INTEGRATED PEST MANAGEMENT IN RICE PRODUCTION: RESOURCE USE EFFICIENCY AND RELATIVE ECONOMICS

By

SAIJYOTHI. D

THESIS

submitted in partial fulfilment of the requirement for the degree of

Master of Science in Agriculture

(AGRICULTURAL ECONOMICS)

Faculty of Agriculture
Kerala Agricultural University, Thrissur

Department of Agricultural Economics

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

2005

DECLARATION

I, hereby declare that this thesis entitled **"Integrated Pest Management in rice production: resource use efficiency and relative economics"** is a bonafide record of research work done by me during the course of research and that it has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara
13.10.06

Saijyothi.D

CERTIFICATE

Certified that this thesis entitled **"Integrated Pest Management in rice production: resource use efficiency and relative economics"** is a bonafide record of research work done independently by **Ms. Saijyothi D** under my guidance and supervision and that it has not formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Dr. P.Indira Devi
Chairperson (Advisory committee)
Assistant Professor (Sr. Scale),
Department of Agricultural Economics,
College of Horticulture
Vellanikkara

Vellanikara
13.10.06

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Saijyothi D,** a candidate for the degree of **Master of Science in Agriculture**, with major field in Agricultural Economics, agree that the thesis entitled **"Integrated Pest Management in rice production: resource use efficiency and relative economics "** may be submitted by **Ms. Saijyothi D**, in partial fulfillment of the requirement for the degree.

Dr. P.Indira Devi
(Major Advisor, Advisory committee)
Assistant Professor (Sr. Scale),
Department of Agricultural Economics,
College of Horticulture
Vellanikkara

Dr. E.K.Thomas
Associate Professor and Head
Department of Agricultural Economics
College of Horticulture
Vellanikkara

Dr. V.K.G.Unnithan
Associate Professor & Head
Department of Agricultural Statistics
College of Horticulture
Vellanikkara.

Dr. Sosamma Jacob
Associate Professor
Department of Entomology
College of Horticulture
Vellanikkara

(EXTERNAL EXAMINER)

To

My beloved

Parents

ACKNOWLEDGEMENT

I bow to the lotus feet of **Almighty** whose grace had endowed me the inner strength and confidence and blessed me with a helping hand at each step during my long sojourn at Kerala.

At this moment of accomplishment, my heart is overwhelmed with gratitude and I wish if these words could convey the subtle feelings.

I am ineffable in expressing my deep sense of gratitude to **Dr.P.Indira Devi,** Assistant Professor(Sr.scale), Department of Agricultural Economics, College of Horticulture, Vellanikkara and Chairman of my advisory committee, whose vision was the guiding light of this investigation. Her empathetic approach, wise counsel, coaching style, willingness to entertain new thoughts and an abundant supply of fresh hope and above all her patience and ever willing help that inculcated the passion to read more and think deep have gone a long way to track my academic pursuit and no doubt, in shaping this thesis. It's my boon to attain her guidance and I am proud of been guided by her.

I also owe my deep sense of gratitude and sincere thanks to **Dr.E.K.Thomas,** Associate Professor and Head, Department of Agricultural Economics, College of Horticulture, Vellanikkara and member of my advisory committee whose professionalism, constructive criticisms and efforts to provide food for my thoughts have conferred new dimensions to this investigation.

My sincere thanks are due to **Dr.Sosamma Jacob,** Associate Professor Department of Agricultural Entomology, College of Horticulture, Vellanikkara and member of my advisory committee for the valuable guidance and help rendered in the conduct of the experiment.

I take this opportunity to express my indebtedness with veneration and devotion to **Dr.V.K.G.Unnithan,** Associate Professor and Head Department of Agricultural Statistics, College *of Horticulture, Vellanikkara and member of my advisory committee for his constant support, suggestions, valuable guidance and accommodating with all facilities for the successful completion of my research work.*

Words fall short as I place on record my indebtedness to ***Dr.Jessy Thomas,*** *Associate Professor,* ***Dr.K.Sathees Babu,*** *Assistant Professor,* ***Dr.Prema,*** *Assistant Professor, Department of Agricultural Economics,, for their untiring support and valuable guidance during my course of study.*

My heartfelt gratitude cannot be captured in words for the unflinching support, constant encouragement, warm concern, patience and valuable advice of my friends and colleagues ***G.Srikrishna.*** *and* ***Sujata Sethy*** *whose prayers,, love and affection rendered me a successful path which propped up my career all along.*

I wish to express my sincere gratitude to my senior friends ***K.Vanisri, V.Kousalya, Binisha chechi, Deepthi chechi, Divya chechi, Aswathi chechi, Anisha chechi and Thankamony chechi,*** *my colleagues* ***Sreela.P, Deepa V.V and Jaisal Babu*** *for their whole hearted support.*

My duty is incomplete if I forget my friends ***Ambika, Reena, Sapheera, Renitha, Pratibha, Habeebba, Ampily, Seena, Ramu, Shankar*** *and I am in dearth of words to express my strong emotions and gratitude to my junior friends* ***Smitha, Jyothi, Suja, Meghna, Shiby, Renju, Sarala*** *whose helping hands, love and affection fetched a remarkable place in my days in Kerala.*

Words can never truly portrait the, care and support and help rendered by ***Shilpa*** *and family, which propped up my Research all along in Kuttanad*

My heart never forgets the love, support and help rendered by my ever-friendly pals ***Neelima*** *and* ***Vijaya lakshmi,*** *in completing my research successfully.*

The award of Junior Research fellowship of the Indian Council of Agricultural Research is thankfully acknowledged.

My sincere thanks to **Geevar chetan**, Research Associate, Department of Agricultural Economics **Sulochana chechi**, attender of the Department of Agricultural Economics College of Horticulture, Vellanikkara and **Mr. Santhosh**, Students Computer Club, College of Horticulture, Vellanikkara.

Above all, I am forever beholden to **my loving parents, my sister Jyothsna and brother Prasad** and all my well wishers, for their unfathomable love, boundless affection, personal sacrifice, incessant inspiration and constant prayers, which supported me to stay at tough tracks.

Saijyothi. D.

