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Environmental, Socio-Economical and Institutional Aspects of Technology Adoption: Integrated Pest Management (IPM) in Rice Cultivation in the Union Territory of Pondicherry

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MOEF IGIDR WORLD BANK

FINAL REPORT OF

"ENVIRONMENTAL, SOCIO – ECONOMICAL AND INSTITUTIONAL ASPECTS OF TECHNOLOGY ADOPTION: INTEGRATED PEST MANAGEMENT (IPM) IN RICE CULTIVATION IN THE UNION TERRITORY OF PONDICHERRY"

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Chapter – I: INTRODUCTION

Agricultural development faces unprecedented challenges. Providing adequate supplies of food and improving the health of a rapidly increasing population are two greatest challenges today. By the year 2020, the world may have to support some 8.4 billion people. Even though enough food is being produced in aggregate to feed everyone some 800 million people still do not have access to sufficient food. The annual rate of food production in tropical developing nations is less than 1.0 per cent, while in most of these countries the population is growing at the annual rate of 2.0 per cent. Thus there is a serious gap between food supply and demand.

India, which was threatened by hunger and mass starvation in the 1960's, is now self sufficient in staple foods even though our population has more than doubled. Apart from this success, following serious concerns remain for the future. First, hunger and malnutrition persist in India, often because, past pattern of agricultural growth failed to benefit the poor adequately. Second, agricultural demand will grow along with population growth and rising per capita income, and this will demand continuing increases in agricultural productivity. Yet growth in yield appears to be plateauing, while the prospects for expanding cropped and irrigated areas are limited. Third, if not checked, environmental problems associated with agriculture could threaten future levels of agricultural productivity as well as the health and well being of rural people.

The ever-increasing population (2 per cent per annum) has made Agriculture production an important issue for the Government. To meet the growing requirement of food, crop protection chemicals have an essential and decisive role to play in meeting the objective. It is estimated that on an average of about one-third of world food production is due lost to pests and diseases. In India, the losses are still higher, particularly in rice, cotton, pulses and oil seeds.

The agriculture sector is the backbone of Indian economy and contributes significantly (27 per cent) to the Gross Domestic Product, employing about threefourth of the population in agricultural activity. Food grains account for 60 per cent of agricultural output with an annual production of around 210 M. tones (2001-02), which need to be doubled in the next 25 years to meet the increasing requirements. One of the key inputs essential for sustaining the growth of this sector is the agro-chemicals sector.

Today organophosphorus pesticides, followed by synthetic pyrethroids and organochlorine dominate the Indian pesticide market. In India, pyrethroids resistance has escalated because of indiscriminate and excessive use of pesticides, causing increased level of aphids, termites and bollworms that had created havoc in farm families in states like Andhra Pradesh, Karnataka etc.

Farmers embraced pesticides because of labour saving, increased crop security, higher quality and homogeneity of product and persuasive messages from research, extension and industry advertising activities. Consumers however are becoming increasingly interested in food safety and are demanding wholesome products and production practices that are not detrimental to the environment and their health.

The gains in agricultural productivity necessary to secure food availability and livelihoods in the developing world during the coming decades require an approach in which the intensification of agricultural systems is consistent with conservation of the natural resource base. This approach requires less reliance on the intensive use of external inputs and greater dependence on management skills and location specific knowledge of agro ecosystems. IPM constitutes one such approach. It involves farm practices that promote good plant and animal health and keep pest losses in check with minimum use of manufactured chemicals.

IPM can best be described as the use of an optimal mix of pest control tools and tactics, taking into account a variety of factors including yield, profit, risk, sustainability, safety and pest population dynamics. IPM is a key component of integrated farming practices that are based on an understanding of ecology and the interaction between crops or animals and their pests as well as an undertaking of the environment in which pests operate.

An essential aspect of IPM is, its integration of technical and social knowledge, understanding of key pest constraints, biological and farm management systems are required for this integrated approach, which are highly location specific requiring farmer participation and net working in the design of technology based IPM schemes.

The Food and Agricultural Organisation (FAO) initiated an Inter Country Programme to develop Integrated Pest Management (IPM) in rice, in 1980. India is one of the first seven countries involved in this programme. The main objective is to minimise environmental pollution and maintain ecological balance by discouraging the indiscriminate and excessive use of chemical pesticides and to sustain the green revolution.

The Government of India took a positive initiative for Human Resource Development through a three tier programming, that consisted of a season long training programmes for Subject Matter Specialists (SMS)and establishment of Farmers Field Schools (FFS) to train farmers. FFS are based on the principle of facilitation of farmers in a non-directive manner for their empowerment. FFS are established in the villages where 30 farmers and five extension workers receive knowledge and skill intensive field training in IPM, once a week for 10 weeks. The extension methodology involved in FFS is entirely different from the top down extension methodology followed for transfer of technology during the last three decades where role of extension agent was of a teacher or a trainer and the main objective was transfer of technology. The role of extension agent in FFS is that of a facilitator and the main objective is to empower the farmer.

FFS are established in villages, which consume a high level of pesticides. The main objective of these FFS is to make the farmers understand the role of naturally occurring beneficial fauna, and any built in compensatory mechanism of the plant and to analyse the agro eco-system. This would empower them to make their own decisions. These FFS are run by core training team comprising one master trainer and two or three specialists. During their visits, the core of the team trains the farmers to recognise beneficial /pest species, agro-ecosystem analysis, detillering and defoliation, experiments to stimulate damages caused by pests.

The Food and Agricultural Organisation, World Bank and other developmental agencies have been advocating and supporting efforts to implement IPM which remains an elusive goal in most parts of the world. Government influences the prospects for widespread implementation of IPM through the intensive structures and regulations affecting the choice of pesticides or alternative approaches. Hence this study attempts to analyse the environmental, socio-economical and institutional aspects of adoption of IPM technology in Union territory of Pondicherry (India).

ORGANISATION OF THE REPORT

The report comprises of seven chapters and is organised as follows:

Chapter-I: Introduction, Organisation of the report.

Chapter-II: Objectives of the study (With problem focus and scope of the study)

Chapter-III: Methodology: Description of study area and Sampling design

Chapter-IV: Data Analysis: Methods of analysis adopted are presented in detail.

Chapter -V: Results and Discussion: Results of general features of farm and that of objectives are presented along with discussion.

Chapter-VI: Recommendations; Summary of the research study, salient findings and conclusions are drawn with recommendations of the study.

Chapter VII: References: List of all references used in the study is presented

Chapter II: OBJECTIVES OF THE STUDY

While the adoption of IPM has been analysed by several researchers there are few farm level econometric studies in India on the effect of IPM on pesticides use, crop yield and farm profits. Moreover, little farm level empirical research has been published in the country on the effect of IPM on the overall toxicity and other environmental characteristics of pesticides and that pesticides used in IPM differ from those used on a routine schedule have not been empirically examined. Further the role of the government in popularizing IPM technology transfer and in adoption are important and least researched aspects warranting a study of this kind.

The union Territory of Pondicherry is highly developed in terms of highest cropping intensity, largest percentage of net area irrigated to net cultivated area, highest coverage of paddy area under High Yielding Varieties. The high input intensive rice cultivation in the Union Territory has led to highest pesticides and fertiliser consumption per cropped hectare in the country, whereas the average yield of rice has started to show a downward slide.

The Government of Pondicherry has reoriented its policy in 1994-95 with the introduction of IPM for rice as a centrally sponsored scheme and since then the pesticide consumption has shown a declining trend. Hence this study has been undertaken in the U.T. of Pondicherry to examine the level of IPM technology adoption by the rice growers with the following specific objectives.

1. **To study and evaluate the impact of IPM on pesticide use, yield, toxicity and other environmental characteristics.**

This will make the comparison of the IPM vis-a-vis the conventional pest control system.

2. To identify the prime factors responsible for adoption of IPM techniques for different farm size holdings in two regions of U.T. of Pondicherry.

This will bring out the salient socio-economic factors of farmers who adopt IPM techniques, which can be used as a input for future policy proposals on clean or green technologies.

3.To study the institutional aspect of IPM technology transfer.

Levels of programme participation in IPM may be influenced both by farmer receptivity and by the availability and attractiveness of programme activities. The later two factors are largely controlled by the ability of supervisory and field level staff and by programme design and fiscal resources. Each of which partly, depends upon government programmes. This will help in understanding the institution factors that influence technology transfer useful for replication elsewhere.

4. To identify the problems and constraints in the adoption of IPM technologies and suggest suitable policy measures for adoption.

This will help in rectifying deficiencies in the technology and it's mode of transfer, which can also be used to form appropriate technology, and it's transfer methods of similar clean technology in other regions or other crops.

2.0. SCOPE OF THE STUDY

The study is confined to rice in Pondicherry territory. The study tries to attempt the advantages of IPM technology over conventional pest control system on toxicity and biodiversity impact. It examines that socio-economic background of the adopter and non-adopter farms so as to gain insights into the type of farmers who adopt IPM.

This will be helpful in strengthening the existing programme and so evolve more effective programmes for similar technologies in the future as well. The study also examines the role of institutions and institutional arrangements needed to strengthen the adoption of IPM technology. Constraints often hinder the adoption of technology. The study examines the binding constraints, which affect the adoption of technology. This will be useful in the adoption of appropriate technologies in IPM, which reconcile grand conduction with the requirements of technology.

The study also examines rigorously the factors influencing IPM use, its efficacy in tackling the conflicting requirement of food together with preserving the environment and livelihood of the people. It also tries to understand the dipraminnes of IPM technologies.

2.1. LIMITATIONS OF THE STUDY

The study has tried to overcome all the limitations within its control. However, the major limitation is with respect to the duration of the study. IPM technology would have a cumulative effect, which will gather momentum with continuous use. These aspects, which are time dependent, could not be studied as it was beyond the scope of this study.

Chapter III: METHODOLOGY

This chapter deals with the Description of the study area and methodology followed in carrying out the study. It has been organized under the following heads.

3.0 Description of study area

3.1. Sampling Design

3.2. Data

3.3. Residual Analysis

3.4. Biodiversity Index

3.5. Microbial Analysis

3.0 Description of study area

The Union Territory of Pondicherry comprises of four regions viz, Pondicherry, Karaikal, Yanam and Mahe. Among these, the study was undertaken in the first two regions. (See Figure.1)

Demography

The union territory of Pondicherry extending over an area of 492 sq.km. has a total population of 9,73,829 persons with density of 2029 according to 2001census, comprising of 4,86,705 males and 4,87,124 females. The rural and urban populations are 3,25,596 and 6,48,233 respectively. The total literacy rate in the territory is 81.49 percent with male and female literacy at 88.89 percent and 74.13 percent respectively. There are 129 revenue villages in the Union Territory of Pondicherry of which 81and 36 are present in Pondicherry and Karaikal region alone.

The total number of agricultural holdings in the Territory as per agricultural census of 1990-91 was 34975 comprising 26096, 5011 and 3868 numbers under the marginal, small and large size holdings. Correspondingly the area operated by the operational holders is 82197acres, which included 22967, 17549, and 41678 acres under the marginal, small and large size category of farms.

The average size of holding worked out to 2.35ac and 0.89, 3.61and 10.77 acres respectively for marginal, small and large sized farm category.

The other allied activities of the territory included, dairying, fisheries, goat rearing, poultry and duckery. It is well developed in industries with, 12 large scale industrial units and 28 medium scale industrial units, 2687 registered small industries and 5622 village cottage industries.

The agricultural labour population as per the 1991 census show a total population of 77203, comprising of 57764, 17286, 482 and 1671persons belonging to Pondicherry, Karaikal, Mahe and Yanam regions respectively. As much as 74.8 per cent and 22.4 per cent of the total labour force are engaged in Agriculture sector in Pondicherry and Karaikal regions respectively.

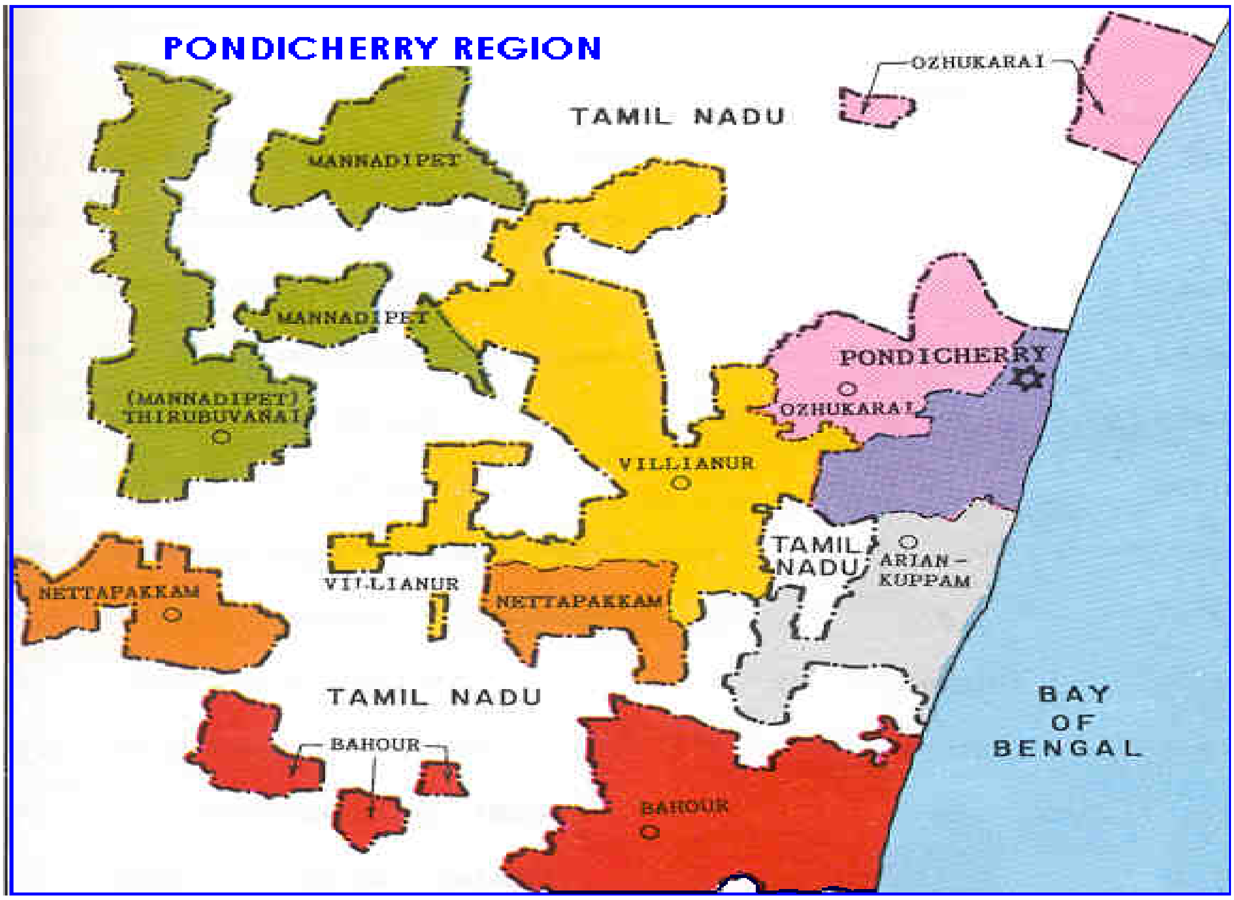


Figure - 1. Map showing study area

Climate and Rainfall

The average maximum temperature is about 33 degree Celsius and minimum is about 24 degree Celsius in Pondicherry region and about 32.3 degree Celsius and minimum is about 24.8 degree Celsius in Karaikal region during the year 1998-99.

The rainfall received in Pondicherry region is 865 mm with North-east monsoon contributing 492 mm, South-west monsoon contributing 327 mm of rainfall. Similarly in Karaikal region, 613 mm and 252 mm of rainfall are contributed by North-east and South-west monsoons respectively.

Soil types

The predominant soil types of Pondicherry region are Sandy loam, sandy soil, clay and clayey loams, whereas in Karaikal region it is deep clay, clayey loam, and sandy loam along the seacoast.

Land use Pattern

The land use pattern (1997-98) in Union territory of Pondicherry is presented in Table 3.1. It is seen from the table that of total area in the territory, only 61412 acres is put under cultivation that account for 51 per cent of the total area. The net area under irrigation is 53147 acres with remaining area under dry crops. The area sown more than once has stood at 46784 acres and there is no forest area in the territory.

Table. 3.1. Land use pattern (1997-98) in Union territory of Pondicherry (in ac)

S.No	Description	1997-98
1	Total area as per village Papers	120640
2	Forests	-
3	Land not available for cultivation	37569
4	Other uncultivated land excluding fallow land	9371
5	Fallow land	12288
6	Net area sown	61412
7	Net irrigated area	53147
8	Total cropped area	108196
9	Area sown more than once	46784

Source: Directorate of Economics and Statistics, Pondicherry

Irrigation

The Paddy is the major crop cultivated under irrigated conditions in the Territory. The total area under irrigation was 80243acres, which accounts for 77.01 percent of the total area sown during 1998-99. The area irrigated more than once in the same year accounted to 26933acres during the same year. The major sources of irrigation were tube wells, canals and other sources irrigating an area of 32370,20728 and 161acres respectively.

Table.3.2. Area irrigated under different sources in 1997-98 (in ac)

Source	Pondicherry	Karaikal
Canals	-	19829
Tanks	-	0
Tube wells	32075	225
Ordinary wells	-	0
% Net irrigated area to net sown	87.2	93.26
Area irrigated more than once	26859	3668
Total irrigated area	58949	23779
% of total irrigated to total sown	89.8	62.43

While the major source of irrigation in Pondicherry region is tube wells, Karaikal region is benefited by the canals from Cauvery (See Table.3.2.) Some of her tributaries like Arasalar, Mullaiyar, Vanjiar etc., flow through canals across Karaikal region before emptying into Bay of Bengal

Cropping Pattern

The cropping patterns for the regions of Pondicherry and Karaikal have been presented in the Annexure – I. It is worth to mention that the major share in cropping pattern comprise Paddy in an area of about 40520 and 22899 ac respectively in Pondicherry and Karaikal, which constitute 61.7 and 60.6 percent of total area under crops during 1997-98.

