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Since independence, agriculture in India has undergone significant transformations. Agricultural production increased tremendously due to introduction of high-yielding varieties, use of agro-chemicals and improved irrigation facilities. However, there are several constraints for further increase in agricultural production. One of the limiting factors is the increased incidence of pests and diseases. The overuse and improper application of plant protection chemicals during the past few decades has resulted in a 'pesticide treadmill' wherein higher doses of these chemicals are required to control insect-pests due to development of resistance and their resurgence. In addition, these chemicals also have adverse impact on the environment and on the health and socio-economic well being of the community. The National Institute of Advanced Studies, with the support from the Department of Science and Technology, Government of India, launched a research project with the objective of obtaining realistic information on use (and misuse) of pesticides through field investigations in a few selected districts of Karnataka, Andhra Pradesh, Maharashtra and Punjab. This involved an extensive and systematic collection of information from farmers, agricultural officers, pesticide dealers, health and medical specialists and the general public. A Local Project Advisory Committee was formed consisting of many distinguished individuals from industry and academia. The

districts were selected based on types of crop grown and the pesticide consumption pattern. Crops such as paddy, cotton and vegetables were selected for the study because pesticides are extensively used on these crops. This report reveals many interesting facts from the field on input driven agriculture, the problems of pests and diseases and the unsustainable agricultural practices that it leads to, and the socio-economic and health externalities resulting in farmers' distress in these districts.

I express my deep gratitude to all those who helped us to carry out this field investigation in four states, particularly farmers, agricultural officers, pesticide dealers and members of government and non-governmental organisations. I am grateful to Prof. R. Narasimha, Director of the Institute, for his support and encouragement in undertaking this project. My special thanks are due to Dr. M. S. Mithyantha, Dr. M. V. Srinivasa Gowda, Dr. V. T. Sannaveerappanavar, Prof. Srivenkataramana, Dr. H. M. Chidanandappa, Prof. M. Ravindram, Prof. S. Rajagopal, Prof. Kenneth Keniston, Prof. T. S. Kathpal, Dr. Ramesh Saxena, Dr. K. C. Gupta, Dr. M. G. Narasimhan, Prof. R. S. Deshpande, Dr. T. Venkateshan, Dr. G. Shankar, Dr. N. Satyanarayana, Dr. Mallikarjunappa, Sridhar K. Chari and Dr. Chandra Mouli for their support and valuable suggestions. I wish to express my sincere appreciation to the Department of Science & Technology, Government of India, for sponsoring this project. I am extremely grateful to

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Contents

1. Introduction

India has been largely an agrarian society. The agricultural sector contributes nearly 26 per cent to the gross domestic product and provides livelihood to two-thirds of the population. Agricultural production has recorded remarkable growth over the past few decades. Foodgrain production increased from 62.5 Million Tonnes (MT) in 1965 to 209 MT in 1999-2000. Adoption of modern technological practices, involving improved irrigation, high-yielding varieties, agro-chemicals and farm mechanization has made notable contributions towards raising the food production in India. For instance, high-yielding varieties introduced in the 1960s, increased the production of rice by about 70 per cent and that of wheat by about 150 per cent. In order to meet the demand of the growing population however, the country needs to increase the food production by 5 MT per year as against the current rate of 3.1 MT. Today, there are tremendous pressures on the agro-ecosystems due to increasing number of small farms, agro-chemical pollution, soil erosion and desertification. The intensive cultivation of high-yielding varieties, monoculture of commercially important crops, overlapping of cropping seasons and excessive application of agro-chemicals have resulted in high incidences of pests and diseases. The increasing losses due to pests and diseases are the major constraints for sustaining crop productivity and production.

Currently, the potential yield loss worldwide due to weeds, diseases and pre- and post-harvest pests is estimated to be 45 per cent (Gwo-Chen Li, 1999). In monetary terms, the pre-harvest loss alone account for almost $ 250 billion and the major share comes from the Asian countries (Oerke *et al.,* 1995). FAO estimates that the annual crop production losses worldwide, as a result of pests, is almost 35 per cent which when combined with post-harvest losses accounts for one half of the world's potential food supply. On an average, 33 per cent of crop loss occurs exclusively due to pests in India (Puri *et al.*, 1999). In monetary terms, annual loss caused by the crop pests and weeds is estimated to be Rs. 200 billion (Singh, 1999). There is an increase in the number of pests attacking economically important crops. For instance, it has been reported that more than 300 species and 160 species of pests attack rice and cotton crops, respectively.

Pesticide is an essential ally in the farmers' struggle to protect crops. Despite higher use of pesticides, losses throughout the production system remain high. Pesticide consumption in India for agricultural purpose is 288 g/ha, which is low when compared to global average of 900 g/ha (Agnihotri, 2000). However, pesticide consumption has not been uniform in the country, it varies with the intensity of pests and diseases, cropping patterns and agro-ecological regions. Pesticide use is high in regions with good irrigation facilities and in those areas where commercial crops are grown. For instance, cotton is grown in only 5 per cent of the total area under cultivation, but consumes about 45 per cent of total pesticides used in the country. Similarly, paddy is cultivated in 24 per cent of the cropped area and receives around 20 per cent of total pesticides used in the country. The use of pesticides is high in a few states such as Andhra Pradesh, Karnataka, Maharashtra, Gujarat and Punjab. The liberal and continued use of pesticides has disturbing consequences on the farming system, particularly due to development of resistance, resurgence of insect pests and decline in population of natural enemies of pests. In order to minimize crop loss, farmers aggressively adopt self-defeating practices such as increasing either dosages or the frequency of pesticide application. As a result of this, these chemicals are slowly showing signs of threats on environment, health and socio-economic well being of the community. Further, it is estimated that annually about Rs. 1,000 crores worth agricultural exports from the country are rejected due to the presence of high pesticide residues (Singhal, 2000). In addition, persons who handle pesticides at the time of application, transportation and storage are susceptible to pesticide-related health hazards. According to the information available with Directorate of Plant Protection, Quarantine and Storage, Faridabad, the number of pesticide-related poisoning cases and deaths in India during 1996-99 was about 15,500 and 7,500, respectively.

Keeping these points in view, the project team initiated work with the objective of obtaining realistic information on use (and misuse) of pesticides through field investigations in a few selected districts in Karnataka, Andhra Pradesh, Maharashtra and Punjab. The study looked into the pesticide-induced problems such as pest fauna change, resistance and resurgence of insect pests. Other factors such as awareness about the ill effects of the pesticides, education among farmers and the safety measures followed while handling these chemicals were also studied.

2. Methodology

2.1 Sample selection

The four states (Karnataka, Andhra Pradesh, Maharashtra and Punjab) account for about 38.14 per cent of total pesticides used in the country (Agnihotri, 2000). A

few districts were selected from these states for detailed investigation based on the types of crop grown and the pesticide consumption pattern. The study focused on crops such as paddy, cotton and vegetables because pesticides are extensively used on these crops (Table 1).

Table 1: Districts and crops identified for the study

States	Districts	Crops
Karnataka	Raichur and Bellary	Paddy
Andhra Pradesh	Guntur and Warangal	Cotton
Maharashtra	Nashik	Vegetables
Punjab	Bathinda	Cotton

The field investigation was carried out in the representative district/s with the help of pre-tested schedules. The respondents for the study included farmers, agricultural labourers, pesticide sellers, agriculture officers and medical specialists. The total sample size was 300 from 48 randomly selected villages belonging to the six districts of the four states. Farmers from different villages were selected randomly and were classified as small (having up to 5 acres or 2 hectares of land), medium (5.1 to 10 acres or above 2 hectares but less than 4 hectares) and large farmers (above 10 acres or above 4 hectares of land).

2.2 Content of schedules

The schedule for the farmers contained 28 major questions on the following issues- (a) Farm size,

(b) economic status, (c) cropping pattern and type of farming, (d) cost of cultivation, (e) changing scenario of pests and diseases, (f) pesticide usage pattern, (g) education, (h) pesticide application procedure, (i) safety measures followed while handling pesticides, (j) pesticide-induced problems like development of resistance and resurgence of insect pests, (k) pesticide- related poisoning and deaths, (l) pesticide sales, (m) Integrated Pest Management practices etc.

