. 	<ul style="list-style-type: none"> • Suppression of pest or potential pest. • Provide essential pollination of many cultivated plants. • Production particularly of honey and silk.
Neutral	<ul style="list-style-type: none"> • Components of natural and modified ecosystems. 	<ul style="list-style-type: none"> • Important components of biological systems essential to human's long-term welfare.

Source: Fenimore, 1984.

Annex 3

Plant tissues and the selected insect groups which feed on them

Tissue	Mode of feeding	Examples of feeders
1. Leaves	<ul style="list-style-type: none"> • Clipping • Skeletonising • Holing • Rolling • Spinning/Webbing • Mining • Rasping • Sucking • Eating • Curling • With bugle-forth 	<ul style="list-style-type: none"> • Sawflies, butterflies • Beetles, sawflies, capsid bugs • Moths, weevils, • Microlepidoptera, aphids • Lepidoptera, sawflies • Microlepidoptera, Diptera, Coleoptera • Thrips • Aphids, psyllids, hoppers, whitefly, mites, etc • Grasshoppers, locusts, caterpillars, beetle grubs & adults. • Aphididae, Psyllidae, Aleyrididae, Cicadellidae • Cercopidae; spittle bugs
2. Buds	<ul style="list-style-type: none"> • Boring • Deforming • Gnawing • Piercing • Stunting/wilting 	<ul style="list-style-type: none"> • Hymenoptera, Lepidoptera, Diptera • Aphids, moths • Noctuidae, Tettigoniidae, Tortricidae • Jassids, Heteroptera • Aphids, scale insects, mealy bugs
3. Herbaceous Stems • Cereal Shoots • Cereal Stems	<ul style="list-style-type: none"> • Removal • Boring • Sucking • Dead hearts • Boring 	<ul style="list-style-type: none"> • Sawflies • Weevils, flies, moths • Aphids, scales, cochineals, bugs • Agromyzid shoot flies, pyralid caterpillars • Pyralid and noctuid caterpillars
4. Bark	<ul style="list-style-type: none"> • Tunnelling • Sucking 	<ul style="list-style-type: none"> • Beetles, wasps • Scales, bark lice
5. Wood	<ul style="list-style-type: none"> • Tunnelling • Chewing 	<ul style="list-style-type: none"> • Beetles, wasps • Termites
6. Flowers	<ul style="list-style-type: none"> • Nectar drinking • Pollen eating • Receptacle eating • Spinning • Petal damage • Anther eating • Flower deformation 	<ul style="list-style-type: none"> • Butterflies • Bees, butterflies • Diptera, Microlepidoptera, thrips • Microlepidoptera • Meloidae, Scarabaeidae Thripidae, <i>Apion</i> weevils • Beetles of <i>Coryna</i> spp. • Cecidomyiidae
7. Fruits	<ul style="list-style-type: none"> • Destruction • Deformation • Tunnelling • Necrotic patches 	<ul style="list-style-type: none"> • Wasps, moths, flies • Mites (Eriophyidae) • Tortricidae, Pyralidae, Noctuidae, • Miridae, Coreidae, Pentatomidae, Capsids

Continued...

Pesticide-use and its Impact on Crop Ecologies: Issues and Options

Tissue	Mode of feeding	Examples of feeders
8. Seeds • Graminaceous Seedlings	<ul style="list-style-type: none"> • Boring • Sucking • Tunnelling/Boring • Dead hearts 	<ul style="list-style-type: none"> • Weevils, moths, bruchids • Lygaeid bugs • Scolytidae, Bruchidae, • Lepidoptera, Diptera, Coleoptera
9. Cell Sap	<ul style="list-style-type: none"> • Phloem • Xylem • Cell contents 	<ul style="list-style-type: none"> • Aphids, whitefly, hoppers • Spittle bugs, cicadas • Bugs, hoppers, mites
10. Roots	<ul style="list-style-type: none"> • Clipping • Tunnelling • Sucking • Swellings • Hollowing 	<ul style="list-style-type: none"> • Beetles, flies • Nematodes, flies • Aphids, cicadas, nematodes • Nematodes • Noctuidae, Scarabidae
11. Tubers	<ul style="list-style-type: none"> • Tunnelling • Narrow Tunnelling • Shallow tunnelling 	<ul style="list-style-type: none"> • Potato tuber moth, Sweet potato weevil (<i>Cylas</i> sp.) • Wireworms of Elateridae • Noctuidae, Scarabaeidae
12. Galls	<ul style="list-style-type: none"> • Leaves • Fruits • Stems • Roots • Twigs 	<ul style="list-style-type: none"> • Hymenoptera, Diptera, aphids, Psyllids, mites • Hymenoptera • Hymenoptera, Diptera • Aphids, weevils, Hymenoptera • Cicidomyid gall midges, gall wasps of Cynipidae, Eurytomidae and Torymidae.