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LIST OF ABBREVIATIONS

Abbreviations / Symbols	
KWA	Kerala Water Authority
KWBS	Kuttanad Water Balance Study
MT	MetricTonnes
BHC	Benzene Hexa Chloride
DDT	Dichloro Diphenyl Trichloro ethane
IPM	Integrated Pest Management
CIPMC	Central Integrated Pest Management centre
FFS	Farmers Field Schools
ICAR	Indian Council Of Agricultural Research
HYV	High Yielding Variety
IRRI	International Rice Research Institute
g/ha	Grams per hectare
a.i.	Active ingredient
VND	Vietnam dollar
Rs	Rupees
Rs/ha	Rupees per hectare
t/ha	Tonnes per hectare
NPV	Net Present Value
BCR	Benefit Cost Ratio
IRR	Internal Rate of Returns
US	United States
FYM	Farm Yard Manure
MSL	Mean Sea Level
ha	Hectare
^0C	Degree centigrade
Cm	Centimeter
OLS	Ordinary Least Square
KAU	Kerala Agricultural University
Kg	Kilogram
NPK	Nitrogen phosphorous potassium
l/ha	Litres per hectare

Introduction

CHAPTER I
INTRODUCTION

Indian agriculture has undergone a sea change since the green revolution era. The major thrust of green revolution was on maximization of foodgrain production through a package of practices *viz.*, assured irrigation, High Yielding Varieties (HYVs) and inorganic nutrients under a constant plant protection umbrella. The impact on environment and biodiversity aspects on account of high input regime was not taken into consideration often.

As a result, the consumption of fertilizers and chemical pesticides have increased manifold especially in the monocropped irrigated areas. The pesticide consumption was only 2353 Metric Tonnes (MT) during 1955-56, which gradually increased to 75033 MT in 1990-91 i.e., more than 30 times. Since then the use has declined and the trend is continuing. The current consumption of pesticides is 46530 MT (Table 1.1). The predominant classes of pesticides used in India are insecticides accounting for 75 per cent of total consumption, followed by fungicides (12 per cent) and herbicides (10 per cent) during 2003-2004 (Table1.2) Further during 2002-2003 54 percent of total quantity of pesticides used in the country are used in cotton, 17 per cent in rice and 13 per cent in vegetables and fruits, which occupy five per cent, 24 per cent and three per cent of the gross cropped area in the country. (Table1.3)

Although, pesticide consumption in India is very low (0.38 Kg/ha) compared to many developed countries like Japan (12 Kg/ha), Taiwan (17 Kg/ha) and West Germany (3 Kg/ha), the negative externalities associated with pesticide use are much high in the country. Persistent pesticides like BHC and DDT remain in the ecosystem for longer periods and pose great threat to the soil/water bodies and the dependent life systems. Chemical pesticide residues have often been detected in foodgrains, vegetables, fruits, oils, cattle feed and fodder in most parts of the country. About 72 per

Table 1.1Pesticide consumption in India (1955-2005)

Year	Pesticide consumption (MT)
1955-1956	2353
1960-1961	8620
1965-1966	14630
1970-1971	24320
1975-1976	45613
1980-1981	54775
1985-1986	61881
1990-1991	75033
1995-1996	61260
1996-1997	56114
1997-1998	52239
1998-1999	49157
1999-2000	46195
2000-2001	43584
2001-2002	47020
2002-2003	48350
2003-2004	49360
2004-2005	46530

Source: Directorate of Plant Protection and Quarantine, Faridabad, India

Table1.2 Groupwise consumption of pesticides in India (2003-04)

S.No.	Pesticide group	Consumption (percentage)
1	Insecticide	75
2	Fungicide	12
3	Weedicide	10
4	Others	3

Source: Directorate of Plant Protection and Quarantine, Faridabad, India cent of food samples in India showed presence of pesticide residues within tolerance level and in 28 per cent samples they were above the tolerance level as compared to 1.25 per cent globally (Singhal 1998)

Table1.3 Crop wise pesticide consumption in India in 2002-2003

S.No.	Crop	Gross cropped area	Percentage Pesticide consumption
1	Cotton	5	54
2	Rice	24	17
3	Vegetables and fruits	3	13
4	Plantation crops	2	8
5	Cereals, pulses and oilseeds	58	2
6	Sugarcane	2	3
7	Others	6	3

Source: Directorate of Plant Protection and Quarantine, Faridabad, India

DDT and BHC residues have been detected in the milk samples including mother's milk (Jensen 1984). Residues of other pesticides like organophosphates, carbamates, synthetic pyrethroids and organochlorines were also found in food products (Chopra 1993). Pesticide residues found in different food samples is an indication of the vulnerability of human population to toxic pesticide residues and resultant health hazards. In a study on health risk of pesticide exposure on human beings sponsored by World Health Organisation (WHO) during July 1999 to March 2000 about 1172 cases of poisoning were reported in 10 selected districts in five states in India. There were 247 deaths in Gulbarga district of Karnataka, Sirsa district of Haryana and Warangal district in Andhra Pradesh. (Singhal, 1998).

In view of the negative effects of high pesticide use in the ecosystem, Integrated Pest Management (IPM) was introduced, which essentially integrated the cultural and biological pest control methods with chemical methods. It aims at pesticide free food supply and a healthy ecosystem.

Benefits of IPM technology at farm level can be expected as follows

1. Reduction in costs of pesticide use (amounts of pesticides, spraying equipment, time for spraying)
2. Increase in yields through better crop management
3. Increase in product quality through better crop management, which may result in higher prices
4. Reduction of risk in terms of variability in net profits through better crop monitoring and improvement of the state of the agro ecosystem
5. Reduction in the loss of domestic animals due to pesticide intoxication (fish, fowl, honey bees etc)
6. Reduction in the health costs incurred by the applicator
7. Reduced negative impact on soil fertility
8. Reduced probability of resistance to pesticides

The reliance on chemical pest control measures is often due to the perceived high risks associated with pest attacks. Pesticides are considered as an insurance against that. Consequently, IPM package that leads to sizeable reduction in use of chemicals is regarded as a high-risk technology in crop production. Often farmer's perception of potential crop losses seems to be higher than actual loss. This perception often result in a poor adoption of IPM technology at farm level.