Apart from these, the following 20 awareness statements were also included in the schedule on the ill effects of pesticides: (1) During pesticide application, the body must be completely shielded, (2) pesticides enter into human body through inhalation while preparing the spray mixture, (3) continuous use of pesticides may destroy physical properties of soil and pollute groundwater, (4) pesticides kill not only harmful organisms but also non-target organisms, (5) agriculture runoff affects the aquatic fauna, in the nearby lakes or ponds, (6) serious health hazards are caused due to consumption of water or aquatic animals contaminated with pesticides, (7) even with several washings, pesticide residues on fruits and vegetables cannot be completely removed, (8) after the last spray, consumption of fruits and vegetables before a specified time gap is harmful; (9) pesticides enter the human body through meat and milk, (10) pesticides cause problems like skin disease, cancer, lung problems, nervous weakness to humans and affect reproductive capacity and the immune

system, (11) after application of pesticides, some amount remains in nail corners and can enter the body, (12) the empty pesticide bottles or cans must be disposed of properly, should be kept away from children, and prevented from use for domestic purposes, (13) different colour symbols on the labels of the pesticide containers represent different toxicity levels of pesticides, (14) different pesticides have different durations of re-entry into fields after application, (15) cattle should not be allowed to graze in the field for 5-6 days after spraying, (16) different pesticides have to be used in different stages in the life cycle of the pest, (17) for different crops there are different minimum waiting periods for harvest, (18) activities such as smoking, drinking and eating should be avoided during spraying, (19) mixing of pesticides and its spraying should be taken up in early morning or late evening hours when temperature is low, (20) mixing of pesticides and spraying should be taken up when the air is still or there is no breeze, avoiding spraying against the wind.

Individual schedules for agriculture officers, doctors or medical specialists and pesticide sellers or dealers were also used to collect specific information. Various issues related to cropping patterns, pests and diseases, pesticide usage patterns, other agronomic problems faced by farmers, pesticide-related poisonings and deaths in the selected districts etc. were also included in these schedules.

2.3 Data processing

Tabular and comparative analyses were done for computing sample mean and percentages for most of the parameters. However, to measure the awareness of farmers regarding the ill effects of pesticides, awareness questions were asked with two possible answers, i.e. complete awareness and no awareness with scores of 1 and 0, respectively. These responses of the farmers were recorded against the appropriate statement and were classified into two groups using the mean as the measure of check. Farmers with total score less than the mean were categorized as less awareness and farmers whose total score was more than the mean as having high awareness regarding the ill effects of pesticides.

3. Agro-Ecological Setting and Cropping Pattern

India is a land of climatic, edaphic and biotic diversity. The Indian Council of Agricultural Research has classified the country into 20 agro-ecological regions, 60 agro-ecological sub-regions and 120 agro-climatic zones based on soil, physiography (climate, crops and vegetation) and length of growing period. This wide range of agro-ecological settings has provided wide scope for agricultural diversification. The impact of the green revolution is highly evident in the irrigated belts of the country. The irrigated areas account for 37 per cent of total arable land and contribute to 55 per cent of the total agricultural

production, whereas rain fed agriculture provides the rest (Kaul and Mittal, 1998).

3.1 Agro-ecological setting of the selected districts

The selected districts belong to either hot semi-arid or hot arid eco-region and precipitation ranges between 400 and 1600mm (Table 2). Farmers are depending on varied sources of irrigation such as rivers, irrigation canals and wells in these districts.

Table 2: Agro-ecological setting and sources of irrigation

Districts	Agro-ecological classification	Precipitation (mm)	Sources of irrigation
Raichur and Bellary	Hot semi-arid eco-region + hot arid eco-region	600-1000 400-500	Tungabadhra irrigation canal, tanks and wells
Guntur	Hot semi-arid + hot sub-humid to semi-arid eco-region	600-1000 900-1600	Nagarjunasagar project right canal (Krishna)
Warangal	Hot semi-arid eco-region	600-1000	Tanks, canals and wells
Nashik	Hot semi-arid eco-region	600-1000	Godavari canal irrigation, wells and tanks
Bathinda	Hot arid eco-region	400-500	Indira Gandhi canal (Satluj), tanks and wells

3.2 Changes in cropping pattern

Cropping pattern of a region is a cumulative result of the agro-ecological setting, sources of irrigation, climatic, edaphic, and socio-economic diversity. Irrigation facilities and easy availability of agro-inputs have influenced and brought about changes in cropping patterns in these districts. Particularly in the last 50 years, these regions have witnessed several multi-purpose irrigation projects. However, one of the most important factors i.e., the agro-ecological setting was not given due importance by the farming community while deciding on cropping patterns.

It was observed that, farmers in the selected districts shifted from traditional, dry, region-specific crops such as coarse cereals, small millets, barley etc., to irrigation-intensive, non-region specific crops such as paddy, sugarcane, cotton, vegetables, etc. In some places in Raichur and Bellary districts, paddy and cotton have replaced *jowar* cultivation. In fact, certain varieties of paddy grown in these regions are being exported to International markets.

The Nagarjunasagar project on the Krishna River is the major source of irrigation in Guntur and in Warangal, the sources of irrigation are canals, tanks and wells. Earlier, rainfed paddy was the major crop in these districts but gradually farmers shifted to cultivation of maize, millets, and pulses and currently there is a large-scale cultivation of cotton and chillies. Presence of black soil in these regions is advantageous for cotton cultivation. Similarly, in Nashik the main crops grown now are cereals, fruits and vegetables but in the previous decades pulses were grown extensively. In all these regions, factors like the demand in local or International markets and better returns have caused changes in cropping patterns (Table 3). Farmers prefer to grow fruits and vegetables in Nashik because these can be

quickly and easily transported to different parts of Maharashtra and Gujarat. Several irrigation projects across the Girna and Godavari rivers in 1980s have resulted in changes in the cropping pattern in Nashik. Bathinda has also witnessed a shift from *Bajra* and pulse cultivation to cotton and wheat.

Table 3: Changes in cropping pattern

Districts	Crops
Raichur and Bellary	*Jowar* (Sorghum) → cotton → paddy and chilli
Guntur and Warangal	Rainfed paddy → maize → millets and pulses cotton and chilli
Nashik	Pulses → cereals and vegetables (local varieties) → cereals and vegetables (hybrids)
Bathinda	*Bajra* (Pearl millet) and pulses → paddy and cotton → cotton and wheat

Undoubtedly, the changes in cropping pattern have positively influenced agricultural productivity and economy. A study conducted by Shukla and Tewari (1996) showed that the area under rice and wheat has increased in arid and semi-arid regions of the country. In the arid ecosystems, area under rice cultivation increased from 3.0 per cent in 1965-66 to 6.2 per cent in 1990-91. Similarly in semi-arid ecosystems, it increased from 14.0 per cent in 1965-66 to 15.9 per cent in 1990-91. A deeper analysis shows that such a shift was mainly due to decline in the market price of cereals such as *jowar* and millets and also because these crops were not included in crop insurance schemes. Farmers are also reluctant to grow coarse cereals because of the fear of drop in market prices associated with increased production (Katyal, 1997). Monocropping of crops such as paddy, cotton and vegetables are common in these districts.

3.3 Crop management and type of farming

Traditional farming practices maintained a rich agro-biodiversity and ensured soil fertility through periodic addition of organic manure. They were in harmony with nature. In these systems the soil supported a good population of microorganisms like bacteria, fungi, protozoa and a host of other organisms that sustained soil health. In modern agriculture, chemical fertilisers are extensively used in order to increase yield. Excessive use of these chemicals may have some adverse effect on the soil micro flora and fauna. Good crop management practices, such as, proper plant spacing, tillage, deep ploughing and mixed cropping were lacking in these regions. These practices are essential as they improve soil fertility and decrease pest attack.

Seventy one per cent of the respondents in Karnataka and 66 per cent of the respondents in Andhra Pradesh were found practising chemical farming. The easy availability of agro-inputs particularly chemical fertilisers and pesticides in the market and quick returns has inspired these farmers to opt for chemical-based agriculture. Further, the unhealthy competition among some farmers to achieve higher yields using increased application of fertilisers and pesticides gave an impetus to agro-chemical markets.