Source: Hashmi, 1989.

Annex 4

The Main Types of Pest Control Procedures

Procedure	Components
Cultural Control	Manipulation of cultural practices to the pest's disadvantage by such means as method and time of cultivation, modification of sowing dates and manipulation of irrigation practices.
Plant Resistance	The use of species or varieties of plants that can grow and produce despite the presence of pests.
Biological Control	In the narrow sense involves the use of parasites and predators (mostly other insects) to control pest species. In the broader sense also includes disease organisms (pathogens). Use of the latter is sometimes referred to as microbial control.
Chemical Control	Principally involves the use of chemicals which are toxic to insects (called insecticides) but also includes the use of chemicals which modify insect behaviour, for example, attractants and repellents.
Plant and Animal Quarantine	Involves restrictions on the international movement of plant and animal material to minimise further spread of pests and diseases.
Mechanical Control	Includes killing or trapping pests by mechanical means or the use of barriers to prevent pests from gaining access to plants, store produce or other materials.
Physical Control	Involves modification of some physical feature of the environment to render it unsuitable to a pest (e.g. the lowering of temperature of store grain), or the utilisation of some physical property as an attractant (e.g. light traps for night flying insects).
Integrated Pest Management	The blending together of two or more of the foregoing procedures into an overall harmonious system of control. Applied practically to the integration of chemical and biological control.
Others	There are other specialised control procedures, such as the sterile male technique. Till now this has very limited application.

Source: Fenimore, 1984.

Annex 5

Area Covered by Aerial Plant protection Operations

Area '000' hectares

Years	Cropped Area	Area Sprayed	% of Total Area
1970-71	16,620	255.0	1.5
1971-72	16,596	404.0	2.4
1972-73	16,930	404.0	2.4
1973-74	18,280	640.0	3.5
1974-75	17,370	714.0	4.1
1975-76	18,020	856.0	4.8
1976-77	18,210	976.0	5.4
1977-78	18,400	659.0	3.6
1978-79	19,300	726.0	3.8
1979-80	19,220	297.0	1.5
1980-81	19,330	173.0	0.9
1981-82	19,780	160.8	0.8
1982-83	20,130	182.6	0.9
1983-84	20,060	164.7	0.8
1984-85	19,920	190.0	1.0
1985-86	20,280	166.0	0.8
1986-87	20,900	196.0	0.9
1987-88	19,520	123.0	0.6
1988-89	21,820	68.0	0.3
1989-90	21,300	66.0	0.3
1990-91	21,350	94.0	0.4
1991-92	21,720	217.0	1.0
1992-93	22,440	355.0	1.6
1993-94	21,870	12.0	0.1
1994-95	22,140	89.0	0.4
1995-96	22,550	22.0	0.1

Source: MINFAL (Agricultural Statistics of Pakistan), 1978 to 1996-97.

Annex 6

Area Covered by Ground Plant protection Operations

Years	Area '000' hectares		
	Cropped Area	Area Sprayed	% of Total Area
1976-77	18,210	1,237.0	6.8
1977-78	18,400	1,019.8	5.5
1982-83	20,130	1,096.7	5.5
1983-84	20,060	940.7	4.7
1987-88	19,520	2,393.8	12.3
1988-89	21,820	2,447.7	12.4
1989-90	21,300	2,464.9	11.6
1990-91	21,820	3,771.9	17.3
1991-92	21,720	4,251.2	19.6
1994-95	22,140	6,773.8	30.6
1995-96	22,550	7,166.8	31.8

Source: MINFAL (Agricultural Statistics of Pakistan), 1978 to 1996-97.

Annex 7

Pesticides Percent Growth per Year in Pakistan

Year	Active Ingredient Million tonnes	% Growth per Year	% Growth Since 1981
1981	915	--	--
1982	1,345	49	49
1983	1,757	31	94
1984	2,585	47	185
1985	3,489	35	285
1986	4,111	18	354
1987	4,429	8	389
1988	4,065	- 8	349
1989	4,706	16	420
1990	5,730	22	533
1991	5,920	3	554
1992	5,619	- 5	520
1993	4,919	- 11	443
1994	6,183	26	583
1995	7,645	24	745
1996	7,325	- 4	709

Source: PAPA, 1997.