While farmers in Pondicherry have gone for third season paddy, those in Karaikal are able to grow black gram and green gram with available residual moisture from second season paddy, which is reflected in the area under black gram being 7190 ac and green gram being 5538 ac constituting 19.0 per cent and 14.7 per cent of total crop area during 1997-98.

The other crops with significant share in the cropping pattern are sugarcane in an area of 5748 and 180 acres constituting 8.7 and 0.5 per cent in Pondicherry and Karaikal respectively.

Production of Paddy Seeds

The quality of seed plays an important role in deciding the level of yield of a crop. “As it is sown; so it is reaped” a well-known saying. A seed is of good quality when the germination percentage and seed vigor have the specified values against them. In addition seeds possess additional attributes as resistance to pest and diseases, soil salinity, drought, lodging etc. The resistance of certain variety of seeds to pest and diseases is one of the components in IPM packages advocated to farmers. This gains its importance, as farmers use the seeds produced in their own farms for seed purpose, which only tend to delimit the yield levels. This is because seeds produced in farmers fields does not meet the standards for a good seed as it is not grown following the necessary procedures for seed production. Therefore the only alternative for a good seed source is the government depots and certified seed agencies. The scenario of paddy seed production in Pondicherry is presented in the following Table.3.3

The department of Agriculture is involved in production of two classes of seeds namely Foundation seed and the Certified seed. The certified seeds are produced from foundation seed following seed production procedures. The production of foundation seed tends to increase except for two years during 1997-99. Similarly the production of certified seeds has been on the increase excepting the year 1997-98. Also the distribution of produced seed has remained increasing year after year. The seed replacement ratio has been maintained at around 30 per cent.

Table. 3.3.Production of Paddy Seeds in UT of Pondicherry (in mt)

Year	Production of		Distribution of certified seed	Seed replacement ratio achieved (%)
	Foundation seed	Certified seed		
1995-96	52.650	225.128	347.600	31.56
1996-97	57.345	329.280	326.600	27.00
1997-98	19.350	221.950	365.700	30.50
1998-99	24.325	345.100	461.600	34.15
1999-00	100.00	350.00	425.724	31.53

Fertilizer consumption

The consumption of fertilizer in Pondicherry has been tabulated in Table. 3.4. With the total area under crops being stagnant, consumption of nitrogen has been reducing, and upward trend in phosphorous and potassium is observed.

Table.3.4. Fertilizer consumption in UT of Pondicherry- Nutrient wise (in mt)

Year	Nitrogen	Phosphorous	Potassium	Total
1996-97	13760	4109	4356	22225
1997-98	11999	4900	4663	21562
1998-99	12263	5111	4436	21810
1999-00	12469	5673	5177	23319
2000-01	12427	5733	5488	23647

Pesticide Consumption

The consumption of pesticide in Pondicherry is tabulated in Table. 3.5. it is evident from the table that during 1995-96, the consumption of pesticides in Pondicherry is 119.401 tonnes and since then the consumption had been decreasing continuously over years with consumption during 2000-01 being 62.636, which is half that consumed during 1995-96. This trend is witnessed in both the Kharif and Rabi seasons.

Table.3.5. Pesticide Consumption in UT of Pondicherry (in mt of technical grade)

S.no	Year	Kharif	Rabi	Total
1	1995-96	46.660	72.741	119.401
2	1996-97	42.870	71.805	114.675
3	1997-98	34.405	47.641	82.046
4	1998-99	30.326	40.721	71.247
5	1999-00	28.880	40.413	69.293
6	2000-01	26.047	36.509	62.636

Source: Department of Agriculture, Govt. of Pondicherry

Input Sales Point

Input sales points for fertilizers and pesticides have been presented in the Table 3.3. so as to understand the present scenario with regard to input availability in Pondicherry region. The role played by the private in supply of fertilizers has been the highest with 96 sales point among the available 143 sources viz, cooperatives, Pondicherry Agro-Service Industries Corporation (PASIC) and private traders.

Table.3.6. Input Sales Point

Sale points	Pondicherry	Karaikal	Total*
a.Fertilizers			
Cooperatives	22	10	32
PASIC	25	12	40
Private	96	7	105
Total	143	29	177
b.Pesticides			
Cooperatives	5	3	8
PASIC	25	9	37
Private	129	10	155
Total	159	22	200

**-Totals represent for four regions of the UT of Pondicherry*

In the case of pesticides again it is the private dealers who dominate the trade with around 155 sales points against total of 200.

3.1 Sampling design

The union territory of Pondicherry consists of four regions with agricultural activities dominant in the regions of Pondicherry and Karaikal, having larger geographical area and area under cultivation. The Farm field schools have been conducted in these two regions only, owing to time and manpower resources constraints; only these two regions were selected to undertake the present study.

The Farmer’s Field Schools (FFS's), a programme by the Department of Agriculture, Government of Pondicherry organises training programme to the farmers on various aspects of IPM. In a year, two to three revenue villages have been identified by extension officials for conducting the IPM training and in each training about 30 farmers are trained. This training is imparted in a particular season for a particular crop (See Annexure II (a) and II (b). The training is conducted once in a week throughout the crop period, thus the number of training classes ranges from nine to thirteen.

To select the respondents, 3 FFS villages were selected randomly in each of the two regions. From these villages, 30 farmers who were trained through FFS and 30 farmers who did not undergo such training were selected randomly. The list of Adopter farmers was collected from Assistant Agricultural Officer (AAO) of that particular village who is the field level IPM trainer. Likewise the selected sample size in each of the two regions was 225. Thus the total sample size was 450. In addition, to meet the objective of studying the institutional factors influencing adoption, 50 Agricultural extension personnel in both the regions were interviewed.

3.2 Data

In order to address the objectives, the study utilizes data from both primary and secondary sources. The primary data from the farmers and officials involved in the IPM technology transfer were collected with the help of one comprehensive interview schedule and questionnaire, respectively. The primary data required for the study were collected through the personal interview method. The schedule for the farmers covered aspects such as general particulars, asset position, crop season and pest incidence, usage of plant protection chemicals, the levels of each of the IPM practices followed and the problems faced in adoption of IPM, cultivation particulars etc. For non-adopters also, necessary particulars on the above lines have been collected. Primary data from officials involved in the IPM programmes comprised their qualification, experience in extension and financial assistance given for them for conducting IPM demonstration and were collected through questionnaire designed for them.

3.3. Residual Analysis

Pesticides don not offer any long-term solution to the pests. Rather they create problems for long. Perusal of the residue data on pesticides in samples of fruits, vegetable, cereals, pulses, grains, wheat flour, oils, eggs, fish, poultry, bovine milk, butter and cheese in India indicates their presence in sizable amounts. Pesticides residues in food are of concern. Residue of pesticides in food items refers to the dietary risks of pesticide application, which can result acute or chronic risk depending on the frequency of intake of such contaminated food. Some pesticides are now present in the human body as persistent deposit in fatty tissue and blood. Certain pesticide residues are found in mother's milk at levels much higher than we would want them. One of the must and effective and important alternative to the pure chemical control of pest is the IPM. Hence it is necessary to evaluate residue levels in the outputs produced by IPM farmer against that of non-IPM farmers.

To carry out the residual analysis, grain, straw, husk, bran and soil samples were collected from the four IPM adopters and four non-IPM farms and were analysed for residues of Pesticides.

Extraction of Paddy grain, husk, bran and straw

Weighed samples of grain (25 gm), bran (5gm), husk (5gm) and straw (10gm) was soaked overnight in 50 ml of Acetonitrile: Water (2:1 v/v). Then the samples were filtered through Buchner funnel. The pooled Acetonitrile extract was evaporated to near dryness and the aqueous remainder was treated with 50 ml of saturated sodium chloride and two 50 ml portion of Dichloromethane:Hexane(9:1 v/v) in a separating funnel. The lower aqueous phase was collected and pooled. Dichloromethane:hexane extract was passed through anhydrous sodium sulphate and evaporated to near dryness. The residue was dissolved in n-hexane.

Cleanup:

For column chromatography 1.5 cm (diameter) X 50 cm (length) glass column were used. The drip tip of the chromatographic column was plugged with cotton wool. The column was covered with 7.5 cm of anhydrous sodium sulphate, 2.5 cm silica gel: charcoal (4:1 w/w) and topped with 7.5 cm of anhydrous sodium sulphate. The column was pre-washed with 20 ml of n-hexane. The residues were poured to the top of the column and eluted with n-hexane. The elute was concentrated to near dryness and the final volume was made up to 10 ml and fed into Gas Chromatograph(GC).

Soil Extraction:

Weighed sample of 20 gm was mixed thoroughly with anhydrous sodium sulphate: silica gel: charcoal (4:2:1 w/w). The mixture was tumbled and placed in the soxhlet apparatus and ran for 6-8 hrs in acetone: hexane (1:9 v/v) mixture. The elute was condensed to 10 ml and fed into GC without any clean up.

3.4. Biodiversity Index

The indiscriminate use of hazardous pesticides had resulted in the reduction of biodiversity of natural enemies. IPM, which is an ecological approach to manage pests, on other hand, augments natural predators, thus increasing bio-diversity.

Biodiversity is a function of the number of species present (species richness), the evenness with which the individuals are distributed among these species (species evenness and the interaction component of richness and evenness (i.e.) heterogeneity (diversity). The species diversity concept is universally used by ecologist to describe biodiversity and characterize biological system or community in agro-ecosystem.

In Integrated pest management settings, the ecological theory concerning stability focuses on pest control by natural enemies. Arthropod biodiversification exerts a natural control of the most of the minor crop pest present in that ecosystem. The biodiversity index is an indicator of heterogeneity nature of the ecosystem, which could be taken into account before going for insecticidal control.

To undertake the Bio-diversity Index study, four farms from adopters and four from non-adopters were selected randomly to carry out the counting of pests, natural enemies and neutrals each in Pondicherry and Karaikal region. The population of arthropods was recorded during samba season (September-October to December-January) in both regions. The method of sampling is visual inspection of rice with a hill as a sampling unit. The total seasonal numbers of arthropod on 3200 rice hills and ten sampling occasions were estimated for nine taxonomic groups of pests, six of predators, one each of parasitoid and neutrals.

Quantitative estimation of diversity of rice ecosystem:

Quantitative estimation of species diversity in eight IPM and Non-IPM adopted fields each in Karaikal and Pondicherry was made using the data derived from field survey.

1.Species diversity (H') was computed based on Shannon-weinner index formula.

$$H' = -\Sigma\, [P_i * \ln P_i]$$

Where P_i = Ni/N; Ni= Total number of individual's in a species.

N= Total number of individuals in all the species,

In P_i = natural log of P_i.

2. The Evenness index (E_1) was computed based on the formula below.

$$E_1 = H' / \ln(S)$$

Where, E_1 – Evenness index

H' – Shannon –Weinner index of Biodiversity

S – number of species.

3.5. Microbial Analysis

The widespread use of pesticides over the years has resulted in problems caused by their interaction with natural biological systems. Microorganisms are involved in soil process such as recycling of essential plant nutrient, humus formation, biogeochemical cycles and soil structure stability besides fixing atmospheric nitrogen and producing plant growth promoting substances. Pesticides influence the density and composition of microbial population in soils especially the organisms responsible for nitrification and nitrogen fixation, thus altering soil fertility. The main objective of IPM is to minimize environmental pollution and maintain ecological balance by discouraging the indiscriminate and excessive use of chemical pesticides. Hence an attempt was made to compare the population of microorganisms in IPM and non-IPM adopted fields.

Sample collection:

Sixteen farmers, eight each for IPM and Non-IPM farms in the study region were selected at random and non-rhizosphere soil samples were collected from 4 different locations within a field at 45 days after transplanting (DAT), mixed well and labeled.

Enumeration of total bacteria and nitrogen fixing bacterial population in IPM and non-IPM adopted rice fields.

The population of total aerobic bacteria and Nitrogen fixing bacteria in soil samples collected from both IPM and non-IPM adopted rice fields were enumerated by following the standard serial dilution and pour plate method using soil extract agar medium (Allen, 1953) and Watanabe and Barraquio medium (Watanabe and Barraquio, 1979) respectively.

Chapter IV: DATA ANALYSIS

The primary data were analysed using various statistical techniques to draw meaningful inferences. Descriptive statistics such as mean, standard deviation were computed and tested for difference using t-test. Econometric models were estimated to understand the cause and effect relationship between the extents of adoption of IPM practices, the factors affecting IPM adoption, yield of crops and related factors. The methods of analyses employed are described below.

The statistical techniques employed were

4.0. Factor Analysis

4.1. Decomposition of output

4.2. Frontier Production Function

4.3. Logistic regression

4.4. Relevancy rating Index

4.0. Factor Analysis

Integrated pest management (IPM), a new concept in the field crop protection, emphasizes the need for simpler and ecologically safe measures for pest control to reduce environmental pollution and other problems caused by excessive and indiscriminate use of the pesticides. The main components of IPM are pest surveillance, use of resistant varieties, mechanical methods, cultural method, physical method, biologically selective chemical (bio-pesticides) and plant pesticides (botanicals), augmentation of natural enemies, and biological control.

An adopter of IPM can completely or partially adopt the components. Rather than to think of adoption and non-adoption of IPM as dichotomous one, it may be more appropriate to think a complete adoption and complete non-adoption of IPM as a continuum. At one end of continuum lie IPM adopting farms, who adopts entire package of IPM components. At other end of the continuum lie IPM non-adopting farm, which does not adopt any one of the IPM component. Many farms lie between the polar extremes of complete adoption and complete non-adoption of IPM components. Hence factor analysis is used to categorize farmers into adopters and non-adopters.

Factor analysis attempts to identify underlying variables, or factors, that explain the pattern of correlations within a set of observed variables. Factor analysis is often used in data reduction, by identifying a small number of factors, which explain most of the variance observed in a much larger number of manifest variables.

Seven components had Eigen roots greater than one (See Annexure - III) and these together accounted for 56.44 per cent of the variation in the data set, using these seven components a composite index of adopters was evolved by aggregating them based on the factor loadings into one composite score. On examining the coefficients of each component, it was observed that in general IPM adoption variable had been higher which implies that higher the coefficient score of an individual greater would be the level of adoption. Accordingly the score obtained by each farmer was used to categorise him or her into high adopters (hereinafter "adopters") and low adopters (hereinafter "non-adopters"). The cut off was based on mean score (7.56185E-17). The low adoption groups of farmers are those who did not adopt IPM technology or adopted it partially.

The adoption of each of the 26 components of IPM technology was scored " 1" for adoption and " 0" for non-adoption. These were subjected to Factor Analysis. Seven significant components emerged with Eigen roots greater than one. Therefore seven factor scores were obtained for each individual. These factor scores were weighted by their respective contribution to the total variance and then aggregated. The entire sample was grouped into two categories viz Adopter (having scores above Mean) and non-adopters (having scores below Mean).

4.1. Decomposition of changes in output

Decomposition is a technique used to discern out the effects of technology or an environmental damage or any other impact on production. To discern the true impact of IPM technology on production of rice in the study area, this tool has been used.

Superior technologies will contribute significantly to output. The effect of IPM on the output of paddy has been studied using decomposition analysis where technology and the factor contribution of inputs have been quantified. The two groups considered were adopters and non-adopters.

Two separate production Cobb-Douglas type functions were estimated for IPM adopted farms and non-adopting farms for paddy. The equations are estimated on a per acre basis. The forms of the equations are specified below.

Adopted farms

$\text{Log output}_A = \log A_A + a_A \log \text{Seed}_A + b_A \log \text{Urea}_A + c_A \log \text{OIF}_A + d_A \log \text{Wage}_A + e_A \log \text{OF}_A + f_A \log \text{OP}_A + g_A \log \text{Area}_A + h_A \log \text{LW}_A + i_A \log \text{PPC}_A + e_a$

Non-adopted Farms

$\text{Log output}_{NA} = \log A_{NA} + a_{NA} \log \text{Seed}_{NA} + b_{NA} \log \text{Urea}_{NA} + c_{NA} \log \text{OIF}_{NA} + d_{NA} \log \text{Wage}_{NA} + e_{NA} \log \text{OF}_{NA} + f_{NA} \log \text{OP}_{NA} + g_{NA} \log \text{Area}_{NA} + h_{NA} \log \text{LW}_{NA} + i_{NA} \log \text{PPC}_{NA} + e_{na}$

Output -	Output value per acre in Rupees
Seed -	Seed cost per acre in Rupees
Urea -	Urea cost per acre in Rupees
OIF -	Other inorganic fertilizer cost per acre in Rupees
Wage -	Total wage cost per acre in Rupees
OF -	Other Fertilizer cost per acre in Rupees
OP -	Other operational cost per acre in Rupees
Area -	Area in acres in Rupees
LW -	Land water cost per acre in Rupees
PPC -	Plant protection chemicals per acre in Rupees
e-	Disturbance term

The subscripts A and NA represent IPM-Adopted and IPM - Non-adopted farms, respectively. A is the scale parameter and a, b, c, d, e, f, g, h, and i are output elasticity with respect to various inputs used. The difference between equation of Adopted and Non-adopted farms is represented in the following form.

$$\text{Log}\,(Output_A/Output_{NA}) = \log\,(A_A/A_{NA}) + [(a_A - a_{NA})\log Seed_{NA} + (b_A - b_{NA})\log Urea_{NA} + (c_A - c_{NA})\log OIF_{NA} + (d_A - d_{NA})\log Wage_{NA} + (e_A - e_{NA})\log OF_{NA} + (f_A - f_{NA})\log OP_{NA} + (g_A - g_{NA})\log Area_{NA} + (h_A - h_{NA})\log LW_{NA} + (i_A - i_{NA})\log PPC_{NA}] + [a_A \log (Seed_A/ Seed_{NA}) + b_A \log (Urea_A/ Urea_{NA}) + c_A \log (OIF_A/ OIF_{NA}) + d_A \log (Wage_A / Wage_{NA}) + e_A \log (OF_A/ OF_{NA}) + f_A \log (OP_A / OP_{NA}) + g_A \log (Area_A / Area_{NA}) + h_A \log (LW_A / LW_{NA}) + i_A \log (PPC_A/ PPC_{NA})].$$

The above equation apportions the differences in total value of output between the IPM adopted farms and the IPM non-adopting farms in the cultivation of paddy. The first term refers to the percent change in total output per acre due to the shift in Scale parameter A. The second term estimates the effect of change in slope parameters also referred to as non-neutral technology change. These two terms in total give the value of effect of technology to the difference in output of adopters (in this case Integrated Pest Management) and non-adopters. The last term measures the contribution of change in output due to change in input levels.