Besides, farmers follow their own methods to enhance agricultural production and also to control pests and diseases. Such practices have created agro-ecological imbalances in these regions. The limited availability of organic manure and slow action of bio-pesticides were some of the important factors that inhibited farmers from using eco-friendly methods. 71 per cent of the respondents in Bathinda and 58 percent in Nashik said that they followed both chemical and organic farming methods.

3.4 Organic farming

Though farmers are aware about the advantages of eco-friendly farming, only few of them practise it. Mr. Mudde Gowda is a farmer in Mukunda village in Sindnoor taluk of Raichur district in Karnataka. The main crop grown in this village is paddy. Mr. Gowda, educated upto the 4th standard, was practicing organic farming on his 60 acres of land. About 22 years ago, Mr. Gowda was inspired by a lecture on organic farming, but he began to practise in his field only about 14 years ago. He took almost 8 years to take a decision to shift from chemical farming to organic farming. He applies only organic manure to his fields and avoids expensive chemical fertilisers. He uses neem-based pesticides and extracts prepared with *Datura*, *Parthenium* etc. to reduce the problems of insect pests. Though Mr. Gowda gets comparatively less yield than other farmers practising chemical farming, his organic products have high demand in the local market and fetch nearly 30 per cent more returns.

Mr. Gowda is of the opinion that farmers practising chemical farming are aware of the fact that organic farming gives better results in the long run. However, they are not willing to undertake the risk of changing over to organic farming, because a sudden shift may decrease the yield drastically. According to him all the crops, which were introduced and grown for the first time in this region, gave good returns in the beginning, but after a few years, the yield gradually decreased because of monoculture and increased incidences of pests and diseases.

3.5 Decline in organic manure

It was observed that farmers in the selected districts have not given due importance to subsidiary farm enterprises like dairy, poultry etc. In Bathinda and Nashik some respondents considered animal husbandry as an important activity. A large number of small and marginal farmers expressed their inability to buy and maintain the improved breeds of animals. The residues from traditional crops provided substantial quantities of fodder for farm animals, which reduced after introduction of short-stalked high-yielding varieties. Further, extensive deforestation and conversion of vast pasturelands to agriculture reduced the fodder available to farm animals.

There are several other reasons for the decreased dependence on farm animals. The country is losing some of the native breeds of animals that were resistant to diseases. Though the improved breeds of animals produce high quantities of milk, they are susceptible to diseases (Gupta *et al.*, 1997). Moreover, the increase in small land holdings and the declining area under fodder crops have reduced grazing opportunities. The government subsidies on power tillers and tractors have reduced the dependence of farmers on farm animals, which are the main source of organic manure. Further, a substantial quantity of organic manure is consumed as domestic fuel, preventing its use as manure. The presence of organic matter in the soil is very essential because a high state of balanced soil fertility means better crop immunity towards pests and diseases. In addition, plants that get no organic matter produce an unbalanced amount of carbohydrates at the expense of proteins and trace minerals. Insect pests are differentially attracted towards these sweet plants (Saxena, 1996).

4. Current Status of Pests and Diseases and their Management

The outbreak of pests and diseases and their intensity are influenced by a number of factors such as the availability and competition for food between different species, agro-climatic ecosystem, presence or absence of natural enemies of pests and cropping patterns. The changes brought about during modernization of agriculture have directly or indirectly led to increased incidences of pests and diseases. For instance, areas under crops such as coarse cereals, small millets and barley are decreasing whereas monoculture and continuous cultivation of paddy, cotton and other commercial crops are increasing. Such practices have led to the decline in genetic base, and have made the agro-ecosystem very susceptible to insect pests. Outbreak of insect pests in rice since the early 1970s has attained serious proportions in India. The rapid increase in area under high yielding varieties from 0.88 million hectares in 1966-67 to 28.0 million hectares in 1990-91 was cited as a major reason for increase in insect pests population in this crop (Dhaliwal and Arora, 1993). The number of insect pests that were considered important in paddy cultivation increased from 3 in 1965 to more than 13 in 1995. Simultaneously the number of major diseases increased from 2 to 7 during this period (Krishnaiah *et al.*, 1999).

The adoption of monoculture by farmers and the use of high-yielding varieties in place of traditional varieties have led to significant loss of genetic diversity. Mixed cropping would reduce pest populations, by encouraging the activity of natural enemies of pests (Shetty, 2000). Monoculture in the selected districts has aggravated the problems of pests and diseases that resulted in increased use of plant protection chemicals. The indigenous varieties of cotton

namely *Gossypium herbaceum* and *Gossypium arboreum* were grown in many parts of the country under rainfed and irrigated conditions. Though these varieties were low yielding, they were better adapted to local climatic conditions and also, to a certain extent, could withstand the damage caused by bollworms and other insect pests. The introduction of hybrid cotton escalated the damage caused by these pests. Synthetic insecticides controlled the pests effectively during the early green revolution period. However, the indiscriminate usage of these chemicals resulted in the elimination of natural enemies of pests that led to increased outbreak and resurgence of insect pests.

4.1 Status of pests and diseases and pest fauna change

Farmers in these districts are concerned about the increasing crop losses due to pests and diseases. Some of the major pests and diseases causing economic losses are shown in Table 4. Insect pests such as brown planthopper (BPH), green leafhopper etc. were considered to be minor in Raichur and Bellary, but today these pests have attained serious status. There are also several other factors that influence the fast build-up of the pests. For instance, the high incidence of BPH in Raichur and Bellary was mainly due to poor drainage, excessive use of nitrogenous fertilisers, close plant spacing and continuous monocropping of paddy. In addition, indiscriminate usage of pesticides helped in development of resistance among pests.

In Guntur and Warangal, a large number of polyphagous pests attack cotton. Pests such as cotton bollworm, jassid, whitefly, pink bollworm and spotted and spiny bollworms are becoming a serious threat. Pest complex has undergone considerable change during the last three decades. Whitefly, which was not a serious pest of cotton, has now attained the status of a key pest. Bollworm caused significant damage to cotton crops in 1977 and 1983. It has become a major pest since 1990 and caused extensive damage in 1993 and 1997. Interestingly, tobacco caterpillar was a serious pest on cotton in Guntur during late 1970's. After the introduction of synthetic pyrethriods, it totally disappeared. Now, it is trying to stage a comeback. The continuous cultivation of cotton led to high incidence of bollworm in Bathinda district of Punjab in recent years, in fact, this was a minor pest of cotton and first appeared in Punjab in 1977 (Arora *et al.*, 1983). In Nashik, serious damage is caused by DBM in cole crops. The insect pests cannot be viewed from the surface because of the compact nature of the inflorescence and closed leaf of cole crops, as a result farmers spray pesticide on each inflorescence.

Table 4: Major pests and diseases causing economic damages

Crop	Pests	Diseases
Paddy	(1) Brown planthopper (*Nilaparvata lugens*) (2) Paddy stem borer (*Scirpophaga incertulas*) (3) Paddy leaf folder (*Cnaphalocrocis medinalis*)	(1) Blast disease (*Pyricularia oryzae*) Sheath blight (*Rhizoctonia solani*)
Cotton	(1) Cotton bollworm (*Helicoverpa armigera*) (2) Tobacco caterpillar (*Spodoptera litura*) (3) Whitefly (*Bemisia tabaci*) (4) Pink bollworm (*Pectinophora gossypiella*) (5) Spotted bollworm (*Earias vitella*) (6) Jassids (*Amrasca biguttula biguttula*)	(1) Damping off (*Pythium* spp.) (2) Wilt (*Fusarium* spp.)
Cole crops (Cabbage and Cauliflower)	(1) Diamond backmoth (*Plutella xylostella*) (2) Aphid (*Lipaphis erysimi*)	(1) Damping off (*Pythium* spp.) (2) Bacterial rot (*Xanthomonas campestris*)

4.2 Pesticide usage pattern

Plant protection chemicals currently cover about 25 per cent of the total cultivated area in India (Sharma and Sharma, 1999), where in, insecticides account for 57 per cent of total pesticide used in the country followed by fungicides (29 per cent) and herbicides (14 per cent). The crop-wise and state-wise consumption of pesticides also vary considerably. It varies with the cropping pattern, intensity of pests and diseases and agro-ecological regions.