IPM programme was introduced in India as a part of a national policy in 1991 focussing the crops cotton and rice. For the rapid dissemination of IPM technology, IPM related activities are being implemented in the country through 26 Central Integrated Pest Management Centers (CIPMCs) located in 23 states and Union territories. The activities include undertaking roving surveys for monitoring pest or disease situations on major crops, production and release of bio control agents and conducting Farmer Field Schools (FFSs). The pest situation reports from field stations and states are regularly compiled and comprehensive reports are circulated to the State Department of Agriculture/State Agricultural Universities and ICAR institutes to take appropriate remedial measures.

In Kerala, the technology is implemented as a scheme by the state Department of Agriculture in rice crop in the major rice growing areas during 1993. The main objectives of the scheme are

1. To keep the pests and diseases of crops below Economic Threshold Levels (ETL) by adopting an Integrated Pest Management practice
2. Constant pest surveillance and monitoring to ascertain pest populations
3. Creating awareness among farmers on the prominent pests and diseases, which cause severe damage to the crops and suggest measures to prevent outbreak or to contain outbreak.

An amount of Rs.75 lakhs was earmarked under this programme for the year 2004-2005. An additional amount of Rs.97 lakhs was also issued for the promotion of IPM programme during the same year under the Government of India project on Macro management scheme. Dissemination of IPM technology in the state had necessitated lot of research in biological, agronomic, physical and other management aspects of crop production. However, little research work has been reported assessing the financial aspects of the technology. Hence, this study was undertaken with the following objectives to bridge this knowledge gap

1) To assess the relative economics of IPM technology in rice production
2) To estimate the resource use efficiency under IPM and Non-IPM packages.

1.4 Limitations of the study

Since the practice of maintaining records on the cost of cultivation was not prevalent among the farmers, the responses were drawn from their memory. This may result in recall bias. However, every possible effort was made to minimize the errors by cross-questioning, cross checking and visual observations.

This study focuses only the private financial aspects of the technology and does not consider the wider social and ecological dimension

1.5. Plan of the thesis

Besides the introductory chapter, the study is organised into five chapters. Chapter two is a review of literature relevant to the study. Chapter three describes the profile of the study area, the methodological framework, analytical tools, and conceptual issues. The results of the study and the discussion of the findings are presented in chapter four. The fifth chapter summarises the main findings and conclusions drawn from the analysis, along with the policy implications.

Review of literature

Chapter II

REVIEW OF LITERATURE

A comprehensive review of past studies is highly essential for proper understanding of the concepts, research design and method of analysis in any research programme. Hence a review of past studies related to objectives of the study is presented in this chapter. For convenience and clarity, this chapter is divided in to four sections as given below:

2.1 Pesticide related Externalities

2.2 Economics of Integrated Pest Management technology

2.3 Resource use efficiency studies

2.4 Farmers adoption of IPM technology

2.1 PESTICIDE RELATED EXTERNALITIES

Pesticide use in agriculture gained importance with the introduction of modern technologies. Coupled with the increased production, pesticides have created negative externalities as well. Researchers across the world have tried to identify and estimate these externalities despite serious methodological challenges. Large volume of literature is available on these aspects. The presence of insecticide residues in soil, water bodies, air and food materials was reported by many scientists. The report on the presence of phosphamidon residues in fresh water fishes by Rao (1982), DDT residues in fish and water of Jamuna river (Agarwal and Mittak, 1986) are examples of such studies on fresh water ecosystems.

Rajagopal *et al.* (1984) reported the effect of carbamate insecticides on soil nitrogen fixation and nitrification. Brahmaprakash and Sethunathan (1987) listed the relative persistence of the Hexachloro Cyclo Hexane (HCH), methyl parathion and carbofuron in all the alluvial soils in India, highlighting the residual effect on soils.

Pesticides cause damage to the beneficial organisms too. Reddy (1997) reported the adverse effect of cypermethrin and permethrin on cross pollinators. Kothari (1999) highlighted the loss in bio-diversity in paddy fields of North East, South West and Central India, due to pesticide use and explained how it affected the diet of tribal population in the area.

Development of resistance to insecticides and pest resurgence are serious problems associated with the pesticide use. Gangamma and Satyanarayana (1991) quoting the findings of the experts of the Food and Agricultural Organisation reported the names of 233 agricultural pests which have become resistant to nine major groups of pesticides. They further reported that all the pests might turn resistant to every available pesticide given the necessary selection pressure. Use of pesticides sometimes causes an increase in the density of pest population known as 'Flareback'. Further, sub lethal doses of pesticides have been found to slow down the development of the enemies of the pests.

In order to combat the serious problems of insect pests, farmers resorted to higher doses and frequent application of insecticides and also often tried disproportionately larger combinations, which has resulted in pesticide treadmill in the pesticide hotspots in India (Shetty, 2003).

The effect of pesticides on the exposed human population was also extensively explored. Jensen (1984) reported presence of organochlorine insecticides in human milk. Godon *et al.* (1989) reported the incidence of cancer of brain, lymphatic tissues and leukemia in rural population as the long-term effect of pesticides and. Headache, dizziness, conjunctivitis and nausea have been observed as short-term effects of pesticide exposure. Mencher (1991) explained the problems of pesticide use in rice in India with respect to the organophosphate insecticides, the residues of which were found to remain in the blood of human beings for 6-9 weeks. Kaushik *et al.* (1995) estimated the dietary intake of DDT and HCH causing serious health effects in human beings

The estimation of economic value of the externalities of pesticide poses serious methodological issues. Langham and Edwards (1969) highlighted the need for a holistic approach in this aspect and tried to identify and value the externalities in pesticide use. They indicated that externalities could not be studied independent of the system, which generated them.

Often the environmental hazards of using pesticides have exceeded the social benefits. When certain insecticides are restricted, farmers still receive higher net returns. (Horne, 1973)

Richardson and Badger (1974) presented a method for analyzing external as well as internal effects of using pesticides in agriculture. They used an environmental impact matrix for the analysis in cotton among Oklahoma farmers. The major parameters considered in the impact matrix were economic factors, environmental quality and social well being. Each major parameter is sub divided into component parts relevant to pesticide use on cotton in the study area and an interdisciplinary research group developed the appropriate weighing factors for the variables under each parameter. The necessity for interdisciplinary approach, in this aspect was highlighted by Park (1986) as well.