4.2. Frontier Production Function

The crucial role of efficiency in increasing agricultural output has been widely recognized by researchers and policy makers alike. It is necessary, therefore, that analysis of farm level efficiency of the IPM adopters and non-adopters. An underlying premise behind this is that if farmers are not making efficient use of existing technology, then efforts designed to improve efficiency would be more cost-effective than introducing new technologies. The purpose of this analysis is to quantify the levels of technical, allocative and economic efficiency of adopters and non-adopters of IPM.

The technical efficiency of production has been analysed in frontier production function approach which has been estimated by method of corrected ordinary least square (COLS) technique. As a first step, ordinary least square (OLS) is applied, which gives the best linear unbiased estimates. The intercept estimates is then corrected by shifting the function until no residual is positive and one is zero. Given the technical efficiency, given input prices and output prices, the allocative efficiency and economic efficiency were obtained.

4.3. Logistic regression Analysis

It is useful for situations in which you want to be able to predict the presence or absence of a characteristic or outcome based on values of a set of predictor variables. It is similar to a linear regression model but is suited to models where the dependent variable is dichotomous. Logistic regression coefficients can be used to estimate odds ratios for each of the independent variables in the model. Logistic regression is applicable to a broader range of research situations than discriminant analysis.

Farmers are assigned a value “ 1” for adopters “ 0” for non-adopters. Since, adopters and non-adopters may be systematically different, these differences may manifest themselves in various individual and cultivation characteristics, which need to be identified. An understanding what contributes and what does not favour adoption is useful for extension agencies to formulate their strategy.

The adoption of IPM practices may be influenced by several factors such as Age, Experience, and contacts with Agricultural extension personnel, etc. Therefore to understand the degree and direction of influence of each factor in the adoption of the technology, the logistic regression Model was used.

The model had been fitted for three groups of farmers viz, Marginal, Small and the Large. This has been done in order to understand the factors in each group, which will pave the way for being replicated in other situations and improve the level of adoption. The model relates the set of factors to set of farmer characteristics and to estimate the probabilities of adoption due the set of factors. Thus the relation will be represented as below

$$P(Y) = 1/(1+e^{-y})$$

Where Y = 1 if he adopts and Y = 0 if he does not adopt. It is assumed that Y is linearly related to the variables shown below:

$$\ln(P/1-P) = \beta_1 + \beta_2 AA + \beta_3 A + \beta_4 AI + \beta_5 OI + \beta_6 IPM + \beta_7 E + \beta_8 EX + \beta_9 L + \beta_{10} M + \beta_{11} NLA + \beta_{12} OA + \beta_{13} PPC + error$$

Where P is the probability of adoption.

AA	Approach made by Agricultural officer (0 = No; 1 = yes)
A	Age of farmers in years
AI	Agricultural Income in Rupees
OI	Other income in Rupees
IPM	Whether attended IPM training (0 = No; 1 = yes)
E	Years of Education obtained
EX	Experience in agricultural activity in years
L	Livestock value in Rupees
M	Membership in organization (0 = No; 1 = yes)
NLA	Non-land asset value in Rupees
OA	Operational area in acres
PPC	Whether reduced usage of PPC (0 = No; 1 = yes)

Based on the sample of 188 adopted (Y = 1) and 262 non-adopted (Y = 0) farms the analysis had been undertaken.

4.4. Relevancy rating Index

Problems and constraints faced by the adopters of the various practices under IPM techniques studied. A similar exercise was undertaken to document the problems and constraints faced by non – adopters in adopting the practices under IPM.

This study is meant to highlight the importance of various constraints faced by farmers in adoption of IPM based on the rating given by the farmers on a three-point scale. The farmers were asked to rank each constraint as " Not a constraint", " Minor constraint" or " Major constraint", which was scored " 0", " 1" and " 2" respectively.

The Relevancy Coefficients of each of the constraint was obtained by using the formula:

$$\text{Relevancy Coefficient (i)} = \sum_{g=1}^{N} X_{g\,i} \;/\; (\text{Maximum on the continuum} * N)$$

Where X_{ji} is the score of g^{th} farmer for the i^{th} constraint;

N is the total number of farmers.

The relevancy coefficient is estimated for all the constraints. These coefficients are then arranged in the descending order and the constraint with the highest coefficient is ranked as the first and that with lowest score is ranked as the last (In this case 26^{th}).

Moreover, as adopters have already taken up IPM techniques and the non –adopters are yet to take up, constraints of both the category may have to be studied separately, this necessitates the construction of relevancy coefficient for the two groups.

Chapter – V: RESULTS AND DISCUSSIONS

This chapter comprises of two parts, the first deals with general features of sample farms and secondly, the results with respect to the objectives of the study are discussed. The discussion of general feature of the sample farms is necessary, as it provides the background, which would make results more meaningful.

ADOPTERS AND NON-ADOPTERS OF IPM

IPM technology consisted of a number of practices, which were either partially or fully adopted by the farmers. The extent to which they adopted the technology formed the basis of categorization of them to adopters or non-adopters. For the purpose a suitable index was developed.

All the respondents were post stratified into adopters and non-adopters using the Factor analysis. Based on the results of Factor analysis the factor score was developed. As per the results 188 adopters and 262 non-adopters were identified in a total sample of 450 farmers. This formed the basis for further categorizations in the study.

A. GENERAL FEATURES OF SAMPLE FARMS

1. Distribution of Sampled Households according to size of holding

The distribution of sample farm households in the study region is presented in the table 5. The table shows that the number of household in the marginal, small and large size category adopter farms were 95 (51percent), 46 (24 percent) and 47 (25 percent) respectively. The same for non-adopter farms was 169 (65 percent), 39 (51 percent) and 54 (21 percent) respectively. As expected the number of household in the marginal size category was the maximum among the three farm categories under both levels of adoption. The number of households in the large size category was found to be higher than the small size group in both adopter and non-adopter farms and for the entire sample.

As regards the average size of holdings, the marginal and small sized farms operated 1.40 and 3.53 acres of land in the adopter category, being higher than that of non-adopter category where it was 1.18 and 3.32 acres, respectively for marginal and small farms. On the contrary, average size of holding held by large size group in non-adopter category was 9.50 acres and it was higher than that of adopter farms, being 8.41 acres. The average size of holding in adopter and non-adopter farms was 3.67 and 3.41 acres respectively and 3.41acres for the total samples.

Table.5.1. Distribution of Sampled Households according to size of holding

category	Adopters		Non-Adopters		Total	
	Number of households	Average size of operational holding(acres)	Number of households	Average size of operational holding(acres)	Number of households	Average size of operational holding(acres)
Marginal	95	1.40	169	1.18	264	1.26
Small	46	3.53	39	3.32	85	3.44
Large	47	8.41	54	9.50	101	8.99
Total	188	3.67	262	3.22	450	3.41

2. Education level

The level of education of the sample farmers in different size category of farms are presented in Table 5.2. The level of education refers to the number of years of education. It is observed that the level of education was higher among adopter category of farmers than among non-adopter farms, in all size categories that level of education had increased with increase in farm size. It was 7.1(marginal), 9.1 (small) and 9.2 (large) in adopter farms and 5.2 (marginal), 7.4 (small) and 8.1 (large) in the non-adopter category of farms. On an average adopter farms and non-adopter farms had 8.1 and 6.1 years of education, respectively.

Table.5.2. Education level of sample farmers (in years)

Category	Marginal	Small	Large	Total
Adopters	7.1	9.1	9.2	8.1
Non-adopters	5.2	7.4	8.1	6.1
Grand Total	5.9	8.3	8.6	6.9

3. Age distribution

The age is one of the important variables that influence decision making of individuals. Age has a bearing on the farmers' attitude towards risk in adopting new technologies. The age of the sample farmers has been presented in Table 5.3. It could be seen that age was higher in adopter farms over that of non-adopter farms in the marginal and small farms being 49.8 and 47.6 and 47.2 & 45.4 respectively for adopter and non-adopter farms. Meanwhile the large size farmers had 47.4 and 48.5 as average age in adopter and non-adopter groups respectively. In overall the age for adopters was higher than that of non-adopters.

Table 5.3. Age of sample farmers (in years)

Group	Marginal	Small	Large	Total
Adopters	49.8	47.6	47.4	48.7
Non-adopters	47.2	45.4	48.5	47.2
Total	48.1	46.6	48.0	47.8

4. Experiences in Agriculture

Experiences in paddy cultivation have been studied to determine whether it has any influence of adoption. The results presented in Table 5.4 reveals that adopters had more experience in paddy cultivation than the non-adopters, respectively.

Table 5.4. Experience in Agriculture of sample farmers (in years)

Category	Marginal	Small	Large	Total
Adopters	24.8	24.3	23.7	24.4
Non-adopters	21.1	20.9	23.9	21.6
	22.4	22.8	23.8	22.8

5. Family size

The family size in different farm sizes are presented in Table 5.5. It could be seen from table that the size of family in marginal, small and large size of farms of adopters was 4.0, 4.6 and 4.5 respectively, whereas in non-adopter farms it was 4.5, 4.7 and 4.5, which were comparatively higher than the adopter farms and the size of family tend to increase with size of holding except in case of large size farms. The overall family size of the entire sample was 4.4.

Table 5.5. Family size of sample farmers (in numbers)

Category	Marginal	Small	Large	Total
Adopters	4.0	4.6	4.5	4.3
Non-adopters	4.5	4.7	4.5	4.5
Grand Total	4.3	4.6	4.5	4.4

6. Income distribution

The income accrued from sample farms from the different sources viz, agriculture and non-agriculture are presented in Table 5.6. Agricultural incomes from non-adopter farms were observed to be higher than adopter farms for small (Rs.28512) and large (Rs.84958) size category, whereas in marginal farms it was higher in adopter farms (Rs.15123) over that of non-adopter farms (Rs.8149). In overall, income from agriculture was higher for adopters than non-adopters.

Similarly the income from other non-agricultural sources reveals the reverse trend. The income from these sources in marginal farms of adopters (Rs.35553) was lower than that in non-adopter farms (Rs.37154) and that for small farms (Rs.47764) and large farms (Rs.90786) where higher in adopter farms over that of small (Rs.46105) and large farms (Rs.48488) in non-adopter farms. The income from the agricultural sources and other sources for the adopters were than the non-adopter farms.

Table.5.6. Income of sample farmers (in Rupees)

Category	Income	Marginal	Small	Large	Total
Adopters	Average of Agriculture income	15123	28038	77119	33782
	Average of Other income	35553	47764	90786	50024
Non-adopters	Average of Agriculture income	8149	28512	84958	27011
	Average of Other income	37154	46105	48488	40721
Total Average of Agriculture income		10658	28255	81310	29840
Total Average of Other income		36711	46995	61946	43836

7. Participation in IPM training

The participation of the farmers in IPM programmes conducted by the Department of Agriculture in the respective villages needs to be studied, as it guides in the understanding the reasons for and against in the process of adoption. The results for the sample farms have been presented in Table 5.7. which reveals that about 24, 42 and 38 percent of marginal, small and large farmers in the total sample had participated in IPM trainings, whereas it was only 19, 21 and 19 percent in the respective farm sizes of non-adopters.

In toto, there were 31 percent of adopters and 19 percent of non-adopters who participated in the IPM trainings. Thus a higher percentage of participation in trainings in IPM in adopter farms over non-adopters was observed.

Table.5.7. Participation in IPM training by sample farmers (in Percent)

Category	Whether Attended IPM training?	Marginal	Small	Large	Total
Adopters	No	12	12	9	11
	Yes	24	42	38	31
Adopters Total		36	54	47	42
Non-adopters	No	45	25	35	39
	Yes	19	21	19	19
Non-adopters Total		64	46	53	58
Grand Total		100	100	100	100

8. Approaches with Agricultural Extension Personnel (AEP)

Among the institutional factors that determine rate of adoption, the number of approaches made by the farmer with AEP or AEP with farmer plays the complimentary role with IPM trainings. It is they who actually sow the seeds of awareness on IPM among farmers. Therefore to study the frequency of contact of farmers in sample farms with AEP's in the Department of Agriculture would only improve our understanding of the process of adoption. These AEP's also conduct Farm Field Schools on IPM that lasts for the entire crop duration.

The results of the study are presented in Table 5.8, and it could be seen that the percentage of farmers approaching AEP was 26.52, 47.06 and 41.58 in marginal, small and large size farms, whereas it was 20.45, 25.88 and 27.72 percent in the respective farm sizes of non-adopters. It was 33.78 and 23.11 percent for adopters and non-adopters of the entire sample, indicating a higher extension contact among adopter farms.

Table.5.8. Contacts with AEP by sample farmers (in Percent)

Category	AEO approach?	Marginal	Small	Large	Total
Adopters	No	9.47	7.06	4.95	8.00
	Yes	26.52	47.06	41.58	33.78
Adopters Total		35.98	54.12	46.53	41.78
Non-adopters	No	43.56	20.00	25.74	35.10
	Yes	20.45	25.88	27.72	23.11
Non-adopters Total		64.02	45.88	53.47	58.22
Grand Total		100.00	100.00	100.00	100.00

9. Membership status

The membership in organizations viz, water user association, milk society, farmers association etc, is an indication that how open people are. It has a role to play in the decision making process of adoption of IPM. This can be mainly through demonstration effects of the practice in fellow farmer fields and in particular, collective adoption being preferred by farmers. Table 5.9 throws light on the membership pattern in adopter and non-adopter farms. The percentage of farmers with of membership of various organization were 17.8, 23.53 and 25.74 in marginal, small and large size category of farms of adopters, whereas it was 10.98, 9.41 and 14.85 percent in respective size classes of non-adopters. For the sample as whole, it was higher in adopter than non-adopter farms being 20.67 and 11.56 percent respectively, which is 32.23 percent.

Also the sizewise observation is an increase in the percent of farmers owning membership in organization, which increased with size in both categories of farms, excepting in small farms of non-adopters wherein it was the lowest of all size categories for that group and in total.

Thus a very significant difference in percentages of holding membership exists between the adopter and non-adopter farms in all size categories, being very high in adopter farms over non-adopters.

Table.5.9. Membership status of sample farmers (in percent)

Two category	Membership	Marginal	Small	Large	Total
Adopters	No	18.18	30.59	20.79	21.11
	Yes	17.80	23.53	25.74	20.67
Adopters Total		35.98	54.12	46.53	41.78
Non-adopters	No	53.03	36.47	38.61	46.67
	Yes	10.98	9.41	14.85	11.56
Non-adopters Total		64.02	45.88	53.47	58.22
Grand Total		100.00	100.00	100.00	100.00

10. Value of non-land assets

The non-land asset position of sample farms, which comprise of buildings, livestock and other tools and implements are presented in Table 5.10. The level of these assets would help to measure the extent of their wealth, which could influence the adoption of new technique. It also reflects the investments made in the farm.

The values of buildings, livestock and tools and implements are found to be higher in marginal farms of adopters than in non-adopter farms. Similarly in small farms the value of buildings, livestock and tools & implements were higher in adopters than in non-adopter farms. It was a different situation in large farm category as one could notice that the value of buildings and livestock in non-adopter farms were higher than the value of buildings and livestock in adopter farms. But the value of tools and implements were higher in adopters than in non-adopter farms in large farm category.

Overall, the values of buildings was higher for non-adopter group than adopters, whereas tools & implements and livestock where higher in adopter farms than in non-adopters farms. Increase in value of assets with farm size could be observed, as one would normally expect.

Table.5.10. Value of assets of sample farmers (Rupees per farm)

Category	Value	Marginal	Small	Large	Total
Adopters	Tools & implements	9831	22418	57192	28123
	Livestock	12370	16366	17985	14984
	Buildings	153653	260326	343191	227138
Non-adopters	Tools & implements	4112	15837	50869	17823
	Livestock	12064	16141	18865	14055
	Buildings	110298	166154	454722	189601

11. Average yields

The average paddy yields on farms of the sample farmers are presented in Table 5.11. It could be seen that yields have been higher in adopter farms over non-adopter farms in all size category of farms with the yields being 1973 kg/acre, 2099 kg/acre and 2028 kg/acre in marginal, small and large farms of adopters, whereas in non-adopter farms it was 1664 kg/acre, 1991 kg/acre and 2007 kg/acre, respectively. Also yield levels reveal an increase in yield from marginal to small farms in both categories of farms, whereas in the large farms it was marginally lower than the small farms of adopter category and was marginally higher in non-adopter category. On overall, the yields were higher in adopter farms than that of non-adopter farms.