Prophylactic and remedial use of pesticides is widely adopted in these regions. Farmers prefer the use of chemical pesticides because these are easily available in the local market and have an immediate knockdown effect on insect pests. Pesticides account for a major share of the cost of cultivation. In normal seasons, they account for about 40-50 per cent, 25 per cent and 38 per cent of cost of cultivation for cotton, paddy and cole crops, respectively (Table 5). The amount spent on pesticides varies depending upon the severity of pests and diseases and also the weather conditions in a particular season. It was observed that some farmers take enough care while selecting crops. Initially, cultivation of chilli gave better returns than paddy or cotton. Over a period of time, farmers were reluctant to grow this crop, because in case of attack of yellow mosaic virus, it may completely devastate the crop.

Table 5: Comparative analysis of cost of cultivation and returns per acre of selected crops

Districts	Crops	Cost of cultivation in Rs.	Amount spent on pesticides in Rs.	Gross returns in Rs.
Raichur and Bellary	Paddy	7,786	1,980 (25)	12,954
Guntur and Warangal	Cotton	10,840	4,508 (42)	12,740
Nashik	Cole crops	21,640	8,200 (38)	33,200
Bathinda	Cotton	7,365	3,666 (50)	12,250

Note: Figures in parentheses indicate per cent cost of pesticides to the total cost of cultivation of crop

4.3 Repeated application of pesticides

Based on the conditions prevailing in different agro-climatic zones, the State agriculture departments or Universities publish package of practices. This specifies recommended practices for cultivation of different crops and also includes the doses of pesticides to be used to control different insect pests. Though the package of practices mentions the different pesticides to be used for controlling insect pests at various stages of their life cycle, farmers are confined to one or two selected chemicals in these regions. It was observed that majority of the farmers follow their own spraying schedules and doses to control pests and diseases. For instance, 15 sprays are optimum to control cotton pests in Guntur and Warangal, the actual number of sprays followed has gone up to 20-30 during a cropping season (Table 6). Such uncontrolled increase in the number of sprays makes agriculture less profitable.

Table 6: Optimum and followed sprays of pesticides in the selected districts

Districts	Crops	Optimum sprays	No. of sprays followed
Raichur and Bellary	Paddy	8	15
Guntur & Warangal	Cotton	15	20-30
Bathinda	Cotton	10	15-20
Nashik	Cole crops	10	15-20

4.4 Over application of pesticides

Majority of the respondents considered that the use of pesticides brings down the pest population, and thereby increases crop yield by about 50 per cent. However, they are of the opinion that the prescribed doses in the package of practices are not effective in controlling pests and diseases. The problem of pest resurgence and development of resistance in insect pests has increased over the years. This has provoked farmers to opt for higher doses and more frequent application of pesticides and also resort to combinations of insecticides. For instance, the optimum dose of Monocrotophos per litre of water is 1.3 ml to control an insect pest of paddy in a particular stage of its lifecycle, farmers in Raichur and Bellary were found to use 4 to 4.5 ml per litre (Table 7a). On the other hand, some farmers were also found spraying lower concentration. For instance, in Bathinda, it was observed that, the package of practice recommends 600 ml/acre of triazophos to control cotton bollworm, but some farmers apply only 500 ml/acre (Table 7b).

The concentration of the spray mixtures mentioned in the package of practices is specific only for a particular type of sprayer (either high volume or low volume sprayer). Farmers in these districts use different sprayers such as power sprayer or knapsack sprayer, which require different concentrations of spray mixture. It would be convenient to the farmers, if the package of practices were to contain dosages for all types of sprayers. Instead of using measuring cups, it was observed that farmers use their own convenient scale to measure the chemicals. This type of application may result in inappropriate dosages and pesticide poisoning.

Table 7a: Pests and diseases and commonly used pesticides on paddy and cotton in the selected districts of Karnataka and Andhra Pradesh

Districts	Crops	Insect pests & diseases	Name of the pesticides	Trade names	Optimum dose	Followed dose
					In 10 lires of water	
Raichur & Bellary	Paddy	**Insect pests** Brown planthopper (*Nilaparvata lugens*)	Monocrotophos 36 SL Phorate 10 G Imidacloprid	Nuvacron Thimet Confidor	13 ml 5 kg/acre -	40-45 ml 10 kg/acre 50 ml/acre
		Stem borer (*Scirpophaga incertulus*)	Endosulfan 35 EC Monocrotophos 36 SL	Endocil Monocil	20 ml 13 ml	40 ml 40 ml
		Diseases Paddy blast (*Pyricularia oryzae*)	Carbendazim Edifenphos	Bavistin Hinosan	10 g 10 ml	20 g 15-20 ml

Table 7a (Contd...)

Districts	Crops	Insect pests & diseases	Name of the pesticides	Trade names	Optimum dose	Followed dose
Guntur & Warangal	Cotton	**Insect pests** Cotton bollworm (*Helicoverpa armigera*)	Monocrotophos 36 SL Endosulfan 35 EC	Nuvacron, Hexasulfan, Endon	20 ml 20 ml	40 ml 40-60 ml
			Quinalphos 25 EC . Chlorpyriphos 20 EC Cypermethrin 25 EC Fenvalerate 20 EC	Ekalux Dursban Cymbush Sumicidin	30 ml 25 ml 10 ml 20 ml	90 ml 50 ml 30 ml 40 ml
		Whitefly (*Bemisia tabaci*)	Triazophos 40 EC Acephate 75 SP	Hostathion Orthene	20 ml 15 g	40 ml 25 g
		Diseases Wilt (*Fusarium* spp.)	Copper oxychloride Mancozeb	Blitox Indofil M-45, Dithane M-45	30 g 25 g	40-45 g 30 g

Table 7b: Pests and diseases and commonly used pesticides on cole crops and cotton in the selected districts of Maharashtra and Punjab

Districts	Crops	Target pests & diseases	Name of the pesticide	Trade name	Optimum dose	Followed dose
					Dose per acre	
Nashik	Cole crops (Cauliflower and Cabbage)	**Insect pests** Diamond backmoth (*Plutella xylostella*)	Quinalphos 25 EC Endosulfan 35 EC Malathion 50 EC Dimethoate 30 EC Oxymethyl dematon Phosphamidon 40 SL Neem oil	Quin guard Thiodon Sandoz Rogor Metasystox Dimecron Neem guard	250 ml 120 ml 100 ml 100 ml 100 ml 25 ml 500 ml	300-350 ml 200-250 ml 150 ml 150-200 ml 150 ml 100 ml 600 ml
		Diseases Damping off (*Pythium* spp.)	Carbendazim	Bavistin	300 g	350 g
		2. Bacterial rot (*Xanthomonos campestris*)	Copper oxy chloride	Blitox	300 g	350 g

Table 7b (Contd....)

Districts	Crops	Target pests & diseases	Name of the pesticide	Trade name	Optimum dose	Followed dose
					Dose per acre	
Bathinda	Cotton	**Insect pests**				
		Bollworms (*Helicoverpa armigera*) (*Pectinophora gossypiella*) (*Earias insulana*)	Cypermethrin 10 EC	Cymbush	200 ml	250 ml
			Alpamethrin 10 EC	Alphaguard	100 ml	200 ml
			Fenvalerate 20 EC	Fenval	100 ml	200 ml
			Monocrotophos 36 SL	Monocil	500 ml	500 ml
			Ethion 50 EC	Fosmite, Volthion	800 ml	1000 ml
			Endosulfan 35 EC	Thiodan	1000 ml	1000 ml
			Quinalphos 25 EC	Ekalux	800 ml	1000 ml
			Chlorpyriphos 20 EC	Coroban	2000 ml	1000 ml
			Triazophos 40 EC	Hostathion	600 ml	500 ml
		Whitefly (*Bemisia tabaci*)	Triazophos 40 EC	Hostathion	600 ml	500 ml
			Ethion 50 EC	Fosmite	800 ml	1000 ml

4.5 Insecticide combinations

According to the farmers in the selected districts, use of single insecticide was found to be ineffective during the high pest infestation. To overcome this, farmers were found to mix two or more insecticides either of the same chemical group or of different groups (Table 8). Use of combinations of insecticides is not advised as pests can develop resistance rapidly to both the insecticides present in the mixture. The compatibility of pesticides in tank mixtures and the proportions at which they are mixed, are important factors. A scientific blend of pre-mix is always superior to tank mixture.