Harper and Zilberman (1989) opined that inputs such as water, pesticides and even time may have the unintended effect of stimulating some pest populations, leading to crop losses and developed a conceptual model for estimating the real effects of Integrated Pest Management technology

Rola and Pingali (1993) while estimating for the value of pesticide related externalities on human health in Philippines argued that an indiscriminate pesticide use in rice crop leads to larger pest related yield losses than not applying pesticides at all. They further said that under normal circumstances, when pesticide related health impairments are explicitly accounted for, the natural control is the best one.

Antle and Pingali (1995) integrated the production data from a farm level survey with data collected from the same population of farmers to measure the impact of insecticide use on farmer health and the impacts of farmer health on productivity in two rice producing regions of the Philippines. Results showed that pesticide use had negative effect on farmer health and farmer health had a positive effect on productivity, and that there are likely to be social gains from a reduction in insecticide use in Philippines rice production. They estimated the value of crop lost due to pest attack and it was found to be lower than the cost of treating pesticide caused diseases.

Owing to rising reports on the questionable financial/environmental rationality of high pesticide use in agriculture, IPM was introduced as a viable solution. It involves integration of resistant crop varieties with cultural, mechanical, physical, biological and chemical methods to maintain pest populations below economic injury levels. International Rice Research Institute (IRRI) had taken a lead role in introducing IPM and as a result insecticide use has dropped substantially in IRRI farms Both fungicide and molluscide use have also fallen. Reduced insecticide use has resulted in increased numbers of birds and beneficial insects observed in fields (Bell *et al.*, 1998)

2.3.ECONOMICS OF INTEGRATED PEST MANAGEMENT

Estimation of economic aspects of Integrated Pest Management technology poses great challenges to the researchers due to several inherent problems as reported by Miranowski and Reichelderfer (1980). Ruesink (1980) indicated the importance of economists and biologists working together in developing a holistic overview of pest management to develop farm level budgets for each alternatives and to evaluate each alternative against the several lists of criteria for the grower, the community and the nation.

Boutwell and Smith (1981) evaluated the IPM programme and a composite IPM score ranging from 62 to 95 was estimated for Alabama cotton producers. Yield varied from 37 to 943 Kg lint/ha. A correlation analysis revealed a direct relationship between level of IPM adoption and crop yield

Burrows (1983) tested the hypothesis that Integrated Pest Management reduces pesticide use using a limited dependent variable simultaneous equation model. The results of the analysis confirmed the hypothesis with a statistically significant reduction in mean pesticide usage by 31 per cent among cotton growers practicing IPM in California's San Joaquin valley.

Headley and Hoy (1987) analysed economics of ongoing Integrated Mite Management programme for almonds in California and found that growers who adopted the programme could save $60 / ha to $110/ha.

Hara *et al.* (1990) conducted a study on the IPM programme for anthuriums in East Hawaii. In the three farms selected *viz.* Hilo, Partia and Kurtistovan, the reduction in fungicide applications were 45, 79 and 96 percent respectively, economically justifying spray application. There was also no significant increase in thrips and mites and anthracnose injuries. Their study concluded that the IPM concept implemented on a floricultural crop can reduce pesticide applications and increase profitability.

Parish *et al.*, (1994) conducted a study on cotton farmers in the Mississippi river delta area where farmers typically apply pre-emergence and post-emergence herbicides with a bandwidth of 400-500 mm. They followed a remodelled cultural practice reducing the bandwidth to 200 mm and then cultivating close to the row by using precision-guided cultivators. As a result herbicide costs were reduced to $30.22/ha ($12.23/acre) in 1992 and $27.80/ha ($11.25/acre) in 1993 with no differences in weed control or loss of yield. Reduction in the amount of herbicide used also reduced environmental risks.

Rao *et al.* (1995) made an attempt to develop an IPM strategy for cotton farming in Andhra Pradesh . The approach consisted of four modules comprising integrated pest control tactics, judicious use of pesticides, farming practice and an untreated control. IPM was found to be economically viable for sustained cotton production in addition to conserving and augmenting natural enemies in the cotton ecosystem. IPM practice has also resulted in a higher cost benefit ratio (1:5.3) in comparison with conventional farming practice (1:2.5)

Bakhetia (1996) reported that IPM technology has helped in reducing the number of insecticidal sprays to 5-6 in cotton crop as against 8-11 in non-IPM villages in Punjab. The IPM approach proved economical as the farmers obtained an additional income of Rs.7427/ha

Balappa (1997) studied the resource use efficiency and returns to scale in red gram (pigeon pea) production of 75 farmers who have adopted Integrated Pest Management (IPM) vis-à-vis 75 Non-IPM farmers in Gulbarga district of Karnataka. Land and fertilizers were found to influence production significantly in both types of farms. The influence of plant protection chemicals was negative and statistically insignificant indicating its excessive use in Non-IPM farms, thereby resulting in negative returns.

Peshin and Kalra (1998) analysed the adoption and economic impact of IPM at farmers level in rice crop among 10 villages of Ludhiana district in Punjab. The average frequency of pesticide application before, during and after the IPM training in six IPM villages was 1.88,1.64 and 1.52 per season respectively. The average yield per unit area in these six IPM villages was 63.13 q/ha as compared to 52.58 q /ha in Non-IPM village. The average pesticide expenditure of IPM farms was significantly lower than the Non-IPM farms.

The study conducted in Vietnam on the economics of pesticide use in paddy (Dung and Dung, 1999) examined pesticide productivity and estimated the optimal level for profit maximization through empirical analysis by using yield function model. A 10 per cent increase in total dose of pesticides in paddy contributed to a small increase of 0.346 per cent in yield and farmers over used pesticide by 274.4 grams a.i. per hectare resulting in a loss of 105 to 644 VND per hectare

Rajaram *et al.* (2000) compared the Integrated Pest Management with traditional chemical control in cotton crops in Tamil Nadu, India during 1996 and 1999.Data on costs, returns, pest population, predator population and crop damage were gathered and cost benefit ratios were estimated. It was 1:2.2 and 1:2.4 in Integrated Pest Management system, compared to the chemical control values of 1:1.5and 1:1.3.