Table. 5.11. Average yields in sample farms (Kilograms per acre)

Category	Marginal	Small	Large	Total
Adopters	1973	2099	2028	2018
Non-adopters	1664	1991	2007	1783
Grand Total	1775	2050	2017	1881

B. RESULTS OF THE ANALYSIS OF OBJECTIVES OF STUDY

1. IMPACT OF IPM ON USAGE OF PESTICIDE, TOXICITY LEVELS, YIELD AND ON ENVIRONMENT

1.1. Impact of IPM on Rice Production

The real impact of IPM technology can be understood only if they are standardized to comparable levels of scale, input use and the like. This can be accomplished by decomposing the change in output to its constituents like technology, scale and input use. A model proposed by Bisaliah (1977) is conventional to compare the difference in output between two groups. In this study, the two groups considered were the adopter and non-adopter groups. The effect of IPM on the output of paddy has been studied using decomposition analysis where technology and the factor contribution of inputs have been quantified. The results have been presented in the Table 5.12 below.

Perusal of the table reveals prima facie that the average output among the IPM adopter farms is higher than the non-adopter farms. It was 3912 kg /acre viz-a-viz 3245 kg/acre in the non-adopter farms. The outputs of paddy are substantially higher in the IPM adopted lands even as the cost of expenses towards PPC and other inputs was considerably lower in the adopted farms. Therefore it was felt necessary to identify the share of different sources of inputs and technology adopted to understand the impact arising due to adoption of the technology in cultivation of Paddy.

Table 5.12. Production Function estimates: Adopted and Non-Adopted farms
Dependent Variable: Total output value(Rs)

Details	Adopted farms		Non-adopted farms	
	Coefficient	Geometric Mean	Coefficient	Geometric Mean
Constant	2.8576		3.7317	
Land lease& water charges	-0.0269	6.1	0.0011	10.2
Manure & Compost	0.0020	14.3	0.0054	11.2
Other inorganic fertilizer	0.0329	601.8	0.0897	571.4
Other operations	0.2168	2111.8	0.1914	2148.9
Plant protection chemicals	-0.0121	5.3	-0.0055	23.1
Seed	0.1012	432.2	0.1548	402.2
Wages	0.3413	1693.8	0.1405	1994.7
Urea	0.0002	161.3	-0.0123	217.0
Area	0.9942	1.6	1.1087	1.4
Output		3912		3245
R2	0.777		0.908	
N	188		262	

It is evident from the analysis that the increase in output value in adopter farms (Rs3912) was 21 percent over the non-adopter farms (Rs3245). It is noteworthy that the cost incurred towards usage of Plant protection chemicals was very high in the Non-adopter farms (Rs23) accounting 333 percent higher over adopter farms (Rs.5.4). Also, the amount spent on Urea fertilizer in non-adopter farms (Rs. 217) was as high as 35 percent over the adopters' farms (Rs. 161). Alternatively, the expenses incurred on organic source of fertilisation viz, manure and compost was higher (27.7 percent) in the adopter farms (Rs.14.3) than non-adopter farms (Rs.11.2). Expense incurred towards seed cost had been higher (7.4 percent) in the adopter farms (Rs.432) than non-adopter farms (Rs.402).

Thus it could be inferred that the use of higher levels of urea in non-adopter farms could have led to higher incidence of pests in farms leading to high expenses in usage of Plant protection chemicals, whereas in adopter farms the usage had been lower for both urea and plant protection chemicals. This could be confirmed from the negative signs of the coefficients for Urea (-0.0123) and plant protection chemicals (-0.0055) respectively, whereas it was positive in adopter farms for urea (+0.0002) and negative for PPC (-0.0121).

Table 5.13. Output differences due to adoption of IPM and inputs

Source of Change	Percent share
Changes in Techniques used (IPM)	
Neutral technology	- 468.48
Non-neutral technology	+ 521.22
Technology	52.74
Changes in input used	
Land and water cost	47.26
Manure & Compost	
Other inorganic fertilizer	
Other operations	
Plant protection chemicals	
Seed	
Wages	
Urea	
Area	
Changes due to inputs alone	47.26
Changes due to other factors	0.19
Total changes accounted	100.00

The differences in the output of paddy per acre on adopter and non-adopter farms were decomposed into a) neutral technological change b) non-neutral technological change and c) inputs. Components a and b constitutes the contribution of technology.

The results in Table 5.13, obtained from the decomposition analysis to study the contributions of input and technology reveal that value of output (Rs.3912) was higher in farms that opted for practicing IPM techniques than farms that did not practice this technology (Rs.3245) by around 18.85 percent. Also the Table 5.13 showing the output differences due to adoption of technology and without it shows that changes due to neutral technology is –468.48 percent and that due to non-neutral technology is 521.22 percent and that the changes attributed by them together accounting for 52.74 percent.

This result is significant and suggests that IPM technology is an embodied technological change and requires the use of a package of practices. Only if this is done, the farmer will receive a higher output as a matter of fact if only the technology is adopted partially the yield levels will be much lower than the non-IPM farms. But the judicious use of resource and management practices can boost the yield levels by about 53 percent. This increase in value of output was measured as the difference between IPM adopted and IPM non-adopter farms.

It was also observed that the contribution of usage of various inputs viz, Seed, Urea, Other inorganic fertilizers, labour (Wage), organic fertilizers, other operations, area, land lease and irrigation charges and plant protection chemicals is only about 47.3 percent in the total change in output value in the IPM adopted farms.

1.2. Economics of IPM. Adoption

Farmers need not necessarily adopt a technically feasible alternative if it is not in concurrence with the objective of profit maximization. The profitability is determined by the cost involved, crop productivity and output price. There was no difference in price received by adopters and non-adopters of IPM. Thus, given the output price, productivity and cost of technology are the main determinants of profitability. The average costs and returns are presented in the Table 5.14. The IPM adopted farms generated net returns worth of Rs. 5208 per acre, which is 26 per cent higher than the non-adopter farms. Thus IPM emerges as an economic alternative to substitute predominantly chemical pest control technology.

Table 5.14. Cost and Returns under Adopter and Non - adopter farms (Rs/ acre)

Details	Total Costs	Gross Returns	Net Returns
Adopters	6229	11436	5208
Non-adopters	6050	10197	4147

1.3. Technical and Economic Efficiency

Economic Efficiency has been dichotomised into allocative efficiency and technical Efficiency. The former deals with the allocation of resources for profit maximisation based on the prices of input and the other with management efficiency or realising the highest output with the given level of input use. The technical efficiency of the production has been analysed in the frontier production function approach, which has been estimated by method of Corrected Ordinary least Squares.

Table No 5.15: Frontier Production function Analysis

Details	Adopter		Non-adopter	
	Coefficient	Optimum Level of inputs	Coefficient	Optimum Level of inputs
Constant	2.873**		3.824**	
Area	0.984**	2.567	1.110**	2.402
Wages	0.368**	1439.958	0.160**	520.803
Other operations	0.254**	993.276	0.200**	650.558
Seed	0.031^{NS}	119.962	0.158**	511.382
Manure & compost	0.000^{NS}	0.949	0.001^{NS}	3.275
Urea	-0.001^{NS}	49.785	-0.003^{NS}	121.500
Other Inorganic fertilizers	-0.001^{NS}	519.557	0.030**	95.982
Plant Protection Chemicals	-0.002^{NS}	0.001	-0.003^{NS}	0.106
Land & water Charges	-0.009**	0.000	0.000^{NS}	0.002
R^2	0.772		0.907	
Observations	188		262	

**: Significance at 1 per cent level, ^{NS}: Not Significant

The results of frontier functions along with optimum levels of each resource used in production has also been computed and presented in the table 5.15. Using this function the individual farmers efficiency levels were determined and the overall level of technical efficiency calculated and presented in the table 5.16. The average level of technical efficiency was 0.35 among adopters and 0.37 among non-adopters. The levels of technical efficiency were more or less the same, for both adopter and non-adopter.

Table 5.16: Efficiency of Adopter and Non-adopter farms

Efficiency	Adopters	Non Adopters
Technical Efficiency	0.35	0.37
Allocative Efficiency	0.27	0.88
Economic Efficiency	0.09	0.32

Allocative Efficiency deals with allotting resources consistent with the prices of inputs and output. The economic Efficiency was derived from their allocative and technical efficiency levels. Economic efficiency was 32 percent among non-adopters and 9 percent among adopters. These results clearly show that IPM adopter farmers have greater potential that of non-adopter farmers. Though these results are only indicative, they show that the adopter farmers can boost output.

The above results of efficiencies suggest that of efficiencies suggest that eventhough both the adopters and non-adopters are technically inefficient, comparatively the adopter is operating with lower allocative and economic efficiencies. Therefore there are great potentials for IPM adopters to further increase output using available inputs and technology. Policies and programmes aimed at improving technical efficiency, extension and educational programmes. One would expect that such programmes would also improve allocative efficiency and economic efficiency of adopter farms.

1.4. Dosage of PPC used and their sufficiency

Among the indicators of the success of IPM technique in pest management is the impact on consumption of pesticide levels. The farmers were asked their views regarding the dosage levels adopted and their sufficiency as perceived by farmers themselves and are presented in Table 5.17. Of the total adopters and non-adopters numbering 188 and 262, only 111 and 196 of them had used PPC during the year under reference. It was observed that 82 percent of the adopters used the recommended dose of PPC, whereas those using above recommended dose were 12 percent and those using below recommended doses were 6 percent respectively.

Among the farmers using the recommended levels it was observed that 91 percent felt the dosage to be sufficient and only 9 percent did not feel the dosage was sufficient. An examination of the reasons for the feeling of sufficiency of dosage reveals that 70 percent were concerned about the importance of environment and 5 percent found it economical.

Among those who used above the recommended levels, 77 percent felt the dosage was sufficient while 23 percent did not feel sufficiency. On questioning for the reasons, it was evident that it was sufficient to control pest, while 60 percent and 20 percent were concerned about environment and 10 percent concerned on about the high cost of pesticides. In contrast there were 67 percent among those feeling the dosage to be insufficient who were not interested to use pesticides at further higher levels, whereas 33 percent wanted to apply more pesticides but were held back for financial reasons.

Among the seven farmers who used PPC below the recommended dose, 43 percent of them felt the dose they were using was sufficient to control pests, 29 percent of them felt it was economical and the rest 29 felt the dosage to be sufficient to control pests and safe for consumption purpose.

In the case of non-adopters, 73 percent had used PPC at the recommended levels, whereas 22percent were found to use it above recommended dosage and 5 percent below recommended dosage. Among users of PPC within the recommended level, 79 percent feel the dosage was not sufficient and only 21percent feel it was sufficient. The reason attributed for not using sufficient levels as perceived by them was financial constraints by 96 percent followed by lack of interest by 3 percent of farmers. Among those feeling that this dosage was sufficient, the reasons attributed was economy in use by 27 percent, sufficient to control pests by 27 percent and other reasons by 30 percent of them.

Table 5.17. Dosage of PPC used and their sufficiency as perceived by respondents in Sample farms

Dosage	Sufficiency	Reasons for not using sufficient level? (In case of no only)	Reasons for sufficiency in level used? (In case of yes only)	Adopters		Non-adopters		Total	
				Numbers	%	Numbers	%	Numbers	%
Recommended level	NO	Finance (R1)		7	88	108	96	115	96
		Not interested (R2)		1	13	3	3	4	3
		R1R2			0	1	1	1	1
			NO Total	***8***	***100***	***112***	***100***	***120***	***100***
	YES		Economical (R1)	4	5	8	27	12	11
			Less impact on environment (R2)	58	70	1	3	59	52
			Consumption purpose (R3)	4	5	2	7	6	5
			Sufficient to control (R4)	5	6	8	27	13	12
			Others	5	6	9	30	14	12
			R1R2	2	2		0	2	2
			R1R4	3	4	2	7	5	4
			R2R4	2	2		0	2	2
			YES Total	***83***	***100***	***30***	***100***	***113***	***100***
			Total Recommended level	**91**	**82**	**142**	**72**	**233**	**76**
Above Recommended level	NO	Finance (R1)		1	33		0	1	13
		Not interested (R2)		2	67	1	20	3	38
		Others			0	3	60	3	38
		R1R2			0	1	20	1	13
			NO Total	***3***	***100***	***5***	***100***	***8***	***100***
	YES		Economical (R1)	1	10	1	3	2	4
			Less impact on environment (R2)	2	20		0	2	4
			Sufficient to control (R4)	6	60	36	95	42	88
			Others	1	10	1	3	2	4
			YES Total	***10***	***100***	***38***	***100***	***48***	***100***
			Total Above recommended level	**13**	**12**	**43**	**22**	**56**	**18**
Below Recommended level	NO	Finance (R1)				4	100	4	100
			NO Total			***4***	***100***	***4***	***100***
	YES		Economical (R1)	2	29		0	2	14
			Sufficient to control (R4)	3	43	5	71	8	57
			Others		0	1	14	1	7
			R1R4		0	1	14	1	7
			R3R4	2	29		0	2	14
			YES Total	***7***	***100***	***7***	***100***	***14***	***100***
			Total Below Recommended level	**7**	**6**	**11**	**6**	**18**	**6**
			Grand Total	**111**	**100**	**196**	**100**	**307**	**100**

A similar study among non-adopters using PPC above recommended dose reveal that dosage used by them was sufficient in 88 percent of farms. On the contrary 12 percent felt the dosage was not sufficient while 60 percent of them attributed other reasons for not using the required level of PPC and 20 percent each of the respondent were not interested to spend more on pesticides.

Of the non-adopters who used Pesticides at below the recommended levels, 64percent were satisfied with the dose whereas 36 percent were not satisfied. Among those who felt that the dosage was sufficient, 71 percent felt it sufficient to controls pests adequately.

1.5. Reduction in usage of PPC

The success of the IPM programme could also be judged by the impact on the use of pesticides, which is an important indicator. The usage of pesticides vary with climate, incidence of pest, price etc. The study attempted to ascertain the extent of reduction in usage of pesticide and thereby the reasons that they attribute for the action and the results are furnished in Table.5.18. Eighty eight percent of adopters intended to reduce PPC and only 12 percent did not intend to do so. Sixty five percent of them attributed the reasons to their awareness regarding IPM, which constituted the major reason for reduction in PPC. The rest 35 percent had reduced on account of increasing price of PPC (10 percent) and other reasons. Thus a drastic reduction in PPC is evident from introduction of IPM.

Table 5.18. Reduction in usage of PPC in sample farms (in percent)

Whether reduced PPC?	No: of farmers	Percent
No	22	12
Yes	166	88
Total	188	100
Reasons for reduction	No: of farmers	
Price increase (R1)	17	10
IPM Awareness (R2)	106	64
Experiencing benefits by IPM (R3)	19	11
Others (R4)	1	1
R1R2	3	2
R1R3	0	0
R1R4	1	1
R2R3	16	10
R2R4	1	1
R3R4	2	1
Total	166	100
Reasons for not reducing PPC	No: of farmers	
Inadequate IPM knowledge (R1)	4	18
PPC effective than IPM (R2)	5	23

Whether reduced PPC?	No: of farmers	Percent
IPM has no immediate effect (R3)	4	18
Others (R4)	4	18
R1R2	0	0
R1R3	1	5
R1R4	0	0
R2R3	0	0
R2R4	4	18
R3R4	0	0
Grand Total	22	100

Similarly reasons were obtained from the rest 12 percent (22 farmers) who did not go for reducing of PPC. About 23 percent felt that PPC was more effective than IPM, 18 percent had inadequate knowledge and 18 percent believed that IPM has no immediate effect while the rest 18 percent attributed other reasons. About 18 percent of them who did not feel the need to reduce PPC were not properly informed about IPM technology.

1.6. Frequency in usage of PPC chemicals in Nursery and Main field

The comparison of pesticide consumption in both the categories can give an indication of the extent of reduction in pesticide. Moreover, as the information is collected in the same year, the influence of weather conditions that differ from year to year is eliminated.

The frequencies in usage of pesticides in nursery and main-field are presented in Table.5.19. Paddy is vulnerable to infestations by pests mainly during the vegetative stage of the crop. The various pests like stem borer, leaf folder, brown plant hopper, gallmidge and earhead bug etc, invade and cause damage to crop. Hence the need to control them through any means is warranted by the farmer. Similarly pests are also prevalent in the seeds that may manifest itself into higher proportions during the later stages of the crop. Thus farmers resort to control these pests in the seed during the nursery phase of crop itself. The control of pests at this stage would minimize farmer’s cost as it is considered as a precautionary step in pest control. The total number of applications undertaken has an influence on the pest and in turn on the environment.

The table reveals the number of application carried out in the nursery stage of the crop in both the adopter and non-adopter farms. Single application was prevalent in 88 and 81.5 per cent of adopter and non-adopters respectively. Non-adopter farms resorted to 2 or 3 application of PPC in the nursery, whereas adopters rarely made 2 or 3 application in the nursery.

Table.5.19. Frequency in usage of PPC chemicals in Nursery and Main field

Nursery	Adopter		Non-adopter		Grand Total	
	Number	Percent	Number	Percent	Number	Percent
One application	73	88.0	97	81.5	170	84.2
Two application	5	6.0	11	9.2	16	7.9
Three application	5	6.0	11	9.2	16	7.9
Grand Total	83	100.0	119	100.0	202	100.0

Main field	Adopters		Non-adopters		Grand Total	
	Number	Percent	Number	Percent	Number	Percent
One application	58	76.3	113	68.1	171	70.7
Two application	15	19.7	49	29.5	64	26.4
Three application	3	3.9	3	1.8	6	2.5
Four application		0.0	1	0.6	1	0.4
Grand Total	76	100.0	166	100.0	242	100.0

In case of main field application, the percentage of farmers restricting to one application is found high in adopter farms (76.3 percent) than non-adopter farms (68.1 percent). Farms taking up second application are 19.7 and 29.5 percent in adopter and non-adopters, respectively, three applications it is 3.9 and 1.8 percent of farms, whereas not a single farm in the adopter category had gone for four applications and it was 0.6 percent in non-adopter category.