Table 8: Combinations of insecticides used for controlling major insect pests

Crop	Target pest/s	Combinations
Paddy	Brown planthopper	(a) Chlorpyriphos OP + Cypermethrin SP
Cotton	Bollworms	(a) Cypermethrin SP + Quinalphos OP (b) Chlorpyriphos OP + Quinalphos OP (c) Monocrotophos OP + Quinalphos OP (d) Acephate OP + Quinalphos OP (e) Monocrotophos OP + Fenvalerate SP (f) Cypermethrin SP + Chlorpyriphos OP (g) Cypermethrin SP + Endosulfan OC (h) Cypermethrin SP + Ethion OP (i) Ethion OP + Fenvalerate SP
	Whitefly	(a) Monocrotophos OP + Chlorphyriphos OP (b) Quinalphos OP + Cypermethrin SP (c) Monocrotophos OP + Cypermethrin SP (d) Cypermethrin SP + Triazophos OP
	Spodoptera	(a) Quinalphos OP + Cypermethrin SP (b) Monocrotophos OP + Quinalphos OP
Vegetables (Cole crops)	Diamond backmoth	(a) Monocrotophos OP + Quinalphos OP (b) Cypermethrin SP + Monocrotophos OP (c) Cypermethrin SP + Endosulfan OC (d) Monocrotophos OP + Endosulfan OC (e) Cypermethrin SP + Quinalphos OP

(OP- organophosphorus, OC- organochlorine and SP- synthetic pyrethroids)

4.6 Uncommon agronomic practices

A small group of farmers in Raichur and Bellary were found applying insecticides such as Bipvin and other organophosphorous pesticides with alcohol (arrack) or kerosene in order to control Brown planthopper in paddy. The volatile nature of such mixture may prove to be dangerous to human health. Further, a large-scale extension of area under paddy cultivation has resulted in adoption of zero level cultivation (i.e., removal of the natural topography for retaining the water in the paddy fields).

In Nashik, it was found that farmers were using growth regulators such as gibberlic acid excessively in order to increase the size of fruits and vegetables. This may result in pest proliferation. It was observed that some farmers in Bathinda mix surfactants like surf powder with pesticides to control foliar diseases of cotton and paddy. Besides they also mix kerosene with pesticide and spray it over flooded paddy fields. They were of the opinion that the thin film of kerosene formed on the water helps in spreading the chemical evenly. In Bathinda, some farmers were found taking up spraying activity during the night to control nocturnal pests of cotton.

4.7 Pesticide marketing

The proactive approach and extensive network of pesticide companies help in popularizing and promoting

pesticides in the rural areas. The dealers promote the products of those companies that give maximum incentives. Besides, unlicensed dealers and retailers who are not completely aware of the toxicity of pesticides also sell them. This uncontrolled marketing has escalated pesticide abuse in these districts.

Interaction with some of the pesticide dealers reveal that actual pesticide consumption was higher than the available figures in the Government departments. The Insecticide Act specifies that every dealer need to display the stock of the products that are being sold and should provide details of actual sales and turnover. However, most of the pesticide sellers in the selected districts were reluctant to provide information on sales and turnover. In fact, the sellers were trying to hide the facts regarding illegal exports and imports from neighbouring states, credit systems prevailing in the districts and also to avoid sales tax. The sales tax for pesticides is very high in Maharashtra, so dealers get the stocks from nearby cities in Andhra Pradesh where the tax is low. Similarly, dealers in Raichur and Bellary get the stocks from Andhra Pradesh rather than Bangalore due to high transportation charges. If in case, pesticides are given on credit to the farmers, the dealers usually do not enter the quantity and sales amount in the logbook in order to avoid taxes. In addition, banned pesticides like DDT, BHC etc. are still being sold and used for agricultural purposes in these districts. The sale of spurious and substandard pesticides of local companies also prevails in these regions. The sales of such pesticides are not recorded in the logbook either.

5. Pesticide - induced Problems

5.1 Pesticide resistance

Continued and liberal use of pesticides has disturbing consequences on agro-ecosystems and human health. This also poses a threat to further increases in productivity. One of the important pesticide-induced problems in these regions is the development of resistance by the insect pests. Pesticide resistance is a dynamic phenomenon that is dependent on biochemical, physiological, genetic and ecological factors (Mehrotra, 1992). It is the acquired ability of a population of insects to tolerate one or more pesticides. The problem with synthetic pesticides is that they are likely to lose their effectiveness after prolonged use. Pest populations invariably have a genetic pool of widely differing susceptibilities to any poison. The use of pesticides creates a selection pressure on the population. It kills some of the susceptible pests within the population and those, which are not killed, are resistant. These resistant pests may have developed certain genetic properties such as less permeable cuticles, faster storage of toxin in fat or a better enzyme system for metabolising the toxin (Anon, 1984).

When the competition from susceptible individuals is eliminated due to pesticide application, the survivor population multiplies rapidly and passes on these properties to their offspring, which continue to develop further resistance against that particular chemical. Repeated reproduction of these pests finally gives rise to pest populations containing a high proportion of resistant individuals. The phenomenon of resistance development is greater with pests having shorter life cycles (Agnihotri *et al.*, 1999). Another problem associated with the use of insecticides over a long period of time is the development of cross-resistance in insect pests. It is generally observed that when an insect develops resistance to a particular insecticide, it automatically becomes resistant to all the other pesticides having same target or activity. Insect pests also become resistant to different groups of insecticides, which is termed multiple resistances. Frequent application of insecticides with higher or sub-optimal doses may also lead to resistance. Globally, about 504 insects and mites, 150 plant pathogens and 273 weeds are known to have developed resistance. It was estimated that insect resistance cost about $ 1.4 billion per year for cotton growers in US and reduced the yield in China to about 30 per cent. In India, about 31 insect pests have already developed resistance to different pesticides (Saxena, 1996).

Large-scale and repeated application of pesticides over a long period in the selected districts for the control of BPH in paddy, *Helicoverpa* in cotton and DBM in vegetables have led to development of resistance in these key pests. In Guntur and Warangal districts, the excessive use of synthetic pyrethroids resulted in development of resistance in cotton bollworm. Defective spraying, over dosages coupled with spraying of spurious insecticides have also aggravated the problem of pest resistance. To overcome this problem, farmers apply pesticides in more than the optimum doses and also resort to combinations of pesticides. The problem of resistance is of great concern not only to farmers but also to pesticide manufacturers, scientists, regulatory authorities and the general public. Sequential application of pesticides from different chemical groups and also adopting IPM practices are the viable techniques for managing the resistance problem.

5.2 Pest resurgence

Resurgence is an abnormal increase of pest population often exceeding economic threshold level following the insecticide application (Chelliah, 1979). Resurgence of pests occurs in two ways- (i) rapid resurgence of pest populations exposed to the pesticide and (ii) minor pests or unimportant target species developing into major pests or serious pests as a result of decreased competition for food and shelter (Dudani, 1999). The phenomenon of resurgence of insect pests has brought about serious economic losses to crops like cotton and paddy. The loss due to bollworm is

estimated at around 50-60 per cent in cotton, whereas loss from BPH is estimated to be 10-70 per cent on paddy (Puri *et al.*, 1999).

There is a regular occurrence of BPH in Raichur and Bellary districts of Karnataka and of bollworm in cotton-growing areas of Andhra Pradesh and Punjab. This is mainly due to excessive use of agrochemicals, particularly nitrogenous fertilisers, which enhances the vegetative growth of the host plant, thereby harbouring numerous insect pests. Continuous use of pesticides over a long period of time in these regions has resulted in decline of natural enemies of pests, which is one of the reasons for resurgence of insect pests. For instance, the large-scale use of broad-spectrum pesticides for the suppression of cotton bollworm led to the mortality of the natural enemies of the insect pests and resulted in the resurgence of cotton bollworm in 1977, 1983, 1993 and 1997 (Dhawan, 1999). In addition, unpredicted or delayed rains and other changes in climatic conditions are also identified as causes for resurgence of insect pests. It was reported that application of sub-lethal doses of insecticides brings about changes in reproductive cycles of the insect pests leading to resurgence (Chelliah, 1979). The Whitefly menace is a typical example of how a minor pest attained the status of major pest.