Razack (2000) studied the economics of Integrated Pest Management (IPM) in paddy and cotton in Tamil Nadu. The overall benefits were calculated in terms of increased income by using partial budgeting analysis. An IPM farmer gained Rs.1142.22 per hectare in paddy and Rs.6821.27 per hectare in cotton. In cotton crop this gain was mainly due to the reduction in the pesticide use rather than increase in yield

Qadeer and Tomar (2000) conducted IPM and Non-IPM field trials in rice in Haryana villages. It was found that in non-IPM fields the cost of plant protection was 58.2 per cent greater than in IPM fields. Rice grain yields were increased by 3.3 per cent in IPM compared to non-IPM fields.

Chakraborti (2001) conducted a field study to assess the effects of IPM in rice in West Bengal. The programme was very effective in controlling the growth and development of the pest population and the damage caused by it. It gave very good yields of 4.59 t /ha and 4.39 t /ha in two seasons and was significantly superior to chemical method which recorded yields of 3.71 t/ha and 3.62 t/ha in the two seasons and appeared quite safe to the natural enemies.

Mullen *et al.* (2001) presented a method for assessing the environmental benefits of Integrated Pest Management (IPM). Effects of IPM on environment, risks posed by pesticides and society's willingness to pay to reduce those risks were attempted in the study on groundnut in Virginia, USA. The annual environmental benefit of the IPM programme was estimated at $844000.

Tamizhenian (2001) attempted to compare the economics of IPM paddy farms and Non-IPM paddy farms in Tiruvarur district of Tamil Nadu and results highlighted the higher net returns in IPM farms (Rs.6180.93/acre) compared to Non-IPM farms (Rs. 4449.17/acre). The net gain per acre from IPM practice was found to be Rs1731.76.

Fleitscher *et al.* (2001) conducted cost benefit analysis of an IPM project in paddy cultivation in Philippines, both at farmer's level (financial analysis) and Society's level (economic analysis). The Net Present Value (NPV) was estimated as Rs. 1,921,616, Benefit Cost Ratio (BCR) was 1.37 and Internal Rate of Return (IRR) 17.3 per cent, favouring the implementation of IPM project.

Katti *et al.* (2002) conducted a study in West Godavari district of Andhra Pradesh, India comparing the economic performance of IPM and Non-IPM paddy farms. IPM blocks had higher mean yields and net returns compared to those in conventional blocks. 85 per cent of the farmers opined that 2-3 applications of pesticides were enough to control pests during the season and 66 percent opined that insecticidal application was not always necessary at the early crop stages.

1.4.RESOURCE USE EFFICIENCY STUDIES

Studies on the resource use efficiency in crop production area are plenty. Cobb Douglas production function is widely seen adopted to assess the resource productivity. Azad and Garg, 1974; Raju, 1975; Chamak *et al.*, 1978; Balishter, 1983;Deshmkh *et al.*, 1991,Singh *et al.*, 1996 Viswanath, 1997;Preeti, 1998 were few among them.

Srikanthamurthy (1986) studied the productivity of resources in two major food crops (ragi and paddy) in Bangalore district of Karnataka using Cobb Douglas production function.

Sunandini and Parthasarathy(1993) examined the resource use efficiency and resource productivity on paddy farms in Andhra Pradesh. There was under utilisation of tractor power, manures and fertilisers.

Thimmappa (1994) evaluated economic efficiency of upland paddy and its competing crops in Sorab taluk of Shimoga district in Karnataka. Land, manures and seeds were under-utilised while fertiliser and human labour were over utilised on the small farms. Land, seed and fertiliser were found to be under utilised while manure and bullock labour were over utilised on large farms.

Sharif and Dar (1996) investigated the patterns and sources of technical efficiency of Bangladesh farmers in the cultivation of two traditional rice crop and HYV. Farm specific technical efficiency was estimated through stochastic production frontier model. The technical efficiency was the major source of yield variability in HYV cultivation, while it was random effect in the case of traditional crop.

Viswanath (1997) analysed resource productivity in paddy cultivation and indicated that seed and human labour contributed significantly to the total output in most of the zones in Karnataka during kharif season. Fertiliser contributed significantly only in southern transition zone and hilly zone in summer. Seed contributed significantly to the output only in central dry zone. In most of the zones, human labour was a major contributor to the output. Fertiliser did not contribute significantly to the output but its coefficients were positive in all the zones.

Cobb Douglas model was extensively used in assessing the performance of paddy crop in Kerala especially in Kuttanad, the rice bowl of Kerala. Samuel (1963) conducted a study in Kuttanad and Onattukara regions and observed diminishing returns to scale. Human labour and farm size were found to be the most important variables influencing the output. In a similar study by Muraleedharan (1981) in Kole lands of Thrissur district (Kerala), it was reported that the allocations of resources were inefficient. Joseph 1982 conducted a resource use efficiency analysis of rice in Kuttanad farms, but he could not establish any significant relation between the independent and dependant variables. Mohandas (1994) indicated a significant and positive contribution of machine labour, human labour and fertiliser towards the gross income from paddy in the area.

1.5. FARMER'S ADOPTION OF IPM TECHNOLOGY

Rola and Pingali (1993) presented a number of case studies, which showed that pesticides being used heavily in rice production even when pest populations were low and population of natural enemies are high. Thus the productivity of pesticides were often quite low and sometimes negative. Evidence from IPM training programme suggested the reason as partly a gap in knowledge regarding pest ecology.

Hurd (1994) stated that production uncertainty is commonly believed to be an impediment to the adoption of less pesticide intensive methods in agriculture such as Integrated Pest Management by evaluating the data from cotton producers in the San Joaquin Valley, California. The results showed that yield variability was not found to be significantly affected by production inputs including pesticides and IPM practices

White and Wetzein (1995) reported that farmers in US poorly adopted Integrated Pest Management (IPM) in cotton despite favourable research results. Many US farmers have not adopted IPM. Given the rising marginal cost and diminishing marginal benefits from the IPM technology transfer, they developed an optimal control framework to identify optimal rates of technology transfer through educational programmes.