Annex 8

List of Banned Pesticides in Pakistan

Banned Pesticides		
1. Binapacryl	9. Dalapon	16. Ethylene dichloride + Carbontetrachloride
2. Bromophos	10. DDT	17. Mercury Compound
3. Captafol	11. Dibromochloropropane +	18. Mevinphos
4. chlordimeform	12. Dibromochloropropene	19. Propergite
5. Chlorobenzilate	13. Dicrotophos	20. Toxaphene
6. Chlothiophos	14. Dieldrin	21. Zineb
7. Cyhexatin	15. Disulfoton	
8. Leptophos	16. Endrin	

Source: *Crop Protection Association of Pakistan, 1996.*

Annex 9

Pesticides Declared ineffective by Hyderabad Laboratory

No	Name	Batch No	No	Name	Batch No
1	Karate 2.5 EC	A-6	24	Sharpa 5 EC	Pak/001/92
2	Thiodon 35 EC	W-245	25	Curacron 500 EC	203188/22073
3	Anthio 25 EC	098081	26	Heptachlore 32.1 EC	0024
4	Raxion 35 EC	1011003	27	Deltaphos 350+10 EC	W-221/00338
5	Karate 2.5 EC	B-85	28	Thioluxan 35 EC	L-138
6	Karate 2.5 EC	B/98/1	29	Raxion 40 EC	A-202
7	Karate 2.5 EC	B/49/2	30	Monitor	---
8	Raxion 35 EC	920614	31	Systoate 40 EC	A-204 (A)
9	Lazer 25 EC	001-10	32	Systoate 40 EC	L-105 (S)
10	Curacron 500 EC	92	33	Raxion 40 EC	202
11	Raxion 40 EC	101003	34	Thiodon 35 EC	A-136 (T)
12	Lazer 25 EC	B-001o3/92	35	Thioluxan 35 EC	HPL-L-252
13	Paramet 50 EC	A-102	36	Systoate 40 EC	A-119
14	Raxion 35 EC	101003	37	Systoate 40 EC	A-119
15	Nogos 100 EC	902221	38	Aflin 35 EC	1-104/K
16	Thiodon 35 EC	A-136/T	39	Thiodon 35 EC	L-108 (C)
17	Paramet 50 EC	A-205	40	Biothroid TM 525 EC	304634
18	Raxion 40 EC	101003	41	Raxion 35 EC	92/001
19	Anthio 25 EC	103041	42	Anthio 25 EC	013062
20	Birlanic 240-G/L	920204	43	Hygonate 40 EC	930220
21	Thioluxan 35 EC	920716	44	Raxion 40 EC	HPL-212
22	Zolon 35 EC	P-I/1004/92	45	Thioluxan 35 EC	A-126
23	Folidol 50 EC	101639	46	Systoate 40 EC	A-203

Source: Aziz, et.al. 1994.

Annex 12

Experts Interviewed During the Surveys:

- Dr. Ashraf Poswal, Scientist-in-Charge, CABI Biosciences Centre, Rawalpindi.
- Dr. Zahoor Ahmad, Director, CCRI, Multan.
- Mr. Tanvir Javed, Principle Scientific Officer (Plant Pathologist), CCRI, Multan.
- Mr. Rafiq Ramay, Senior Entomologist, CCRI, Multan.
- Dr. Mushtaq Ahmad, Plant Pathologist, CCRI, Multan.
- Dr. Shakeel Ahmad, Senior Entomologist, Ciba-IPM Laboratories Multan.
- Mr. Abdul Ghaffar Khan, Principle Scientific Officer, PARC-IPM Laboratory, Multan.
- Mr. Amir Hamza, Research Officer, PARC-IPM Laboratory, Multan.
- Mr. Nazir Ahmad, Entomologist, Cotton Research Institute (CRI), Multan.
- Mr. Siddique Akbar Bukhari, Cotton Grower, Bukhari Farms, Multan.
- Mr. Jahangir Tareen, Cotton Grower, Tareen Farms, Multan.
- Mr. Munir Ahmad Bhatti, Senior Entomologist, Ayub Agricultural Research Institute, Faisalabad.
- Dr. Ismail, Plant Protection Institute, Faisalabad.
- Mr. Hammad Naqi, Environmental Officer, WWF-Pakistan, Lahore.

Annex 13

Questionnaires Used During the Survey

Questionnaire 1
for Pesticide use and its effect on crop ecology
(Reported data and expert opinions)

1. Primitive pest control methods

2. Examples of Pesticide use and its effect on crop ecologies (biodiversity)

3. Cotton crop ecology (biodiversity)
 - Before 1980's

 - After 1980's and now

3. Change in pest complex (Species & populations overtime)

4. Change in parasite/predator complex (Species & populations overtime)

5. Examples of development of pest resistance against pesticides

1. Examples of health hazards due to pesticide use

Questionnaire 2
for IPM Development in Pakistan
(Reported data and expert opinions)

1. Organizations (GOP & NGOs) involved in IPM
2. Various completed/ongoing IPM projects
3. Successful stories of IPM projects
4. Examples of farmers who are practising IPM
5. Extension services in this regard & successes
6. Hurdles in the way of IPM
7. Development in alternatives to pesticides
 - Biological control
 - Botanical pesticides
 - Environment friendly use of pesticides
8. Examples of organic farming

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