5.3 Decline in agro-biodiversity

Pesticides are necessarily poisons and hence they have adverse effects on any organism having physiological functions similar to the target organism. Some pesticides have greater detrimental effects on non-target organisms than on target organisms. With the present pesticide use pattern the sustenance of non-target organisms i.e., beneficial organisms, natural enemies of pests, parasites, pollinators etc., are greatly jeopardised. Pesticides that reach water bodies as runoff kill fish, water bugs, snails and aquatic plants, which are a part of the food web and play an important role in maintaining eco-balance. Overuse of pesticides has brought about a decline in the bio-diversity of non-target organisms in these districts. About 70 per cent of the respondents in these districts reported a significant decline in populations of beneficial organisms. According to them, populations of natural enemies of pests like *Chrysoperla carnea*, ladybird beetles, green lacewings, spiders and parasitoids like *Apanteles* spp., *Trichogramma* spp., *Chelonus blackburni*, etc., have come down drastically in the last few years. Farmers also revealed that significant decline in populations of birds and earthworms are noticed in fields treated with pesticides. Some of the major socio-ecological concerns among small and marginal farmers are the declining population of beneficial organisms, natural enemies of pests and also the increased expenditure on synthetic pesticides.

6. Integrated Pest Management Programmes

Integrated Pest Management is a balanced and eco-friendly approach for controlling pest populations by minimising the use of chemical pesticides. It encourages the use of resistant varieties, biological control methods and modifying agronomic practices to reduce pest incidences. The aim of IPM is not eradicating the pest, but keeping its population below the economic injury level and also minimising environmental contamination. IPM practice is essential, as it is more efficient, feasible, safe and economical. IPM acts as a unifying force to stimulate interdisciplinary problem solving, and to promote understanding of the socio-economic impact of pest management.

Biopesticides form an integral part of IPM. In 1999-2000, 874 metric tonnes of biopesticides (Neem and Bt) were used in India. However, only one per cent of the total 143 million hectares of cropped area and only 2,500 villages out of over six lakh in the country have been covered by IPM (Singhal, 2000). Biopesticides like neem, NPV formulations and herbal pesticides are gaining importance in the Nashik district of Maharashtra. DBM is a serious pest of cole crops, which has developed resistance to most of the available pesticides. Biopesticides were found effective in controlling DBM in this region. Farmers are of the opinion that during high incidences of insect pests, biopesticides are not effective. It was observed that a few farmers apply both bio-pesticides and chemical pesticides together to control insect pests. Experiments conducted on cotton crops by the Indian Agriculture Research Institute, New Delhi have proved such combinations are ineffective. However, biopesticides such as neem or Bt together with synthetic pyrethroids in four-sprays schedules were found effectively suppressing the bollworm population (Gupta *et al.*, 1996).

6.1 Limitations

IPM is a knowledge-intensive and systematic approach, which demands a lot of patience on the part of farmers. Besides, different regions have different biotic and abiotic factors influencing agronomic practices. Hence, the individual components of IPM suitable for that particular region should be selected carefully. Poor knowledge of IPM may prove to be disastrous and instead of decreasing pest population, may increase it.

The lack of an efficient monitoring system with respect to the economic thresholds of insect pests, the lack of extension support and poor transportation facilities are other major constraints in these regions that prevent the farmers from following these eco-friendly methods. In addition, the limited availability of biopesticides and other selective ingredients required for IPM are among the other factors that restricts its use by farmers. Moreover, farmers are used to the spraying of pesticides during pest attacks,

which is less labour intensive and more effective in the short term when compared to IPM, which is a continuous and more complex process throughout the cropping season. Further, certain region-specific problems also exist. For instance, in Punjab the parasitoid eggs are largely imported from south India, as there are limited IPM cells in the region. But the eggs lose their viability and effectiveness during transportation.

6.2 What needs to be done for popularizing IPM?

Better opportunity for IPM exists in the selected districts, by improving the distribution network and good extension service. Proper application of IPM techniques needs basic skills and farmers need to be trained in these aspects. Further, farmers should be made aware of the life cycle, and behaviour of each pest and should also be able to differentiate between the beneficial organisms and insect pests. An effective monitoring system that will look into the economic threshold levels of pests and diseases need to be developed. An early warning system with respect to pests and diseases, adverse climatic conditions etc. should also be made available. In addition, some of the successful IPM models of other countries need to be examined and applied to solve the problems specific to local conditions. Therefore, IPM units should be set up for each region and need to develop a suitable model for these regions.

7. Socio-economic and Health Externalities

Modern agriculture has brought about several changes in farming communities. For some, these changes have helped to improve their economic status, whereas for others, it has resulted in socio-economic distress. Majority of the farmers are greatly influenced by the market, agricultural extension, agro-industrial agencies, credit institutions and government policies, with respect to the crops to be cultivated in their fields. Farmers take up cultivation of those crops, which give them maximum returns. They continue to grow these lucrative crops even if they incur loss in a season or two with the anticipation of getting better returns in the following season.

Farmers make short-term assessments of pesticide use. In the process, they put their efforts to maximise the net returns by minimising the crop losses. They take into account the money saved from preventing crop loss versus the cost of pesticide and other farm resources required for pesticide application. Unfortunately, important factors such as the health risks involved, loss of money due to health care, loss of labour due to sickness, decreasing potential of the work, long-term health effects of pesticides and downstream effects are not given equal attention. A study in the Philippines has shown that farmers spend as much money on health care as they do on the pesticides themselves (Ralo and Pingali, 1993). Further, they do not take into account the additional cost incurred due to development of resistance among insect pests

or the economic externality caused due to decline in natural predator population. Humans also suffer from harmful effects of pesticides in the form of residues in food and the environment. The external costs of illnesses in the community due to pesticide residues are a major cause of concern.

The use of expensive agro-inputs has its adverse impact on the socio-economic status of the farming community. There are several other problems that contribute to agrarian distress in these regions. Over-dependence of farmers on credits for agricultural activities is one of the major problems that exist in the selected districts of Karnataka and Andhra Pradesh. It was observed that majority of small and marginal farmers in these places borrow money for agricultural activities from moneylenders or traders by paying heavy interests. And also 74 per cent and 47 per cent of the respondents in Karnataka and Andhra Pradesh, respectively buy pesticides on credit and many of them sell their produces back to these traders. On the contrary, it was observed that only 35 per cent and 29 per cent of respondents in Maharashtra and Punjab respectively buy pesticides on credit. Tenancy or lavani system of cultivation largely prevails in Karnataka and Andhra Pradesh. Small and marginal farmers and agricultural labourers lease land for cultivating crops. As they get less support from institutional credits or crop loans for such arrangements, they turn to moneylenders for loans. Under adverse conditions, when the crops fail they are answerable to the landowners, moneylenders or traders and others. By and large, these farmers come under the most vulnerable group often involved in taking the extreme step of committing suicide, when they cannot pay their debts or incur very huge losses (Shetty, 2002).

Subsidiary farm enterprises such as dairy and poultry have been sources of assured income for farming families. These activities help farmers to overcome distress due to crop failure or indebtedness. Interestingly, 36 per cent of respondents in Nashik and 50 per cent of respondents in Bathinda are dependent on subsidiary farm enterprises like dairy when compared to 28 per cent of respondents in Karnataka and Andhra Pradesh.

7.1 Education and awareness about ill effects of pesticides

Education plays an important role as it widens the vision of farmers and exposes them to the various aspects and opportunities related to agriculture and other fields. It also plays an important role as it enables farmers to read and understand instructions in the package of practices, the labels on the pesticide bottles that describe the safety measures to be followed etc. It was observed that farmers with education have high awareness about various developments in agriculture, recommended practices, ill effects of toxic chemicals etc. Table 9 shows the education levels among the respondents in different districts.