The cost incurred on application of Pesticides at the nursery and main field level in the sample farms is presented in Table.5.20. The cost incurred on PPC in paddy cultivation was Rs.95 and Rs.271 in the nursery and main field phase of crop growth in adopter farms. In non-adopters farms it was Rs.113 and Rs.289.2 respectively for the nursery and main field phase of the crop. The total PPC cost spent in non-adopter farms was higher than adopters' farms at Rs.366 and Rs.402.2 per acre respectively. The dependence on PPC by the non-adopters farms was also higher.

Table.5.20. Cost of PPC used in sample farms (in Rupees per acre)

Area of application	Adopters		Non-adopters	
	Actual cost	Percent	Actual cost	Percent
Nursery	95.0	26.0	113.0	28.1
Mainfield	271.0	74.0	289.2	71.9
Total	366.0	100.0	402.2	100.0

1.7. Perception of ill effects on usage of pesticides

The perception of the ill effects on the usage of pesticide by farmers is presented in the Table. 5.21. Perusal of the table reveals that under 5 percent of the adopters did not think pesticides had any harmful effect, whereas about 15 percent of the non-adopters felt PPC had no adverse effect. However 13.3 percent of adopters felt it had a negligible effect, whereas 1/5 of the non-adopters echoed this opinion. The adopters were predominantly of the view that pesticides had a moderate effect as endorsed by the opinion of 48.9 percent of the adopter respondents. About 12 percent of the adopters felt it had a serious effect, about 35 percent and 5 percent of the non-adopters perceived pesticide as having a moderate to serious effect, respectively.

Table 5.21 Perception of ill effects on usage of pesticides

Perception	Adopters		Non-adopters		Total	
	Number	Percent	Number	Percent	Number	Percent
No effects	9	4.8	39	14.9	48	10.7
Negligible effect	25	13.3	56	21.4	81	18.0
Little effect	39	20.7	61	23.3	100	22.2
Moderate effect	92	48.9	93	35.5	185	41.1
Serious effect	23	12.2	13	5.0	36	8.0
Grand Total	188	100.0	262	100.0	450	100.0

1.8. Safety measures taken while spraying operation

Having understood the adverse effects we examined whether they have taken precautionary measures. Application of pesticides in farms has mostly been undertaken with safety precautionary measures. This is the first step in preventing the ill effects due to Pesticide application. The studies on these aspects in the farms are presented in Table 5.22. reveal that measures such as use of glove, separate clothing, bathing after spraying, washing hands etc, had been followed in both category of farms.

Both adopters and non-adopters farmers were found to use these measures on par with 82 percent and 79.6 percent of the respective groups following one of the safety measures. Similar with the perception on the ill effects of using PPC, with adopters perceiving higher than non-adopters, here too the measures taken as safety are higher in adopter farms than non-adopter farms.

Table 5.22. Safety measures taken while spraying operation

Whether takes Safety measures	Adopters		Non-adopters		Grand Total	
	Number	Percent	Number	Percent	Number	Percent
No	20	18.0	40	20.4	60	19.5
Yes	91	82.0	156	79.6	247	80.5
Total	111	100.0	196	100.0	307	100.0

1.9. Ill-effects noticed by usage of pesticides on crop on livestock

Though the PPC is perceived to cause ill effects by both categories of farms, a study of the components of environment prone to it was studied. Livestock was one component that has chances for being affected by usage of Pesticides, as the major source of feed to livestock is farm produce, usually grass and paddy straw in the region. Contrary to the expectations it could be observed from Table 5.23, that the ill effects noticed on livestock was minimal and only seven and six percent in adopters and non-adopter farms reported that it would have an adverse effect.

But there was an interesting observation that we came across in two farms at village, Oozhiapathu, in Karaikal region wherein in one case there was death of a cow, which had grazed the paddy fields of a farmer who had sprayed the field with Endosulphon, pesticide to control Stem borer and leaf folder only a day before. The other case was severe presence of diarrhea in a goat in the same village, but had been treated and survived. When asked for the reasons, it was said that high doses of PPC cause ill effects on livestock. Moreover livestock were prevented from entering fields sprayed with PPC. Only high doses of chemicals were found to cause effect in livestock as dysentery, diarrhoea and death.

Table 5.23. Ill-effects noticed by usage of pesticides on crop on livestock

Harmful effects on livestock	Adopters		Non-adopters		Grand Total	
	Number	Percent	Number	Percent	Number	Percent
No	53	93.0	123	93.9	176	93.6
Yes	4	7.0	8	6.1	12	6.4
Total	57	100.0	131	100.0	188	100.0

1.10. Effects & Symptoms of PPC on persons involved in spraying.

Unabated use of pesticides can result in various health and environmental problems. Health hazards associated with the pesticides manifest in chronic and acute toxicity in living beings. Chronic toxicity of pesticides like cancer, cardiopulmonary, neurological and skin disorders, adverse reproductive effects, such as foetal deformities, miscarriages, lowering the sperm count of applicators etc., arising due to long term exposure to pesticides. While acute toxicity, arising out of short term/immediate exposure to pesticides probably affects those who are involved in the formulation, manufacture, trade and application of pesticides.

Application of PPC has its effect mainly on the person spraying, the one most vulnerable to PPC as he is exposed to it directly. The study of the effects and symptoms of PPC on persons involved in spraying had been studied. The results of responses are tabulated and presented in Table 5.24. The results reveal the varying symptoms namely, headache, vomiting, Irritation in eyes, Irritations in skin, giddiness, etc, to be commonly witnessed in about 28.6 percent and 19.2 percent of adopter and non-adopter category of farms. The highest symptoms observed with adopters had been Irritations in eye (28.6 percent) followed by vomiting and giddiness (14.3 percent). The symptoms of other nature were prevalent in 10.7 percent of farms. Likewise in non-adopter farms, headache (29 percent), Giddiness (19.4 percent), Irritations in skin (16.1 percent) and vomiting (6.5 percent) are noticed. The farms where symptoms were not noticed constituted 84.18 percent. Over 80.8 percent of all farms did not notice any immediate symptoms in this regard.

Table 5.24. Effects & Symptoms of PPC on persons involved in spraying.

Whether affected?	Symptoms	Adopters		Non-adopters		Grand Total	
		Number	Percent	Number	Percent	Number	Percent
No		83		165		248	
	N Total	**83**	**74.8**	**165**	**84.18**	**248**	**80.8**
Yes	Headache (R1)	1	*3.6*	9	*29.0*	10	*16.9*
	Vomiting (R2)	4	*14.3*	2	*6.5*	6	*10.2*
	Irritations in eye (R3)	8	*28.6*	1	*3.2*	9	*15.3*
	Irritations in Skin (R4)	3	*10.7*	5	*16.1*	8	*13.6*
	Giddiness (R5)	4	*14.3*	6	*19.4*	10	*16.9*
	Others (R6)	3	*10.7*	2	*6.5*	5	*8.5*
	R1R2	2	*7.1*	2	*6.5*	4	*6.8*
	R1R4		*0.0*	1	*3.2*	1	*1.7*
	R1R5	2	*7.1*		*0.0*	2	*3.4*
	R2R3		*0.0*	1	*3.2*	1	*1.7*
	R2R4		*0.0*	1	*3.2*	1	*1.7*
	R2R5	1	*3.6*	1	*3.2*	2	*3.4*
	Y Total	**28**	***25.2***	**31**	***15.8***	**59**	***19.2***
Grand Total		**111**	**100.0**	**196**		**307**	**100**

1.11. Source of Medical help availed by affected persons

Among those affected it is observed that 32.1 percent and 21.4 percent of the adopter farms seek medical aid from government hospitals and followed by self-medication respectively, whereas in non-adopter farms 48.4 percent and 22.6 percent undergo self-medication and seek medical aid from government hospitals respectively. The higher percentage of self-medication in non-adopter farms may be because of their lack of awareness of effects of pesticides, which is evident from Table 5.25. The other sources of medical help availed had been from neighbours (6.8 percent), private clinics (6.8 percent), nearest medical shop (3.4 percent) and others (5.1 percent).

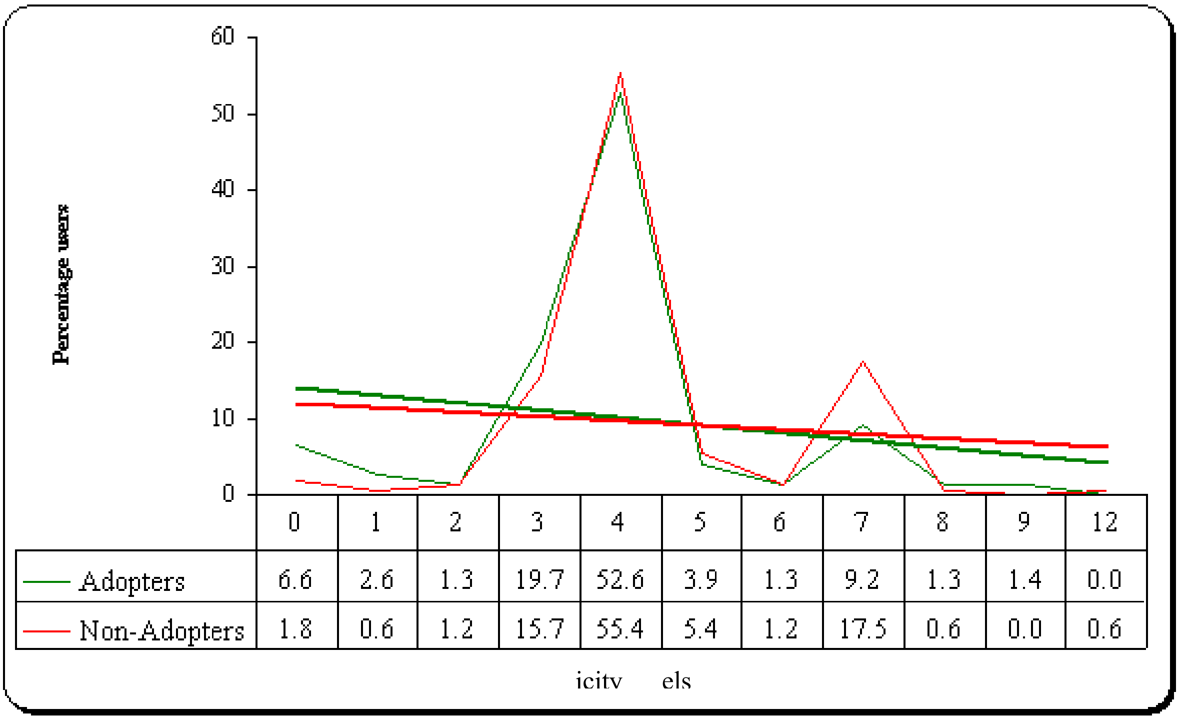
Table 5.25. Source of Medical help availed by affected persons

Affected	Source of Medical help	Adopters		Non-adopters		Grand Total	
		Number	Percent	Number	Percent	Number	Percent
Yes	Self (R1)	6	21.4	15	48.4	21	35.6
	Neighbours (R2)	3	10.7	1	3.2	4	6.8
	Private clinics (R3)	3	10.7	1	3.2	4	6.8
	Government hospitals (R4)	9	32.1	7	22.6	16	27.1
	Nearest medical shop (R5)			2	6.5	2	3.4
	Others (R6)	1	3.6	2	6.5	3	5.1
	R1R4	2	7.1	1	3.2	3	5.1
	R1R5			2	6.5	2	3.4
	R2R3	1	3.6			1	1.7
	R3R5	1	3.6			1	1.7
	R4R5	2	7.1			2	3.4
Grand Total		**28**	**100**	**31**	**100**	**59**	**100.0**

1.12. Usage pattern according to Toxicity levels

An attempt has been made to understand the usage of pesticides according to their toxicity level. The pesticides used in farms had been grouped under the standard classification as Red, Yellow, Blue and Green indicating the descending order of toxicity levels. A farmer using PPC labeled “Red” is given a score of 4, “Yellow” as 3; “Green” as 2 and “Blue” as 1respectively. The total scores of individual farms were arrived by summing up scores of each pesticide used and for each time used. The percentage users under each score, representing the toxicity levels are represented in the Figure.2.

It could be seen that the proportion of users of chemicals with high toxicity had decreased with toxicity level in both categories of farms and that the rate of decrease was higher in adopter farms than non-adopters, confirming the greater awareness of impact on environment in adopter farms than non-adopter farms.



1.13. Perception of ill effects on the environmental components by Adopters

Table 5.26 presents an analysis of the impact of pesticides on the environmental components viz, fish population, beneficial insect, air quality and butterfly population as perceived by the adopter farms.

Table.5.26. Perception of ill effects on the environmental components

Component	Not noticed	Minor	Considerable	Drastic	Total
Fish population	146 *(77.7)*	35 *(18.6)*	7 *(3.7)*	0 *(0.0)*	188 *(100)*
Beneficial insect	127 *(67.6)*	30 *(16.0)*	15 *(8.0)*	16 *(8.5)*	188 *(100)*
Air quality	163 *(86.7)*	17 *(9.0)*	8 *(4.3)*	0 *(0.0)*	188 *(100)*
Butterflies	138 *(73.4)*	27 *(14.4)*	18 *(9.6)*	5 *(2.7)*	188 *(100)*

(Figures in parenthesis are percent to the respective total)

The effect of pesticides on the environment has been studied based on the impact it has on the fauna. The results are presented in table 5.26. Majority of the respondents had not noticed any perceptible impact, as evident from their response. About 78 percent said they had not noticed any impact on the fish population, 68 percent said it did not affect beneficial insects and 73 percent felt it had no impact on butterflies. However, many of the respondents, numbering about 9 to 18.6 percent felt there was a minor impact. About 8 percent felt that there was either a considerable or drastic effect on the beneficial insects and butterflies but not so much on fish.

1.14. Residue Analysis

The results obtained from the residual analysis of the grain, bran, husk, straw and soil from IPM and non-IPM farms are presented in the Annexure – IV (a), IV (b) and IV (c). The analysis was done to observe any residue in the produce and soil and the findings are presented below.

a.) Residues of Endosulfan:

The harvest time residues of endosulfan isomers were detected in non- IPM farms. The harvest time residues of α isomers in straw was detectable in three farms and there levels were 0.006, 0.003 & 0.003 respectively in non-IPM farms, whereas in the case of grain sample, 0.001 µg / kg was detected in one farm among the three, which took up the spray of Endosulphon. Similarly 0.012 and 0.006 µg / kg respectively were detected in one farm each of bran and husk samples.

The β isomer in straw, grain and bran were detected in two non-IPM farms each and there levels were 0.004 & 0.004, 0.002 & 0.002, 0.035 & 0.035 respectively. One farm in the non-IPM category showed 0.009 µg / kg of residue in Husk. For all other case it was below detectable levels. (BDL).

The results also revealed that, residues of α, β isomers and endosulfan sulphate were below detectable limit (BDL) in the grain, straw, husk, bran and soil samples collected from IPM farms.

b.) Residues in Monocrotophos :

The harvest time residues of monocrotophos were detected in straw and husk samples of one non-IPM farm, which was 0.035 and 0.071 µg / kg respectively, whereas in the other farms it was below detectable limit. The residue was not observed in any of the IPM farms taking up spraying of monocrotophos.

c.) Residues of chlorpyriphos:

The harvest time residues of Chlorpyriphos was detected in grain sample of one non-IPM farm, which was 0.025 µg / kg. whereas in the other farms it was below detectable limit. The residue was not observed in any of the IPM farms taking up spraying of Chlorpyriphos.

From the results it was concluded that α, β isomer of Endosulfan (Organochlorine compounds) residues were observed in straw, grain, bran and husk samples collected from Non-IPM farms. But the level of residues in all the samples were found to be below Maximum Residual Limit (MRL). Though the residues were below the MRL, in due course these residues may get accumulated in body fat tissues of human beings and cattle’s. These insecticide residues may cause chronic toxicity to human beings and animals. Since straw and bran are fed to cattles like cows, the residues present in those commodities will in turn be secreted in their milks. The results also indicated that the organophosphorus compounds namely monocrotophos and chlorpyriphos residues were observed in straw, husk and grain samples collected from Non-IPM plots. The level of residues of monocrotophos was above the Maximum Residual Limit (MRL), while the chlorpyriphos was below the MRL. The insecticide residue will cause deleterious effects to man and animals, which feed on these paddy fractions (straw, bran,husk, grain). These insecticide residues were due to indiscriminate use of insecticides in non-adopters farms.

1.15. Biodiversity

The Shannon Weinner index of diversity for IPM adopted farms were 2.40 and 2.28 in Pondicherry and Karaikal region respectively, while in non-IPM farms it was 2.31 and 2.15 respectively. (See Annexure – V). It is seen that IPM farms were more diverse than non-Adopter farms in both region, which could be attributed to the indiscriminate use of Pesticides in non-adopter farms, while it was need based in IPM adopted farms.

Table.5.27. Biodiversity indices in Rice Ecosystem

Category	Pondicherry region	Karaikal region
Sahnnon-Weinner index of Biodiversity		
IPM farms	2.40	2.28
Non-IPM farms	2.31	2.15
Evenness index		
IPM farms	0.85	0.80
Non-IPM farms	0.81	0.75

Stability refers to the existence of pests, natural enemies and neutrals in a balanced proportion. To assess this proportion the Evenness index of IPM was constructed and the results show a higher value in IPM farms of both regions than non-adopter farms, indicating that IPM adopter farms are more stable. i.e. this will not cause any pest outbreak, whereas in the non-IPM farms, the Evenness index is lower, showing the unevenness in population of pests, natural enemies and neutrals, which would cause sudden pest outbreak due to absence of competition between pests and natural enemies.