Gandhi and Patel (1997) examined farmer perception, awareness and behaviour on the use of pest control technology in agriculture in relation to environmental concern. The study found that farmer perception of the significant impact of pesticides on the environment seemed to exist but was limited to their immediate surroundings of labour, other human beings and animals.

Ooipac (1998) presented the importance of farmer participation in IPM programme using three detailed case studies from Indonesia. It demonstrated how farmers can solve problems to improve the productivity. Their discoveries often went to solutions which did not depend on insecticides but which maximized the effectiveness of natural cycles and predators.

Kavitha (2001) studied the knowledge and adoption behaviour of rice growers of Nagapattinam district of Tamil Nadu. Majority of the farmers had adopted practices like summer ploughing, land levelling and shaping, tillage practices, strengthening the field bunds, periodical cleaning of the channel, alternative wetting and drying, growing short duration varieties and crop rotation with other crops which are the important cultural practices in IPM programme.

Vijayalayan (2001) has assessed the adoption level of the rice growers of Thanjavur district of Tamil Nadu. Summer ploughing, FYM application, bio-fertiliser application and neem cake application and continuous submergence were adopted by more than 90 per cent of the growers.

Muthuraman *et al.* (2002) conducted survey in the Tambirabarani delta in Tamil Nadu, India during kharif season of 2001 to investigate the knowledge and attitude of rice growers regarding IPM the role played by existing rural institutions in disseminating IPM and the constraints in the adoption of IPM in the region. Results indicated that the farmers have limited understanding of IPM but have a positive attitude towards the programme

The reports of Kerala State Planning Board (2004) highlighted the main hurdles in the implementation of IPM programme as non co-operation, indifference of farmers on account of excessive fragmentation of holding and the spirit of the individualism prevailing among themselves. The other problems were lack of irrigation and drainage facilities, more office work for Agricultural officers and lack of co-ordination among the officials

Material and Methods

Chapter III

MATERIALS AND METHODS

The present study on "Integrated Pest Management in rice production: resource use efficiency and relative economics" was taken with the objective of evaluating the economics of adopting the Integrated Pest Management (IPM) in paddy cultivation with a view to identify the economic advantages of the technology The present chapter is divided into two sections viz., area of study and methodology, the former part explaining the geographic and socioeconomic aspects of study area and the later on the methodology followed for conducting the study.

3.1 AREA OF STUDY

Kuttanad is the rice bowl of Kerala which comprises ten taluks, spreading over three districts of Alappuzha, Kottayam and Pathanamthitta. It is known for the special type of cultivation, as the land is on an average three metres below Mean Sea Level (MSL). This area is a deltaic formation of four river systems Meenachil, Pamba, Manimala and Achencoil. The area has a monsoon climate with wet season from May to November and a dry season from December to April. Agriculture is the major activity in the area employing about 40 per cent of the population. Paddy is virtually the only crop grown and the poor drainage conditions make most of the land in the area unsuitable for other crops. Coconut is grown on the bunds and on higher elevations. The main paddy growing season in Kuttanad is the Punja season taken in the early part of the dry season i.e., November to March.

3.1.1 Location and Topography

Kuttanad is a low-lying area near the coast of Kerala extending from $9^{0} 17^{1}$ N to $9^{0} 40^{1}$ N and $75^{0} 19^{1}$ E to $76^{0} 33^{1}$ E (Chattopadhyay and Siddarthan, 1985) measuring about 11,000 square kilometers area (1,10,000 hectares). Originally it was part of the shallow coastal area of Arabian Sea. The coast has been formed by the silt deposits carried by Meenachil, Pamba, Manimala and Achencoil rivers that drain into Vembanad Lake, which is the largest in Kerala covering an area of 80 square kilometers.

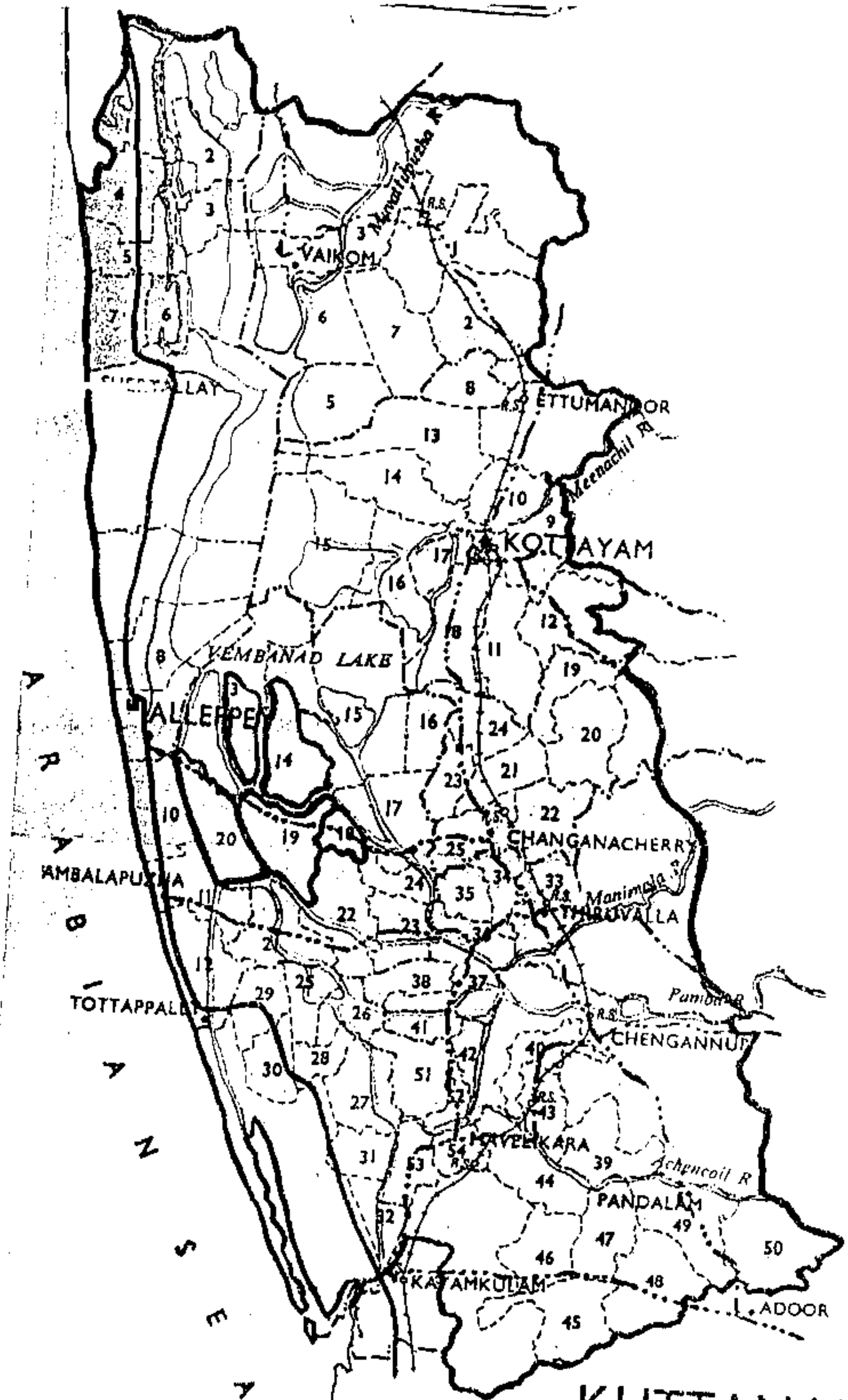
The whole Kuttanad is physiographically demarcated into three regions.