Table 9: Education among respondents

Education	Percentage of respondents			
	Raichur & Bellary	Guntur & Warangal	Nashik	Bathinda
Illiterate	37	38	21	21
Primary	28	21	55	36
Secondary	24	23	17	30
Tertiary	11	18	7	13

(Primary: 1st – 7th standard; Secondary: 8th – 10th standard; Tertiary: 11+)

Awareness in the farming community is the net result of their education, involvement in programmes conducted by agriculture department, pesticide industry, exposure to media and interaction with other progressive farmers. Education plays an important role in creating awareness on ill effects of pesticides. Majority of the respondents were found to have low awareness regarding the ill effects of pesticides. It was observed that 49 per cent of illiterate respondents, 39 per cent of respondents with primary education and 12 per cent of respondents with secondary education have low awareness regarding the ill effects of pesticides, whereas most of the respondents with tertiary education have high awareness in this aspect. The results revealed that most of the farmers were less informed about the importance of insecticide formulations, guidelines and dosage details on the insecticide labels or guidelines in the leaflets. Farmers, especially illiterate ones, cannot read the instructions, so they are unaware of any dangers associated with the pesticides. They cannot identify the warning symbols on the labels and are often subjected to the risk of poisoning. Pesticides of local companies do not carry registration numbers, warnings, colour symbols and percentages of active ingredients. Farmers are also not aware of the re-entry interval i.e., the time needed for a chemical to dissipate in the environment. According to Rola and Pingali (1993), most of the organophosphorous and organochlorine pesticides require an interval of at least 72 hours for dissipation. Farmers in the selected districts were found to enter the pesticide sprayed fields with in 24 hours to perform routine farm work. Hence many of them are subjected to the risk of pesticide poisoning. Although farmers are aware of the "minimum waiting period" for harvest, they do not follow it as per the guidelines. It was also noted that the size of the land holding and the economic status of the farmers have an impact on their awareness about the ill effect of pesticides. It was observed that 64 per cent of small farmers have low awareness about ill effect of pesticides (Table 10).

Table 10: Awareness about ill effects of pesticides among different categories of respondents

Category	Awareness (%)	
	Low	High
Small farmers	64	36
Medium farmers	47	52
Large farmers	40	60

It was observed that 44 per cent of the respondents, especially the medium and large farmers, do not personally take up spraying of pesticides, instead they hire agricultural labourers on contract basis for this purpose. Large and progressive farmers have a greater access to the new and

latest information on agriculture, and they often take risks of adopting certain innovative agricultural practices when compared to small or marginal farmers. It was observed that about 40 per cent of the respondents in the selected districts of Karnataka and Andhra Pradesh were depending on company representatives for technical information regarding plant protection (Table 11). In Bathinda, 46 per cent of the respondents said that they take their own decisions regarding the type of chemicals to be used in controlling pests and diseases.

Table 11: Source of technical information to the farmers regarding Crop Protection (Percentage)

Source of information	Raichur & Bellary	Guntur & Warangal	Nashik	Bathinda
(a) Agriculture officers	18	12	10	12
(b) Company representatives	40	41	26	34
(c) Other progressive farmers	18	36	32	8
(d) Own decisions	13	7	31	46
(e) Media	11	4	1	0

7.2 Pesticide application and safety measures followed

Majority of the farmers and agricultural labourers do not follow any of the recommended safety measures while handling pesticides such as wearing gloves, shoes and facemask and other protective clothing. Farmers found these protective measures uncomfortable in the hot weather and also a hindrance in their work. In addition, the excessive sweat due to the hot weather may result in dermal absorption of pesticides. It was also observed that, some farmers take up spraying activities in hot sun and spray the pesticides irrespective of wind direction. A significant proportions of respondents i.e., 55 per cent in Raichur and Bellary, 42 per cent in Guntur and Warangal and 60 per cent in Nashik use bare hands while mixing pesticides (Table 12). Persons who are involved in spraying indulge in the extremely dangerous practices of smoking, chewing tobacco, and eating while handling these chemicals. Such practices have led to several unintentional poisoning cases in these regions. A doctor in Raichur mentioned that, he observed one or two specific incidence where persons who take up regular spraying activity, were found to carry atropine injections to the field as a precautionary measure in case of any pesticide-related accidents.

Table 12: Comparison of respondents not following safety measures while spraying pesticides (Percentage)

Particulars	Raichur & Bellary	Guntur & Warangal	Nashik	Bathinda
Respondents who do not cover at least their face with a cloth or towel during spraying	38	52	63	34
Respondents who use bare hands for mixing of chemicals	55	42	60	None
Respondents who smoke or chew tobacco during spraying	29	35	37	None
Respondents who are not concerned with direction of wind while spraying of pesticides (across or against)	8	11	5	4

It was observed that farmers do not give much importance to the safe usage of pesticides. Moreover, the

tropical climatic conditions also hinder working with protective clothing and equipment. Maintenance of spraying equipment by preventing clogging of the nozzles is also important, as it helps in uniform spraying of the pesticide. Sprayers, particularly the knapsack type, have loose-fitting caps and were often found to leak or spill their contents. Unfortunately, farmers give little importance to maintenance of spraying equipment.

7.3 Pesticide related poisoning and deaths

WHO has classified chemical pesticides into four different groups based on (lethal dose) LD_{50} values. The LD_{50} value is a statistical estimate of the toxicity in terms of milligram of toxicant/kg of the body weight required to kill 50 per cent of a large population of test animals. Bt products are included under slightly toxic (green triangle) category. Pesticides that are commonly used by the farmers in these regions and reported to cause adverse health effects on them are classified under various categories of WHO classification (Table 13). Of the main class of insecticides used, organophosphorous compounds are the most hazardous and affect the nervous system. Organochlorines are highly persistent in nature, most of which are banned in India, but there is illegal marketing of these compounds. And also synthetic pyrethroids were found to have negative impacts on beneficial insects (Dinham, 1999).

Table 13: Commonly used pesticides causing adverse health effects as reported by respondents

WHO Classification	Name of pesticide
1. Extremely toxic, Class Ia LD_{50} (oral acute) 1-50 mg/kg of body weight (Red triangle)	Phorate *OP* Phosphamidon *OP* Monocrotophos *OP*
2. Highly toxic, Class Ib LD_{50} (oral acute) 51-500 mg/kg of body weight (Yellow triangle)	Dichlorovos (DVDP) *OP* Oxydemeton methyl *OP* Edifenphos *F* Chlorpyriphos *OP* Quinalphos *OP* Imidacloprid *OP* Triazophos *OP* Cypermethrin *SP*. Fenvalerate *SP* Alphamethrin *SP* Dimethoate *OP* Endosulfan *OC*
3. Moderately toxic, Class II LD_{50} (oral acute) 50-500mg/kg of body weight (Blue triangle)	Acephate *OP* Malathion *OP*
4. Slightly toxic, Class III LD_{50} (oral acute) 500 mg/kg of body weight (Green triangle)	

(OP- organophosphorus, OC- organochlorine, SP- synthetic pyrethroids and F- fungicides)

There are several incidences of non-fatal poisoning cases in the selected districts due to not following proper safety measures while spraying, lack of experience of spraying and improper application methods. Majority of the respondents who take up spraying reported that they often face problems of headaches, dizziness, nausea, nasal discharge, skin and eye irritation while handling and spraying of pesticides. There is a lack of proper monitoring of pesticide-related poisoning and deaths in these regions. Moreover, as these cases are medico-legal in nature, farmers are reluctant to undergo several rounds of police inquiry. Therefore, many poisoning cases also go

unreported in the government hospitals. Only the serious cases of poisoning are reported in primary health centers (PHC) or rural hospitals (Table 14).

Though there are several pesticide-related poisoning cases reported during field investigation, pesticide-related deaths were rare in the field, unless the operators involve themselves in chewing tobacco or taking food or drinks during spraying. Cases of intentional poisoning are high in these districts, often resulting in deaths. The easy accessibility of pesticides in these regions has turned out as an instrument for committing suicide. It was observed that several reasons were attributed with suicides, such as indebtedness, infighting in the family, etc. There were also cases of accidental consumption of pesticides by children in these districts.

Table 14: Pesticide related human-poisoning cases reported

Study area	No. of poisoning cases (Intentional and Unintentional)
1. Raichur and Bellary	
(a) BMC Hospital, Bellary	7-8 cases / month
(b) Jilla Hospital, Raichur	10 cases / month
2. Guntur and Warangal	
(a) Government Hospital, Guntur	6-7 cases / month
(b) MGM Hospital, Warangal	40-45 cases / month
3. Nashik	
(a) Rural Hospital, Dindori Taluk	2 cases / month
(b) PHC, Pimplegaon, Niphad Taluk	2-3 cases / month
(c) PHC, Gooti, Igathpuri Taluk	1-2 cases / month
4. **Bathinda**	
a) Civil Hospital, Bathinda	2-3 cases / month
b) A PHC, Talawadi Taluk	3 cases / month

(Source: Information collected through personal communication with concerned medical specialist in the region and also hospital records)

During 1999-2000, MGM Hospital in Warangal received an average of 42 cases of poisoning per month (Table 14). It was observed that private hospitals do not admit pesticide-poisoning cases or even if they did admit, they were reluctant to share any such information, as these are medico legal cases. As there is a large number of pesticide- related poisoning cases and intentional deaths in these districts, it is essential to have a proper monitoring system.