1.16. Microbial Analysis

The results obtained from the Microbial count of bacteria (Total aerobic bacteria and N fixing bacteria) in soils of IPM and non-IPM farms are presented in the Table 5.28 below. The analysis was done to study the impact of IPM on the soil micro flora.

Of the 8 IPM adopted rice fields soil samples of 6 fields recorded higher total aerobic bacterial (107 to 134 X 10^6/ g soil) and diazotrophic (Nitrogen fixing) bacterial (77- 98

X 10^3 / g soil) population whereas, the total aerobic bacterial (31 to 56 X 10^6 /g soil) and diazotrophic bacterial (17 to 31 X 10^3 /g soil) population of non-IPM adopted fields were significantly low. (See Table 5.25) In general, the total aerobic and diazotrophic soil bacterial population were significantly higher in IPM adopted fields than non-IPM adopted fields.

Table 5.28: Microbial population in IPM and non-IPM adopted fields

Sample plot	Soil bacterial population	
	Total aerobic bacteria @10^6 / gm soil	N fixing bacteria @10^3 / gm soil
IPM Farms		
1	107	77
2	128	91
3	71	36
4	116	85
5	134	98
6	63	38
7	111	83
8	120	87
Non-IPM Farms		
9	56	31
10	45	20
11	31	17
12	39	17
13	51	25
14	48	24
15	42	21
16	36	17

Soil biological activity is an index of soil fertility. The microorganisms and their enzymatic activity in soil play a major role in decomposition of organic matter, solubilization & mobilization of nutrients to plants production of plant growth promoting substances, etc., thereby increasing yield and improving soil physical and chemical characteristics. The results of the study clearly revealed that in general, the soil bacterial and diazotrophic population in IPM adopted fields were 2 to 3 times higher than that in non-IPM adopted fields. Of the 8 IPM adopted fields, except two, six have recorded significantly higher bacterial & diazotrophic population. The primary data collected from the respective farmers through questionnaire has revealed that the IPM farmers whose soil samples recorded higher total bacterial and diazotrophic population were indeed practising IPM in their rice fields for more than three to five years, while those (sample plots 3 & 6) that recorded lower total bacterial and diazotrophic population have adopted IPM for the first time. However, the total bacterial & diazotrophic population in soils of IPM adopted fields where in general higher than in non-IPM adopted fields. This could be attributed to restricted use of pesticides in IPM fields than in non-IPM fields where pesticides were applied frequently based on calendar of operation.

2.0. FACTORS INFLUENCING ADOPTION OF IPM IN DIFFERENT SIZE OF HOLDINGS

The adoption of IPM practices has been influenced by several factors such as Age, Experience, contact with Agricultural extension personnel, etc. To understand the degree and direction of influence of each of these factors in the adoption of the technology the logistic regression model was used, the results of which is presented in Table 5.29.

Table 5.29. Factors influencing adoption and their coefficients

Variable	Marginal		Small		Large	
	Coefficient	Exp (b)	Coefficient	Exp (b)	Coefficient	Exp (b)
AEO approach	1.4764**	4.37716	1.4459*	4.2457	0.2496	1.28351
Age	0.0274	1.02778	-0.0168	0.9833	-0.0157	0.98442
Agricultural income	0.0000137	1.00001	3.08E-07	1	6.86E-07	1
Attending of IPM training	-0.0302	0.97025	0.2516	1.2861	1.7986**	6.04118
Education	0.1208**	1.1284	0.0748	1.0777	0.0496	1.05085
Experience	-0.0091	0.99094	0.0248	1.0251	0.0224	1.02265
Livestock value	-0.0000056	0.99999	-0.0000077	1	0.0000212	1.00002
Membership	1.2459***	3.47606	1.4139**	4.112	0.9561*	2.60153
Non-land assets	2.06E-07	1	4.19E-07	1	-8.5E-08	1
Operational area	0.3314	1.39292	1.2741**	3.5755	-0.0169	0.98324
Other income	-0.000009	0.99999	-0.000002	1	-0.00000057	1
Attitude to reduce PPC	1.2797***	3.59556	1.2672*	3.5509	1.664**	5.28039
Constant	-4.9233	0.00728	-7.2516	0.0007	-3.4346	0.03224

Note: *** - Significant at 1 per cent level
** - Significant at 5 percent level
* - Significant at 10 percent level

The category of three groups of farms included 264, 85 and 101 farmers in Marginal, Small and Large groups respectively. Analyses of factors that have influenced adoption in the marginal category of farms reveal that the adoption has been positively and highly significantly influenced by the memberships in organizations and attitude to reduce usage of PPC. Being a member of any organisation tends to increase the rate of adoption by 3.5 times and the intention to reduce PPC by 3.6 times respectively.

Similarly the education of the farmer and contacts made with Agricultural Extension personnel have both been significant and positive in influencing the rate of adoption of IPM. The other factors such as age, agricultural income, non-land assets, operational area had a positive influencing on adoption but these are not significant.

The scenario in the small farms regarding factors influencing adoption reveals that membership in organizations and operational area of farmers had been significant (five percent level) and positive in influencing adoption by 4.1 and 3.6 times respectively. Similarly the approach made by Agricultural extension personnel and the attitude to reduce PPC had positively and significantly (10 per cent level) influenced adoption by 4.3 and 3.6 times for a unit increase in these variables.

In the large farm category attending IPM training and attitude to reduce PPC have had a positive and significant impact on adoption by 6.0 and 5.3 times respectively, whereas membership in organization was positive and significantly (10 per cent level) influencing adoption by 2.6 times.

In general, it could be inferred from Figure 3, that with decreasing size of farms, the number of contacts made with AEP and the education level of farmers has been instrumental in increasing adoption rate significantly. The membership in organisation was found to influence adoption significantly in small size of farms. The attitude towards reducing PPC had influenced the adoption significantly in all categories of farms and was found to be higher in the large size category. It was interesting to find that the value of other income had negative influence on adoption of IPM, though not significantly.

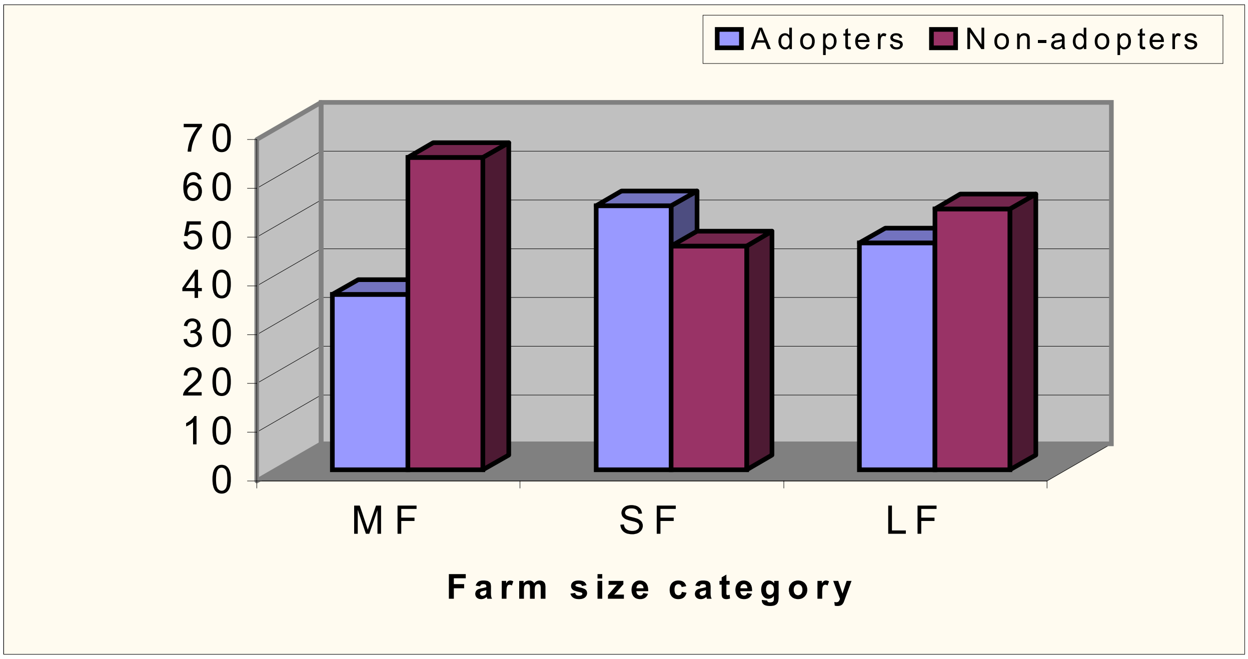


Fig. 3. Percentage levels of adoption in the different sizes of farms

Of the 264 marginal farms, 169 were non-adopters (64 percent) and 95 were adopters (36 percent) of the IPM technology. In the small farmer category (85 farmers), there are 39 non-adopters (46 percent) and 46 adopters (54 percent). In the large farmer category there were 54 non-adopters (53.5 percent) and 47 adopters (46.5 percent).

2.1. Adoption level of IPM components in Adopters farms

Participation of farmers in IPM trainings conducted by the department does not reflect the adoption rate in fields. The adoption varies with the resource base, time availability, financial sources etc. However as IPM in itself is a complex technique with package of components to be followed, it is either followed partially or nearest fully by the farmers. Therefore to ascertain the extent of adoption of the technology in the sample farms, particulars on the components adopted and not adopted were collected and the same are presented in Table 5.30.

Table 5.30. Adoption level of IPM components in Adopter farms

IPM technology	No: of farms not practising	No: of farms Practising	Percent Adoption
Selection of good land site	0	188	100
Soil testing	84	104	55
Preparation of good Nursery	7	181	96
Summer Ploughing	47	141	75
Selection of pest resistant varieties	46	142	76
Seed Treatment	91	97	52
Drying of seeds	40	148	79
Maintaining optimum population	61	127	68
Rogue spacing	61	127	68
Avoiding use of Excess Nitrogen	11	177	94
Alternate wetting and drying fields	16	172	91
Timely weeding	9	179	95
Crop rotation	88	100	53
Clipping of seedlings	118	70	37
Collection and destruction of insects	74	114	61
Light traps	114	74	39
Destruction of diseased plants	66	122	65
Dislodging of Case-worms	114	74	39
Using rat traps	47	141	75
Allowing snakes to control rats	33	155	82
Planting of 'T' stick	24	164	87
Natural enemy conservation	53	135	72
Release of Parasitoids	96	92	49
Maintaining Predator: Pest ratio	75	113	60
Usage of PPC based on the ETL	68	120	64
Neem-chemicals	28	160	85

The results obtained from the sample farms suggest that the practice of selection of good land site for raising nursery was prevalent in cent percent of the farms, while practices of preparation of good nursery, avoiding use of excess nitrogen, alternate wetting and drying fields, timely weeding, summer ploughing, selection of resistant varieties to pests, drying of seeds, using of rat traps, allowing of snakes to control rats, natural enemy conservation, planting “T” stick and usage of neem based chemicals were practiced in more than 75 percent of farms.

The other practices like seed treatment, maintaining optimum population, rogue spacing, collection and destruction of insects, destruction of diseased plants, maintaining predator: pest ratio and application of PPC based on Economic Threshold Level were followed in 50 – 75 percent of farms.

The practices with low adoption rates were clipping of seedlings, setting of light traps, dislodging of caseworms and release of parasitoids, being adopted in less than 50 percent of farms.

The results only confirm that complete package of IPM technology is not adopted by a majority of the adopter farmers. It is visible that adoption levels are varying widely between the various components.

3.0. INSTITUTIONAL FACTORS INFLUENCING ADOPTION OF IPM TECHNIQUES

The IPM programme had been put to implementation only during the 1994-95 in Pondicherry and Karaikal region. Due to several constraints viz, availability of trained manpower, financial resources, material resources, and institutional set up etc, only small-scale trainings could be organized. The group size was limited to 30 per training per village. These trainings apart from creating awareness among farmers directly, induces the trained farmers to disseminate the information among fellow farmers. As such the institution play a vital role in spreading the knowledge on IPM. Hence, an interview with the extension personnel involved in the programme was carried out to study the institutional aspects in relation to IPM adoption.

Twenty-five personnel each from Karaikal region and Pondicherry were selected and interviewed on their knowledge on IPM, experience, resources available with them, incentives, moral support from parent department etc and are presented in the subsequent sections.

3.1. Sample composition

The composition of AEP interviewed are presented in Table.5.31. It is observed that 48 percent and 36 percent were Village Extension Workers (VEW) and Agricultural officers (AO) respectively. The average age of the AEP was 45.2 years and an average year of service put in by the AEP in the various schemes of the department was 22.2 years.

Table.5.31. Sample composition (AEP)

Designation	Sample Composition		Age in years	Service in years
	Nos	Percent		
Agricultural officer (AO)	18	36	40.7	17.6
Training Associate (TA)	1	2	35.0	11.0
Deputy Agricultural Officer (DAO)	1	2	52.0	20.0
Assistant Agricultural officer (AAO)	3	6	49.3	25.3
Village Extension Worker (VEW)	24	48	47.5	25.6
Field man (FM)	3	6	50.7	24.3
Grand Total	50	100	45.2	22.2

3.2. Trainings conducted on IPM

Table.5.32. on the number of trainings conducted by AEP show that the trainings given by TA was the maximum (15) followed by AO (9.7), FM (5.0), VEW (3.8), AAO (3.0) and DA (2.0).

Table.5.32. Average of trainings conducted on IPM

Designation	Average no: of trainings conducted	Average no: of farmers trained	Percent of adopters among farmers trained
AO	9.7	303.6	72.8
TA	15.0	430.0	75.0
AAO	3.0	86.7	85.0
DA	2.0	60.0	75.0
VEW	3.8	112.7	77.2
FM	5.0	126.7	76.7
Grand Total	6.1	186.0	76.0

Similarly average number of farmers trained by the TA's are the highest followed by others. Of the farmers trained by them the percentage of adopters had been highest in the case of training conducted by TA's (75) followed AO's (72.8), FM's (76.7), VEW's (77.2), AAO's (85) and DA's (75).

3.3. Sufficiency of Infrastructure facilities

The survey also covered the sufficiency of infrastructure facilities for conducting IPM programmes in the villages and results from Table.5.33 reveal sixty percent of them had found the prevailing facilities were sufficient for conducting IPM trainings, while the remaining 38 percent did not think it was sufficient. Also it is observed that all the AAO's, DA's, FM's and TA's found the facilities to be insufficient, whereas only 5.56 percent among AO's felt it was insufficient. There was a feeling of insufficiency among 41.67 percent of VEW's.

Table.5.33. **Sufficiency of Infrastructure facilities** (in percent)

Infrastructure facilities	AO	TA	DA	AAO	VEW	FM	Grand Total
No	5.56	100.00	100.00	100.00	41.67	100.00	38.00
Yes	94.44	0.00	0.00	0.00	58.33	0.00	62.00
Grand Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

3.4. Location selected for trainings

The location for conducting of trainings too play an important role in the farmers participation, as they prefer local area and nearby paddy fields as it would help them clear their doubts in the fields itself. Simultaneously the AEP also feel it a convenient place to train people so that practical messages on IPM could be shown on the field as seeing is believing and thereby building confidence in farmers regarding the technology. This could be confirmed from the responses of AEPs, presented in Table.5.34**.** It could be seen that about 84 percent of them have preferred paddy fields for conducting IPM trainings, whereas only 6 percent suggested villages and 2 percent suggested office premises.

Table.5.34. **Location selected for trainings** (in percent)

Location	AO	TA	DA	AAO	VEW	FM	Grand Total
Office premises	0.00	0.00	100.00	0.00	0.00	0.00	2.00
Nearby Paddy fields	88.89	100.00	0.00	100.00	79.17	100.00	84.00
Village	5.56	0.00	0.00	0.00	8.33	0.00	6.00
Paddy fields/villages	5.56	0.00	0.00	0.00	8.33	0.00	6.00
Paddy fields / others	0.00	0.00	0.00	0.00	4.17	0.00	2.00
Grand Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

3.5. Target audience

The trainings on IPM are conducted involving farmers, cultivating paddy and those who are to take cultivation of paddy in the ensuing season, apart from other interested farmers in the villages. It is observed from the Table.5.35 that more than

82 percent of beneficiaries are farmers currently involved in cultivation of paddy and has been the major group in trainings conducted by all categories of AEP. We could observe only a small percentage of farmers being interested in gaining knowledge on IPM and thereby participating in the trainings. This has to be understood with caution that the farmers involved per trainings are restricted to 30 and preference was given to farmers cultivating paddy at present.

Table.5.35. Target audience (in percent)

Target audience	AO	TA	DA	AAO	VEW	FM	Grand Total
Paddy cultivators (1)	77.78	100.00	100.00	66.67	83.33	100.00	82.00
To be Paddy cultivators (2)	5.56	0.00	0.00	0.00	4.17	0.00	4.00
Interested farmers in IPM (3)	11.11	0.00	0.00	33.33	0.00	0.00	6.00
Both 1 & 2	0.00	0.00	0.00	0.00	4.17	0.00	2.00
Both 1 & 3	5.56	0.00	0.00	0.00	8.33	0.00	6.00
Grand Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

3.6. Targets

The AEP from the department were fixed with targets on the number of farmers to be trained and the number of trainings to be conducted, which in itself was a burden. Therefore views of the AEP were obtained with regard to the fixation of targets and responses presented in Table.5.36. It is reported by 76 percent of the respondents that they were fixed with targets.