1. The dry lands varying in elevation from 0.5m to 2.5m above MSL (31,000 ha).
2. The wetlands include low-lying areas slightly above MSL (11,000ha).
3. Area below MSL reclaimed from the lagoons known as Punja lands (55,000 ha).

The paddy fields in Kuttanad are classified into three types.'*Karapadom*', '*Kayal*' and '*Kari*' lands. This study is confined to the Kayal lands, which spread over 32 *padasekharams* (continuous paddy field) in an area of 7900 ha. A contiguous stretch of wetlands bound by waterways or other natural features is called "*padasekharam*" which is a homogenous physical entity. The size of the "*padasekharam*" varies from one hectare to thousand hectares. In Kuttanad they are demarcated as "Blocks"

3.1.2 Climate

Kuttanad is a warm humid region, with fairly uniform temperature through out the year ranging from 21^0C to 36^0C. Humidity is generally very high. The annual average rainfall received is around 3000 mm of which 83 percentage is received during monsoon months. The wet season starts with South West monsoon in July and lasts till September. It continues with North East monsoon until November. The rainfall during North East monsoon is only 15.8 per cent where as during South West monsoon it is 40.3 per cent. Practically very little rain is received in the months of January- February, which are driest months. The monthly mean temperature and rainfall details are shown in table 3.1.1


VAIKOM
ETTUMANOOR
KOTTAYAM
VEMBANAD LAKE
ALLEPPEY
CHANGANACHERRY
AMBALAPUZHA
THIRUVALLA
TOTTAPPALLI
CHENGANNUR
MAVELIKARA
PANDALAM
KAYAMKULAM
ADOOR
ARABIAN SEA
Meenachil R
Manimala R
Pamba R
Achencoil R
R.S.

KUTTANAD

Table 3.1.1 Monthly average temperature and rainfall in Kuttanad, 2004

Month	Maximum temperature(^{0}C)	Minimum temperature (^{0}C)	Total Rainfall (mm)
January	31.35	22.05	4.4
February	32.45	22.97	3.6
March	33.03	24.49	53.6
April	32.51	23.98	178.6
May	31.15	23.46	827.8
June	30.04	24.27	522.6
July	29.92	23.77	369.4
August	29.50	23.97	327.6
September	29.93	24.08	209
October	31.00	23.78	423.2
November	31.52	23.44	199.2
December	31.95	21.87	0.8

Source: Pest surveillance station, Moncompu, (Alappuzha), Department of Agriculture, Government of Kerala

3.1.3 Population

Kuttanad comprises 54 villages in 10 taluks (Sub districts) with a total population of 1.4 million. The rural population density is about 800 per square kilometre and in some area exceeds 2000 per square kilometre. The estimated density in kayal lands is 1314 per square kilometre. According to 2001 census 12.45 per cent of total work force are paddy cultivators and another 50.12 per cent are agricultural labourers. The literacy rate in the area is 93.50 per cent (Directorate of Economics and Statistics, 2002,Govt.of Kerala).

3.1.4 Soils

Kuttanad rice soils are characterized by peatiness, high acidity and partial submergence with low bulk density, high porosity and high water holding capacity due to their high organic matter content (Aravindakshan, 1990)

3.1.5 Cropping Pattern

The general cropping pattern in Kuttanad region is as follows

a) Water fallow-water fallow-Rice

b) Rice-Rice-Water fallow

Most of the rice fields in the area are water logged throughout the year. The main rice crop of the area is the Punja (Summer crop) and in some areas a second crop (*Viruppu*) is also possible. The Punja season is generally the period from October/November to March/April i.e., after the cessation of Northeast monsoon and before the ingression of saline water during the summer months. The second crop *i.e.*, '*Viruppu*' is grown from may to the end of July and is restricted to places, which are less prone to flood damage. The area, production and productivity of paddy in Kuttanad region is shown in table 3.1.2

Table.3.1.2 Area, Production and Productivity of rice in Kuttanad (1989- 2005)

Year	Area (ha)	Production(MT)	Productivity (MT/ha)
1989-1990	26807	109909	4.1
1990-1991	31603	132732	4.2
1991-1992	32559	136750	4.2
1992-1993	32138	144621	4.5
1993-1994	31725	142762	4.5
1994-1995	31560	146381	4.65
1995-1996	31396	150000	4.8
1996-1997	28415	69730	2.45
1997-1998	30082	66180	2.2
1998-1999	29625	88952	3.2
1999-2000	30015	125655	3.8
2000-2001	28669	143345	5.0
2001-2002	25495	127475	5.0
2002-2003	27081	140821	5.2
2003-2004	26097	73072	2.8
2004-2005	23040	87552	3.8