Agriculture has become a high-risk venture, particularly for small and marginal farmers. The problem starts even before the cropping season begins. If the sowing is delayed due to lack of funds or non-availability of inputs, delayed monsoon or any other reasons, it is almost certain that the farmers will have a poor harvest. Most of the farmers in these regions who have taken up modern agricultural practices have high levels of debt. Many of the small and marginal farmers prefer to take loans by paying high interest from private finance corporations, moneylenders and local merchants because of quick and easy accessibility and less procedural delay. However, when these farmers are faced with crop loss due to unseasonal rains or outbreaks of pests and diseases, they are answerable to those individuals or organisations from where they have purchased the agro-inputs on credit. Also, agricultural labourers usually demand more wages or share from harvested crops during adverse climatic conditions.

Apart from this, the inconsistency in the market prices and other factors sometime result in farmers taking the extreme step of committing suicide (Shetty, 1999). Plant protection forms an essential factor in the agricultural sector and cannot be neglected. When the country's natural resources are shrinking, prevention of crop losses due to pests and diseases are necessary to increase agricultural production and to ensure food security. The concept of group farming should be initiated, with the primary objective of reducing the cost of farming among small and marginal farmers. It is essential that Government and non-government organisations need to promote programmes on education about basic pesticide use to the farmers, so that misuse of these chemicals could be prevented to a grater extent.

8. Conclusion and Suggestions

Farmers in the selected districts prefer to grow crops like paddy, cotton and vegetables in place of coarse cereals like *jowar* and millets, because of better market demand.. Monoculture of such crops resulted in increased incidence of pests and diseases. Farmers were also of the opinion that chemical methods of pest control are very effective in combating serious pest infestation in these districts. As a result, pesticides take up almost 25-50 per cent of the cost of cultivation of paddy, cotton and vegetables in these regions. Farmers have adopted prophylactic and remedial use of these chemicals. It was observed that, to combat the problems of insect pests, farmers apply larger quantities of pesticides and try irrational combinations, which has resulted in pesticide treadmill in the selected districts.

8.1 What can Governments do?

Farmers often interact with pesticide sellers, who can play an important role in educating them about safe and proper handling of agrochemicals particularly maintenance of spraying equipment. It is essential that Government needs to prescribe a minimum educational qualification i.e. either a diploma or a degree and also special training in the field of plant protection for obtaining the license to trade pesticides. Further, such traders, along with farmers and extension workers, need to be involved in regular training on latest developments in agriculture, pest management programmes and also in safe and effective use of pesticides. It is important that scientists and agricultural extension workers attached to the Universities and Institutions should have constant interaction with personnel of pesticide companies to be conversant with new products. Pest and natural enemy identification kits should be provided to the farmers in the form of photographs or pictures. Many respondents in these districts informed that personal safety devices or equipment currently available do not suit them because of warm weather and consequent perspiration. It is essential to devise safety equipment suitable for local climatic conditions.

Pest-related surveillance and forecasting systems need to be evolved by Government agencies and communicated to farmers for selection of crops. It is essential to have a good monitoring system for identification of pests and diseases. Agricultural Universities need to develop location specific spray schedules to optimize pesticides use. Development in pesticide application technology has to be kept in pace with pesticide development. There is a need for effective regulation of pesticide trade.

Spurious pesticide products account for about 10-15 per cent of the market share in India. There need to be a strict legislation in order to prevent marketing of such spurious and substandard chemicals. The results of such tests should be made public, so that farmers will be aware of the quality of the products that are being sold in the market. In addition, only registered pesticide companies should be authorized to market their products. It was reported that the sale of unlabeled and spurious pesticides is highly prevalent in these districts. All pesticides need to be labeled in local language and should contain information regarding proper handling of these toxic chemicals.

Alternative approaches such as integrated pest management, which depend on natural biofactors have to be popularized. The current approach on promotion of IPM technology by the Government departments is laudable and Government agencies need to take up the responsibility of providing biocontrol agents. Government agencies need to provide more subsidies on IPM ingredients, so as to promote it among small and medium farmers. Some of the constrains for promotion of IPM in these districts are non-availability of eco-friendly and safe pesticide formulations at reasonable prices and also lack of information on cost and benefit of IPM techniques. For easy accessibility and availability of IPM components (especially biocontrol agents like *Trichogramma*, *Chrysoperla* etc), Government needs to establish IPM units or cells in each taluk. These cells need to monitor crop pests on day-to-day basis in these localities and keep the farmers informed about the economic threshold level. Further, unemployed educated youths need to be trained and encouraged to promote IPM activities. Since chemical pesticides cannot be completely eliminated in a short span of time, the IPM cells can also provide guidance to farmers regarding the safe and effective use of chemical pesticides.

8.2 What can industry do?

Research and Development divisions in the industries need to promote those chemicals, which are efficient and environmentally safe. Company representatives in the selected districts have succeeded in promoting their products by establishing a strong extension network. This is evident from the fact that majority of the farmers, particularly in Karnataka and Andhra Pradesh, are highly dependent on company representatives or dealers for

information on plant protection. Pesticide companies should see to it that their representatives do not misguide the farmers by not providing proper information about their products with the only intention of increasing their sales target. In addition, pesticide manufacturers need to intensify training of farmers about safe and judicious use of pesticides. Regular checks to prevent the selling of spurious or expired pesticides need to be taken up by the industries at their respective outlets.

8.3 What can farmers do?

It is essential to follow the proper time for application of pesticides for its effective use and also necessary to rotate the pesticides with safe formulations in order to avoid the development of resistance. Efforts should be made to follow proper pesticide application methods, and also care should be taken to prevent the clogging of sprayer nozzles to ensure application of proper quantity of pesticides. And also it is essential for a gradual transformation from chemical-based farming practices to eco-friendly alternatives, such as diversification in cropping patterns, crop rotation, inter-cropping, organic farming and integrated pest and disease management, integrated nutrient management, growing green manure in fields etc. Following mixed cropping will discourage monoculture without disturbing the yield or profits by encouraging the activities of natural enemies of pests and reduce the dependence of farmers on expensive chemical inputs.

Stress must be laid on self-reliance and timely action for all agricultural operations. The concept of group farming needs to be initiated, with the primary objective of reducing cost of farming for small and marginal farmers. Farmers need to take up subsidiary farm enterprises like dairy, poultry, etc. In case of unforeseen crop failure, these activities would help them to become more self-reliant, and thus reduce agrarian distress. Finally, agricultural scientists, policy makers, government and non-government agencies and pesticide industries should step-in to promote IPM techniques among the farming community. In addition, this community needs to be educated and provided necessary assistance so that they could readily appreciate the need to change from chemical intensive farming to eco-friendly farming techniques, which in turn will ensure long-term food security and environmental safety.

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List of acronyms

Anon	Anonymous
BHC	Benzene hexachloride
BPH	Brown planthopper
Bt	*Bacillus thuringensis*
DBM	Diamond backmoth
DDT	Dichloro diphenyl trichloroethane
DDVP	Dichlorvos
et al.,	And others
EC	Emilsifiable concentrate
etc	Excetra
FAO	Food and Agricultural Organisation
g	Grams
ha	Hectare
HYV	High-yielding variety
i.e.,	That is
IPM	Integrated Pest Management
Kg	Kilograms
LD_{50}	Dose required to kill 50 per cent of test organisms (Lethal dose)
ml	Millilitre
mm	Millimeters
MT	Million tonnes
NPV	Nuclear Polyhedrosis Virus
OC	Organochlorine
OP	Organophosphorus
PHC	Primary health centre
SL	Soluble concentrate
SP	Synthetic pyrethroid
spp.	Species
WHO	World Health Organisation

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