Table.5.36. Details on Targets fixed (in percent)

Fixed with targets?	AO	TA	DA	AAO	FM	VEW	Grand Total
No	27.78	0.00	0.00	33.33	33.33	20.83	24.00
Yes	72.22	100.00	100.00	66.67	66.67	79.17	76.00
Grand Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

3.7. Incentives for targets

Apart from fixing targets, the department also offers incentives to the trainers. The incentives have been felt as tangible by only 8 percent of AEP whereas 92 percent of them see no incentives to them. (See Table.5.37a). They were questioned on the need for incentives among them. It was observed that 66 percent felt the need for them and only 34 percent did not want incentives for achieving targets. (See Table.5.37b)

Table.5.37a. Incentive status (in percent)

Do you get incentives?	AO	TA	DA	AAO	VEW	FM	Grand Total
No	88.89	100.0	100.0	66.67	95.83	100.0	92.0
Yes	11.11	0.00	0.00	33.33	4.17	0.00	8.00
Grand Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table.5.37b.Feel of incentives (in percent)

Feel of incentives	AO	TA	DA	AAO	VEW	FM	Grand Total
No	61.11	100.00	100.00	33.33	12.50	0.00	34.00
Yes	38.89	0.00	0.00	66.67	87.50	100.00	66.00
Grand Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

3.8. Farmer incentives

Though incentives are a part of encouragement to the trainers of IPM, the need for giving incentives to the Trainees (farmers) has become a convention and necessity to attract them attend the trainings. This has become necessary, as the farmers are reluctant to sacrifice their day's wage from employment outside (applicable to cultivator labourers). Also any new concept to be disseminated needs certain incentives to lure the beneficiaries. This could be confirmed form the results obtained from the experiences of the AEP, wherein we could observe 86 percent of them advocating for farmer incentives and only 14 percent were expressing views against providing incentives.(See Table.5.38).

Table.5.38.Farmer incentives (in percent)

Farmer incentives?	AO	TA	DA	AAO	VEW	FM	Grand Total
No	27.78	0.0	0.0	0.0	8.33	0.0	14.0
Yes	72.22	100.0	100.0	100.0	91.67	100.0	86.0
Grand Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

3.9. Awareness Creation

The IPM programme is of recent development and owing to several constraints regarding manpower, finance etc, it is not pragmatic to train each and every farmer on the benefits of the technology. Therefore to ascertain the extent to which awareness has been created among fellow farmers, data were collected from AEP and the results are tabulated here under in Table.5.39. It could be observed that more than half of the respondents believed that the department publicity had created awareness among farmers, which was followed by radio and the rest through television and others. The other ways of awareness creation included farmer-to-farmer message transfer, neighbours, friends, etc.

Table.5.39. Awareness Creation (in percent)

Awareness created	AO	TA	DA	AAO	VEW	FM	Grand Total
Radio (1)	5.56	100.00	100.00	0.00	12.50	66.67	16.00
Television (2)	0.00	0.00	0.00	33.33	8.33	0.00	6.00
Department Publicity (3)	83.33	0.00	0.00	33.33	45.83	33.33	56.00
Others (4)	11.12	0.00	0.00	33.33	33.35	0.00	22.0
Grand Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

3.10. Post –training contacts with farmer by AEP

The success of IPM does not stop with creation of awareness through trainings alone; indeed it is more dependent on timely suggestions to be provided in the course under different stages of paddy cultivation. The Farm field schools conducted by the department of agriculture is one step in this direction, wherein training is imparted to farmers on IPM practices for the entire crop duration. The duration of training lasts about ten to twelve weeks. The trainings usually begin with the transplanting time of farmers in the locality. The practices to be followed by farmers at various stages of the crop are disseminated on one day in a week for ten –twelve weeks. The AEP is available at the farmers' door very often to attend to his problems and needs. The days of availability or the number of contacts AEP had with farmers are presented in Table.5.40. It was observed that majority (48 percent) attended weekly and followed by those attending fortnightly (40 percent).

Table.5.40. Post –training contacts with farmer by AEP (in percent)

Contacts	AO	TA	DA	AAO	VEW	FM	Grand Total
Alternate days	6	0	0	0	4	0	4
Monthly	6	100	0	0	4	33	8
Fortnightly	44	0	100	100	25	67	40
Weekly	44	0	0	0	67	0	48
Grand Total	100	100	100	100	100	100	100

3.11. Sufficiency of Post-training contacts.

The AEP were also enquired on the sufficiency of the number of trips taken to the field and responses are tabulated here under. Almost the entire sample (86 percent) was satisfied with the number of trips undertaken and felt additional visits unnecessary. There were 11.11 percent in AO and 20.83 percent in the VEW category who felt that additional trips were essential to guide the farmers. Also the reasons attributed to inability to undertake additional trips were said to be due to the additional work and other reporting procedures in the department that curtailed their time in performing visits (14.29 percent). Similarly the reason attributed by VEW was the lack of sufficient funds under the scheme to undertake additional visits (100 percent) (See Table.5.41).

Table.5.41. Sufficiency of post –training contacts (in percent)

Sufficient?	AO	TA	DA	AAO	VEW	FM	Grand Total
No	11.11	0.00	0.00	0.00	20.83	0.00	14.00
Yes	88.89	100.00	100.00	100.00	79.17	100.00	86.00
Grand Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Reasons, for not being able to undertake required visits	AO	TA	DA	AAO	VEW	FM	Grand Total
Additional work, reporting procedures	50.00	0.0	0.0	0.0	0.00	0.0	14.29
Inadequate funds	50.00	0.0	0.0	0.0.	100.00	0.0	85.72
Grand Total	100.00	0.0	0.0	0.0	100.00	0.0	100.00

3.12.Stages during which advise provided by AEP.

The AEP render their advises on IPM at different stages of the crop. The stages of crop more prone to pest and disease incidence is the vegetative stage. At this stage a wide variety of the pests affect the crop plants. The harbouring of pests is influenced by the management practices undertaken by the farmer in accordance with the IPM packages. As such advises at these stages will help the farmers in adopting suitable practices to prevent the pest incidence. From the Table.5.42 below it could be observed that the AEP were involved in advising farmers mostly at all stages of crop (68 percent), whereas advises after incidence of pest had been only 12 percent followed by nursery (8 percent) and weeding stage (2 percent).

Table.5.42. Stages during which advise provided by AEP (in percent)

Advise stages	AO	TA	DA	AAO	VEW	FM	Grand Total
Nursery (1)	16.67	0.00	0.00	0.00	4.17	0.00	8.00
Weeding (2)	5.56	0.00	0.00	0.00	0.00	0.00	2.00
Pest incidence (3)	5.56	0.00	0.00	0.00	16.67	33.33	12.00
Others (4)	0.00	0.00	0.00	0.00	4.17	0.00	2.00
Above 1 & 4	0.00	0.00	0.00	0.00	4.17	0.00	2.00
Above 1,2 & 4	0.00	100.00	0.00	0.00	0.00	0.00	2.00
Above 2,3 & 4	0.00	0.00	0.00	33.33	4.17	0.00	4.00
Above 1,2,3 & 4	72.22	0.00	100.00	66.67	66.67	66.67	68.00
Grand Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

4.0. PROBLEMS AND CONSTRAINTS FACED IN ADOPTION OF IPM

Problems and constraints faced by the adopters and non-adopters in adopting the various practices under IPM techniques are ranked and presented in Table 5.43, below. It was well established that scarcity of labour has been the most important constraint faced by either category of farmers in the project area and had a relevancy coefficient of 0.8457 and 0.8836 for adopters and non-adopters respectively. This could be attributed to the fact that adoption of IPM technique involves additional labour. In a situation of scarcity for labour to undertake normal agricultural operations the adoption of IPM had only worsened the situation in this regard.

Table.5.43. Problems and constraints faced by the farmers in adopting IPM practices

Constraints faced by the farmers	Adopters		Non-adopters		Total	
	Coefficient	Rank	Coefficient	Rank	Coefficient	Rank
Labour scarcity	0.8457	***1***	0.8836	***1***	0.8678	**1**
Additional labour wages	0.6809	***2***	0.6489	***2***	0.6622	**2**
Time consuming nature of IPM	0.6622	***3***	0.5706	***3***	0.6089	**3**
Lack of assured irrigation	0.2846	***4***	0.5115	***4***	0.4167	**4**
Lack of sufficient knowledge on IPM	0.1223	***17***	0.3015	***5***	0.2267	**5**
Not convinced with the IPM technology	0.0824	***23***	0.3015	***5***	0.2100	**6**
Lack of soil testing laboratory in vicinity	0.1596	***10***	0.2137	***7***	0.1911	**7**
Inadequate credit facilities	0.1622	***8***	0.2042	***9***	0.1867	**8**
Weak extension service	0.1463	***13***	0.2080	***8***	0.1822	**9**
Reduction in yields	0.0532	***28***	0.1489	***14***	0.1778	**10**
Lack of Technical guidance	0.1516	***12***	0.1718	***13***	0.1633	**11**
Lack of diagnostics skill	0.0931	***21***	0.1756	***10***	0.1411	**12**
Lack of training on IPM	0.0957	***20***	0.1737	***12***	0.1411	**12**
Non availability of Good quality of inputs	0.2181	***5***	0.1279	***17***	0.1389	**14**
Unawareness on IPM practices	0.0612	***27***	0.1756	***10***	0.1278	**15**
Non adoption in Neighboring fields	0.1622	***8***	0.0973	***19***	0.1244	**16**
Lack of knowledge and skill	0.1011	***19***	0.1336	***16***	0.1200	**17**
Non availability of pest resistant Varieties	0.1356	***14***	0.1050	***18***	0.1178	**18**
Lack of advance planning in purchase of inputs	0.0798	***24***	0.1393	***15***	0.1144	**19**
Non-availability of Bio-control agents.	0.1702	***6***	0.0553	***23***	0.1033	**20**
Non availability of Bio-pesticides	0.1649	***7***	0.0534	***24***	0.1000	**21**
Non-availability of Traps in the market.	0.1223	***17***	0.0725	***20***	0.0933	**22**
Complex nature of IPM technology	0.1250	***16***	0.0592	***22***	0.0867	**23**
Distributed & fragmented holdings	0.1277	***15***	0.0401	***25***	0.0767	**24**
Difficulties in using bio-control agents	0.0904	***22***	0.0649	***21***	0.0756	**25**
High Cost of Bio-pesticides	0.0745	***25***	0.0286	***27***	0.0478	**26**
Difficulties in using plant based formulations	0.1543	***11***	0.0401	***25***	0.0456	**27**
Unevenness of land	0.0718	***26***	0.0248	***28***	0.0444	**28**

The other interesting observation is from the additional labour wages (ranked 2nd) that farmers had to pay to attract labour into the farms for carrying out skilled operations with regard to IPM. Though this had been general phenomenon, to take up normal agriculture practices, it only adds to the woes of adopting farmers.

The other important problems faced by the farmers in both categories are with regard to time-consuming nature of IPM operations and lack of assured source of irrigation (ranked 4th), the basic necessity to take up cultivation of paddy.

The other constraints faced by the adopters in their order of rank included non-availability of quality inputs, non-availability of bio-control agents, non-availability of bio-pesticides and non-adoption in neighbouring fields etc. Whereas in the case of non-adopters it was observed that they ranked lack of sufficient knowledge on IPM, not convinced with the IPM technology, lack of soil testing laboratory in vicinity and weak extension service etc. in order as the constraints faced by them in adopting IPM practices. Thus the non-adopters had shown their lack of confidence on the IPM technology, which hindered the adoption of IPM itself.

Chapter –VI: EXECUTIVE SUMMARY AND RECOMMENDATIONS

Integrated Pest Management (IPM), a new concept in the field of crop protection emphasizes the simpler and ecologically safer measures for pest control to reduce environmental problem and other problems caused by excessive and indiscriminate use of the pesticides. Agenda 21 of the United Nations on Nations Conference on Environment and Development (UNCED) at Rio de Janerio in June 1992 identified IPM as one of the requirements for promoting sustainable agriculture and rural development. The Government of India recognized the benefits of IPM and adopted it as the main plank of the plant protection strategy in overall crop production programme. The Pondicherry administration has introduced IPM for rice from 1994-95 and since then the pesticide consumption shown a decline trend. Hence this study was undertaken to evaluate the IPM adoption by the rice growers.

The study was carried out to examine the impact of Integrated Pest Management (IPM) technology in rice cultivation on the pesticide use, residual toxicity, yield of rice and other production related parameters in the Union Territory of Pondicherry. The factors responsible for the adoption of IPM have been studied along with the institutional arrangements, which further the adoption of this technology. The problems and constraints faced by the farmers in the adoption of IPM have been documented to gain an insight into how IPM can be promoted by addressing the binding constraints.

Two districts, Pondicherry and Karaikal were purposively selected, as these are predominantly rice grown areas. Each district is unique and represents diverse agro-climatic, demographic, source of irrigation and other rice growing characteristics

The study was based on a sample of 500 respondents comprising 450 farmers and 50 extension workers. Major statistical techniques employed were factor analysis, frontier production function, logistic regression and relevancy rating index. Besides above econometric tools biodiversity index were developed based on field observations, residue analysis were carried on the products from farms and soil micro-organisms were also studied on soil samples collected from rice fields.

Based on the extent and intensity of adoption of 26 IPM attributes, the farmers were categorised into adopters (high adopters) and non-adopters (low-adopters). The methodology followed was factor analysis. The farmers were further divided into marginal (<2.5 acres), small (2.5- 5 acres) and large (>5 acres) farmers based on their holding size, expressed in standard acres.

The findings from the study were as follows:

- Contrary to the indispensed belief that IPM leads to reduction in yield, the yield level of rice among adopters was 2018 kg/acre, as against the non-adopters who, realised only 1783 kg/acre.

- To determine the relationships between the outputs and its determinants a Cobb_Douglas regression was fitted to the data on total output. The independent variables such as PPC was found to be negative, in both adopters and non-adopters farms clearly indicating that it is overused and its use could be reduced.

- Comparing the output difference of rice between the adopters and non-adopters farms, it was found that the difference of around 19 percent could be attribute to adoption of superior technology (53 percent) and use of inputs (47 percent) which proves the superiority of IPM technology over the conventional method of rice cultivation.

- The best incentive to motivate adoption among the farmers is the proved improvement in the profitability upon adoption of IPM. The increase in net returns of the IPM farms by 26 per cent over the non-IPM farms shows the economic advantage of using IPM.

- The analysis of technical, economic and allocative efficiencies of adopter farms reveals that there is a considerable room for improvement in the above efficiencies than the non-adopter farms.

- Farmers use pesticides over and above the recommended levels as they felt the recommended doses were insufficient to control pests. The reverse reason was put forth by the respondents to explain the sub-optimum level of pesticides usage to lack of knowledge with regards to the efficacy of pesticide use and was an important determinant for the sub-optimal use of pesticides in rice cultivation.

- Since the adverse impacts of pesticides are not immediately visible, a majority of the farmers (50 percent) opined that it had little or no effect on human, livestock and the environment. About 42 percent opined that it would have moderate effect and only 8 percent felt the impact would be serious. However over 80 percent of both adopters and non-adopters took safety measures during the application of pesticides.

- Majority of the respondents did not observe any major apparent effect of pesticides on livestock and human beings whereas adverse effects on beneficial insects and butterflies were reported.

- The Biodiversity index in adopter farms was more diverse than non-adopter farms, so was the case with reference to Evenness index, indicating more stable IPM farms than non-IPM farms. Similarly the soil micro-flora population was abundant in IPM adopted fields than non-adopted fields.

- The residue analysis of rice grains, straw, husk, bran, and soil revealed that the residues of organo-chlorines compounds were found Below Detectable Limit (BDL) in adopter farms whereas it was found above BDL and below the Maximum Residue Limit (MRL) in non-adopter farms. With regard to organo-phosphorous compounds, the residue of monocrotophos was above BDL as well as MRL in non-adopter farms, whereas it was below detectable limit in adopter farms.

- Small and marginal farms were influenced by membership of several organizations and contact with the AEP. On the other hand large farmers were influenced by the IPM traps. However, the overriding consideration for the adoption of IPM was the attitude to reduce the use of pesticides. This was an important factor influencing IPM across size groups.

- Education and experience was in general higher among the adopters.

- Farmers adopting IPM had higher agricultural incomes per household per annum. The same was true of non-agricultural income.

- The fact that IPM training had bearing on the levels of adopters of the technology is borne out by the fact that about 75 percent of the adopters were trained. The corresponding figures of non-adopters were only about 33 percent.

- About 75 percent of the adopters had frequent contact with the agricultural extension personnel, whereas among the non-adopters only 35 percent of them had this vital contact. This underscores the importance of the extension personnel in promoting IPM in a big way.

- Training on IPM is an important determinant of adoption and shall be strengthened. Farmers preferred to have it on the nearby fields, rather in the village or office.

- 64 percent of Agricultural Extension Personnel have felt the need for incentives for them, which is likely to improve the efficiency of the work and thereby the adoption rate, also incentives to farmers need to be given as opined by 86 percent of AEP.

- The post training contact between farmer and AEP was fulfilled in about 86 percent of cases, whereas the remaining 14 percent have not been able to take additional trips due to additional work and other reporting procedures that curtailed their time.

- Over 70 percent of the Agricultural extension personnel respondents felt that the they were indeed important functionaries in promoting IPM and that fixing of targets for training was essential. They also felt that (66 percent) the farmers should be attracted to attend these training programmes, through inducements as incentives etc., and that wide publicity should be given for IPM through fellow IPM adopters.

- It was observed that the major problem faced in the adoption of IPM was scarcity of labour, compounded with increased wages and time consuming nature of IPM practices.

RECOMMENDATIONS

Based on the findings of the study, the following important recommendations are suggested.

1. Government intervention to influence farmers' choice of technology can be justified by the environmental and public health implications of pesticide use. Hence orientation of research and technology policies to generate a steady supply of relevant pest management information and technologies, including adequate budget allocations for research, extension and training are required.

2. Establishment of a national IPM policy framework providing a useful first step in implementing an IPM strategy at national level.

3. Development of a system that increases the awareness of policymakers, consumers and producers of the hazards of pesticide use.

4. The adverse impact of pesticides was not felt by majority of the farmers, therefore educational activities must be organized to help develop more positive attitude towards IPM.

5. Reorientation of agricultural and environmental policies to introduce appropriate economic incentives, including withdrawal of subsidies, taxes and special levies on pesticide use, to account for negative externalities, and short-run subsidies to account for positive externalities in the use of IPM.

6. Development of reliable, location specific and easy to use IPM technology are needed. For instance efficient production and delivery system for bio-agents must be available for successful adoption of biological control methods

7. One of major barrier for biological pest control and IPM is the existing well-established pesticide retail outlets. Most retailers are not at present poorly informed even on the proper use of chemicals they sell. In order to promote biological control and IPM, a massive retailer education programme is necessary.

8. The choice of pest management technique is a function of cost and returns. The economic advantage of using IPM has to be well documented in order to persuade the farmers to adopt these methodologies. The Agricultural Extension Personnel need to be trained on the economic advantages of IPM adoption so as to disseminate effectively to the farmers, as monetary benefits are the major driving force behind decisions made by the farmers.

9. The analysis of the efficiencies suggest considerable room for productivity gains for IPM adopter farms and thereby gain in their income through better use of available resources given state of technology. Consequently suggesting that policies to improve education and extension services by further investment in human capital and related factors.

10. Management of pest can be viewed as a common property problem that is best dealt with through effective collective action. Recognizing the positive

externalities of IPM, group action could be much more effective than individual action. The challenge of government is to create an environment that promotes the IPM strategies in ways that achieve growth, equity and environmental sustainability

11. The number of beneficiaries per training or the number of trainings per year are to be increased so as to disseminate the information on IPM widely and to minimise the effect caused due to neighbour fields. As the government machinery may find it difficult to achieve this in the immediate future, steps need to be taken to encourage the voluntary agencies and private institutions into the programme.

12. Most of the small and marginal farmers who often worse to earn the extra income they need by doing off farm activities such as wage labour. If the time spent on earning additional income would be compensated, then the lowest incomer groups would be better represented in the Farmers Field Schools under IPM programmes. Similarly, farmers need to be paid incentives in the form of cash and kind to lure them into IPM adoption.

13. Women farmers/farm-labourers didn't automatically benefit and were under represented from the start of technology transfer of IPM through farm field schools, in spite of the fact that they constitute a very large part in agriculture labour force. To make IPM to the more successful involvement of women is a must

14. Dissemination of IPM practices by fellow farmers needs to be given importance during trainings as it could have a significant exponential effect

15. In general, the adopters and non-adopters are unaware of the toxic residue of pesticides that can cause harmful effects on human and cattle population. Hence, pesticide toxicity and their residual effect are to be highlighted in trainings.

16. The result of residue analysis reveals that the IPM products are having low pesticide residues. One of the incentives hitherto lacking in India, is premium price on pesticide-free or low pesticide residue products due to lack of domestic market for such products. On the other hand the consumers are becoming aware and, particularly in the case of better-off/better-informed, preferring the low pesticides residue given alternative solution. If there is backed up dependable standards, there may be potential for growers to receive a premium for supplying certain markets. There may be good prospect for development of potentially lucrative export market if farmers can establish and maintain an name for quality

17. Efforts need to be taken by research institutions in identifying and developing practices that are time saving, cost effective and sustainable in the long run. As the major problems faced with regard to adoption have been the labour requirement and thereby additional wages, labour saving technologies need to be developed. Strong linkages between research and all the agencies involved in agricultural development are needed.

18. Apart from imparting IPM training the department has to take efforts to enthuse the staff in making frequent trips to fields so as to provide the farmers with regular information on IPM practices and in time. The efficiency of Agricultural Extension Personnel can be improved by providing them with incentives.

19. Wide publicity and emphasis through easy to read and colourful printed materials regarding IPM practices need to be made available to farmers to reinforce the message given to them.

20. Variations in the extent of IPM adoption by farmers call for the intensification of educational efforts by Agriculture extension personnel.

21. Human resource development in IPM needs to be given a time bound priority through utilization of trained resource manpower for imparting training to extension functionaries and to the farmers at gross root levels.

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Annexure - I							
Cropping pattern during 1997-98 in UT of Pondicherry (Area in acres)							
S.no	**Name**	**Pondicherry**	**% to Total**	**Karaikal**	**% to Total**	**Total**	**% to Total**
1	Paddy I crop	10848	16.5	2974	7.9	13867	13.4
2	II crop	16011	24.4	19735	52.2	35751	34.5
3	III crop	13662	20.8	190	0.5	13859	13.4
4	Total paddy	40520	61.7	22899	60.6	63430	61.3
5	Ragi	346	0.5	0	0	358	0.3
6	Cumbu	0	0	0	0	15	0
7	cholam	346	0.5	0	0	363	0.4
8	Varagu	0	0	0	0	20	0
9	other millets	546	0.8	2	0	571	0.6
10	**Total cereals**	**41412**	63.1	**22902**	60.6	**64339**	62.2
11	Pulses	0	0	0	0	27	0
12	Redgram	2	0	0	0	32	0
13	Greengram	173	0.3	5538	14.7	6266	6.1
14	Blackgram	756	1.2	7190	19	7981	7.7
15	Horsegram	0	0	0	0	37	0
16	Other pulses	72	0.1	0	0	111	0.1
17	Total pulses	1003	1.5	12743	33.7	13788	13.3
18	**TOTAL FOOD GRAINS**	**42415**	64.6	**35645**	94.3	**78104**	75.5
19	Other food crops	0	0	0	0	47	0
20	Chillies	10	0	2	0	62	0.1
21	Black pepper	0	0	0	0	52	0.1
22	Tamarind	119	0.2	35	0.1	207	0.2
23	Coriander	0	0	0	0	57	0.1
24	Betal nut	0	0	0	0	59	0.1
25	Sugarcane	5740	8.7	180	0.5	5982	5.8
26	Plantain	566	0.9	32	0.1	662	0.6
27	Mangoes	415	0.6	96	0.3	578	0.6
28	Cashewnuts	447	0.7	15	0	531	0.5
29	Onion	17	0	0	0	89	0.1
30	Tapioca	1294	2	5	0	1373	1.3
31	Misc. food crops	719	1.1	74	0.2	869	0.8
32	**TOTAL FOOD CROPS**	**51742**	78.8	**36084**	95.5	**87905**	84.9
33	Cotton	516	0.8	618	1.6	1215	1.2

34	G'Nut	3498	5.3	114	0.3	3695	3.6
35	Coconut	0	0	0	0	86	0.1
36	Gingelly	287	0.4	17	0	393	0.4
37	Other oilseeds	0	0	0	0	91	0.1
38	Betalvines	0	0	0	0	94	0.1
39	Other non-food crops	9586	14.6	951	2.5	10725	10.4
40	**TOTAL NON-FOOD CROPS**	**13886**	21.2	**1699**	4.5	**15685**	15.2
41	**GRAND TOTAL**	**65628**	100	**37784**	100	**103513**	100
Source: Statistical Abstracts of Pondicherry (Various issues)							

Annexure - II (a)

Details of Farmers Field Schools on IPM in Paddy (Pondicherry region)

Sl.No	Year	IPM adopted Villages	Sl.No	Year	IPM adopted Villages
1	1994-95*	T.N.Palayam	46		Bahour
2		Bahour	47		Kizhur
3		Uruvaiyar	48		Ramanathapuram
4		Sorapet	49		Vinayagampet
5	1995-96*	T.N.Palayam	50		Koonichampet
6		Bahour	51	1998-99*	Othiampet
7		Nettapakkam	52		Ramanathapuram
8		Sanjeevinagar	53		Madagadipet
9	1995-96**	Kombakkam	54		Chettipet
10		Pudhukuppam	55	1998-99**	Nirnayapet
11		Manamedu	56		T.N.Palayam
12		Kirumampakkam	57		Korkadu
13		Aranganur	58		Suthukeny
14		Uruvaiyar	59		Melsathamangalam
15		Sorapet	60		Silkaripalayam
16		Ramanathapuram	61	1999-00*	Sanjeevinagar
17		Katterikuppam	62		Manapet
18		Pangur	63		Nettapakkam
19		Melsathamangalam	64		Chinnakarayamputhur
20		Ramanathapuram	65		Anandapuram
21		Andiarpalayam	66		Ramanathapuram
22		Koonichampet	67		Manadipet
24	1996-97*	Kanniakoil	69	1999-00**	Irulanchandai
25		Karayamputhur	70		Bahour
26		Irulanchandai	71		Kandanpet
27		Kariklampakkam	72		Embalem Nathamedu
28		Pandachozhanallur	73		Kizhsathamangalam

29		Ariyur	74		Koodapakkam
30		Kizhur	75		Sorapet
31		Koodapakkam	76		Sandhaipudukuppam
32		Madagadipet palayam	77	2000-01*	Dharmapuri
33		Thirukkanur	78		Nonankuppam
34		Odaively	79		Eripakkam
35		Embalem	80		Seliamedu
36		Pannaiyadikuppam	81		Odiampet
37		Pinnachikuppam	82		Pillayarkuppam
38		Kizhagragaram	83		Kothapurinatham
39		Thondamanatham	84		Kakilapet
40		Madagadipetpalayam	85	2000-01**	Kaduvanur
41		Sandhaipudukuppam	86		Kirumampakkam
42	1997-98**	Abhishekapakkam	87		Molapakkam
43		Murungapakkam	88		Konerikuppam
44		Seliamedu	89		Thethampakkam
45		Molapakkam			
Note: * - Samba, **- Sornavari					
Source: Department of Agriculture, Pondicherry					

Annexure - II(b)

Details of Farmers Field Schools on IPM in Paddy (Karaikal region)

Sl.No	Year	IPM adopted Villages
1	1994	Thalatheru melaveli
2		Kilianoor
3	1995	Thalatheru keelaveli
4		Karukkangudi
5	1996	Keelakasakudi, Konnakavady
6		Thiruvenkadapuram
7	1997	Subrayapuram,Poomalaian mangalam
8		Mathalangudi
9	1998	Nallalundur,Muppaithangudi
10		Melakasakudi
11	1999	Ponpetti
12	1998-99	Thiruvettakudy
13		Pettai
14	1999-00	Oozhiapathu
15		Ambagarathur
16		Konnakavady
17		Muppaithangudi
18	2000-01	Neravy
19		Keelavanjore
20		Agaramangudi
21		Patthakudi

22		Kottucherry
23		V.Kottapadi
24		Melasubbarayapuram
Source: Department of Agriculture, Karaikal		

Annexure - III

Factor Analysis - Total Variance Explained						
Component	**Initial Eigen values**			**Extraction sums of squared loadings**		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.58796	22.71711	22.71711	6.58796	22.71711	22.71711
2	3.06180	10.55793	33.27504	3.06180	10.55793	33.27504
3	2.40365	8.28844	41.56349	2.40365	8.28844	41.56349
4	1.66129	5.72860	47.29209	1.66129	5.72860	47.29209
5	1.23333	4.25286	51.54494	1.23333	4.25286	51.54494
6	1.18045	4.07051	55.61545	1.18045	4.07051	55.61545
7	1.13925	3.92843	59.54389	1.13925	3.92843	59.54389
8	0.97995	3.37912	62.92301			
9	0.94073	3.24391	66.16692			
10	0.84144	2.90150	69.06842			
11	0.81899	2.82412	71.89254			
12	0.76664	2.64359	74.53613			
13	0.70288	2.42371	76.95984			
14	0.66708	2.40028	79.36013			
15	0.61823	2.31318	81.67331			
16	0.58884	2.23047	83.90378			
17	0.54792	2.13937	86.04315			
18	0.50657	2.02646	88.06961			
19	0.48224	1.97629	90.04589			
20	0.46570	1.75851	91.80440			
21	0.43096	1.58608	93.39049			
22	0.40476	1.49571	94.88620			
23	0.36276	1.35089	96.23709			
24	0.35280	1.31654	97.55363			
25	0.33900	1.26897	98.82260			
26	0.31245	1.17740	100.0			
Extraction Method: Principal Component Analysis						

Annexure - IV(a)

Residues of Endosulfan in IPM and Non-IPM treatments

		Straw			Grain			Bran			Husk			Soil		
Sl.No.	**Farmers**	**α**	**β**	**So4**	**α**	**β**	**So4**	**α**	**β**	**So4**	**α**	**β**	**So4**	**α**	**β**	**So4**
	IPM															
1	Murugaiyan*															
2	V.Rajamanikam	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
3	Arumugam*															
4	Kandsamy*															
	Non-IPM															
1	T.Rajamanikam	**0.006**	**0.004**	BDL	**0.001**	**0.002**	BDL	BDL	**0.035**	BDL	BDL	BDL	BDL	BDL	BDL	BDL
2	Rajendiran	**0.003**	**0.004**	BDL	BDL	**0.002**	BDL	BDL	**0.035**	BDL	BDL	BDL	BDL	BDL	BDL	BDL
3	Chinnappan	**0.003**	BDL	BDL	BDL	BDL	BDL	**0.012**	BDL	BDL	**0.006**	**0.009**	BDL	BDL	BDL	BDL
4	Kennedy*															

BDL-Below Detectable Limit

MRL-2.00 µg/kg

α, β- Isomer of Endosulfan

So4- Endosulfan sulphate

*- Did not take up the spray of Endosulphon

Annexure - IV(b)

Residue of Monocrotophos in IPM and Non-IPM Treatments

Sl.No.	Farmers	Straw	Grain	Bran	Husk	Soil
	IPM					
1	Murugaiyan	BDL	BDL	BDL	BDL	BDL
2	V.Rajamanikam*					
3	Arumugam	BDL	BDL	BDL	BDL	BDL
4	Kandsamy*					
	Non-IPM					
1	T.Rajamanikam	BDL	BDL	BDL	BDL	BDL
2	Rajendiran	BDL	BDL	BDL	BDL	BDL
3	Chinnappan	**0.035**	BDL	BDL	**0.071**	BDL
4	Kennedy	BDL	BDL	BDL	BDL	BDL

MRL-0.025 µg/kg

Annexure - IV(c)

Residue of Chlorpyriphos in IPM and Non-IPM Treatments

Sl.No.	Farmers	Straw	Grain	Bran	Husk	Soil
	IPM					
1	Murugaiyan*					
2	V.Rajamanikam	BDL	BDL	BDL	BDL	BDL
3	Arumugam	BDL	BDL	BDL	BDL	BDL
4	Kandsamy*					
	Non-IPM					
1	T.Rajamanikam	BDL	**0.025**	BDL	BDL	BDL
2	Rajendiran	BDL	BDL	BDL	BDL	BDL
3	Chinnappan	BDL	BDL	BDL	BDL	BDL
4	Kennedy*					

MRL-0.05 µg/kg

*- Did not take up the spray of Monocrotophos/Chlorpyriphos

BDL - Below Detectable level

Annexure-V

Shannon-Weinner Index of Biodiversity in Rice Ecosystem				
Species	Karaikal		Pondy	
	Number(n)	pi*x	Number (n)	pi*x
IPM				
BPH	4	-0.00728	243	-0.22351
Cocinellid beetle	350	-0.2209	434	-0.30087
Damsel fly	213	-0.16255	73	-0.10144
Dragon fly	112	-0.1046	68	-0.09638
Gall midge	196	-0.15391	5	-0.01218
GLH	242	-0.17647	301	-0.25169
Hymenopterans	62	-0.06765	51	-0.07801
Leaf folder	1129	-0.3612	150	-0.16624
Long horned grasshopper	79	-0.08111	43	-0.06864
Mosquito	184	-0.14757	193	-0.19489
Opionea indica	172	-0.14103	67	-0.09535
Short horned grasshopper	164	-0.13655	32	-0.05478
Skipper	19	-0.0267	12	-0.02514
Spider	639	-0.30109	273	-0.23869
Stem borers	143	-0.12427	99	-0.12579
Whorl maggot	38	-0.04641	489	-0.31621
Earhead bug	17	-0.02439	27	-0.04801
Total (N)	3763	-2.28368	2560	-2.39781
Shannon-weinner Index		**2.283679**		**2.397812**
Non- IPM				
BPH	2	-0.00425	183	-0.21265
Cocinellid beetle	281	-0.20183	448	-0.32958
Damsel fly	181	-0.15263	53	-0.09286
Dragon fly	130	-0.12185	42	-0.07824
Gall midge	177	-0.15038	0	0
GLH	309	-0.2136	223	-0.23813
Hymenopterans	39	-0.0499	41	-0.07685
Leaf folder	1191	-0.36667	79	-0.1234
Long horned grasshopper	42	-0.05285	37	-0.07116
Mosquito	112	-0.10972	121	-0.16444
Opionea indica	90	-0.09376	43	-0.07962
Short horned grasshopper	121	-0.11588	38	-0.0726
Skipper	2	-0.00425	5	-0.01438
Spider	587	-0.29874	215	-0.23333
Stem borers	227	-0.17681	93	-0.13804
Whorl maggot	19	-0.02819	453	-0.33086
Earhead bug	9	-0.01527	26	-0.05437
Total (N)	3519	-2.15659	2100	-2.31052
Shannon-weinner Index		**2.15659**		**2.31052**
pi =n / Sum of N				
X - natural logarithm of Pi				