Source:Rice Research Station, Kerala Agricultural University, Moncompu, Alappuzha

3.1.6 Rice cultivation practices in Kuttanad (Punja)

The land gets flooded with the outbreak of Southwest monsoon and the level of water rises to five metres or even more. In July, when the water level falls to about one metre, one or two ploughings are given. In September, when the water level goes down to a manageable level, the outer bunds of each *Padasekharam* are reinforced with clay, stakes, reeds and bushes after which pumping out of water is continued till the fields are completely drained. This construction of bunds is a collective activity and individual farmer has to bear the relative share of expenditure. The State Government gives financial support for this activity and it is monitored by the respective *Padasekharam* samiti, which is a registered society with all the paddy landowners in that *Padasekharam*. After that, the undecomposed organic matter and weeds are removed and the soil is brought to a soft puddle. Then the inner bunds are constructed by the individual farmers. Fresh water is let into a depth varying from a few centimeters to 0.5 metre. Sprouted seed is generally broadcast in the standing water. After three to four days water is drained by pumping out and the fields are allowed to dry for about 10 days. Lime is applied at this stage, after which water is let in and maintained to a depth of 5 to 8 centimeters.

Fertiliser applications are done at the tillering and panicle initiation stages. After draining out water from the fields, the fields are reflooded one or two days after the application of fertilizers. The fields are completely drained 10 days before crop maturity to facilitate harvesting operation. Government provides cent per cent subsidy to electricity for the dewatering purpose. A motor and pump set is maintained by each *Padasekharam* samiti and the relative share is born by the individual farmers

3.2 METHODOLOGY

3.2.1 Selection of sample

This study is focused on the paddy cultivation (Punja crop) in the Kayal lands of Kuttanad. 'Kayal' lands constitute 7900 hectares spreading over 32 *Padasekharams*. Of this seven *Padasekharams* were randomly selected in the first stage. From the selected *Padaekharams* the list of farmers were compiled as two groups, those practicing IPM and those who do not, in consultation with the concerned KrishiBhavan (the Panchayat level officers of the Department of Agriculture, Government of Kerala) and secretary of *Padasekharam* Samiti. A preliminary survey was conducted in selected *Padasekharams* to categorize the farmers into IPM adopter and Non-adopter by calculating adoption index. The questionnaire used for the preliminary survey was developed based on the recommended IPM technology for Kuttanad rice crop by Kerala Agricultural University (Appendix I)

3.2.2 IPM Adoption Index

Twelve practices were identified by the IPM trainers for paddy crop in Kuttanad which are imparted to farmers through Farmers Field Schools. These are a combination of cultural, biological, physical and chemical control methods. The details of the recommended practices are given in the Appendix I.

The farmer who has followed a practice completely, partially and not, has been given a score of two, one and zero respectively for each of the practices. A farmer who has followed all the practices full, scored 24 points (12x2) and who has not followed any of the practice had a score of zero (12x0) while the farmer who has followed at various degrees scored between 0 and 24.To distinguish the IPM adopters from Non-adopters a point 12 is fixed. The farmers having score of more than or equal to 12 were classified as IPM adopter and less than that as Non adopter. For the purpose of the present study thus 70 IPM adopters and 70 non-adopters were selected and the total sample size is made to 140 (70x2)

3.2.3 Type of Data

The primary data pertaining to the socio-economic information of the farmer, holding size, cropping pattern, input use, prices of inputs, yield and returns and plant protection measures adopted in this region were collected by personal interview method using a pretested structured questionnaire designed separately for IPM and Non-IPM farms (Appendix II&III). The secondary data relevant for the study were gathered from various departments of Government of Kerala, published sources and Kerala Agricultural University

3.2.4 Period of Study

The reference year for the study was the agricultural year of 2004-2005 covering Punja crop. The survey was conducted during the period from March 2005 to July 2005.

3.2.5 Analytical Frame work

3.2.5.1 Relative Economics (Partial Budgeting Analysis)

The difference in quantitative aspects of IPM and Non-IPM farming practices was reflected through Partial Budgeting technique. Partial budgeting analysis examines how a new technology adoption affects the farm profitability. It compares the existing situation with the new or alternative method. (Johl and Kapur, 2001)

Partial Budget

Economics of paddy production per hectare by adoption of Integrated Pest Management technology v/s traditional practice

Debit	Credit
A) Additional cost per hectare (Rs)	C) Reduced cost per hectare (Rs)
B) Reduced returns per hectare (Rs)	D) Added returns per hectare(Rs)
X = Total added costs and reduced returns	Y = Total reduced costs and added returns
Net change in income (Gain) (Y – X) = Rs	

ABC cost concept was followed in employing partial budgeting. Both input wise and operation wise costs of cultivation and various income efficiency measures were worked out separately for Non-IPM and IPM farms.

Cost Concepts

The Estimation Committee on Cost of Cultivation (Government of India) has categorized the farm costs into six groups viz., Cost A_1, Cost A_2, Cost B_1, Cost B_2, Cost C_1 and Cost C_2. Cost C_3 has been added later in 1991 to account for the management input of the farmer (Acharya and Agarwal, 1994). The various cost components constituting these cost concepts are outlined as below.

CostA_1: Approximates all actual expenses in cash and kind incurred in production by the owner operator. It includes the following items

a) Value of hired human and machine labour

Human labour employed for various cultural operations like land preparation, seed preparation, sowing, application of fertilizers, plant protection chemicals, weeding and harvesting were included in determining the value of human labour. The actual wages paid for labour was considered as the value of the hired labour. The wage rates prevailing in the area were on an average Rs 150 per day (6 hours of work) for men and Rs 85 per day (6 hours of work) for women. Contract labour was employed for sowing, application of plant protection chemicals, fertilizers and lime at the rate of Rs.250 to Rs.300 per hectare. Machine labour was employed for ploughing and threshing operations which was valued at the rate of Rs. 250 per hour. For expressing the labour use in physical units, the concept of man days (6 hours of work) was adopted. The women labour was converted to man days using the wage rate ratio.

b) Value of material inputs

Expenditure on all the material inputs like seeds, inorganic nutrients, plant protection chemicals, bio-fertilizers, *Trichogramma* cards etc was estimated based on their actual purchase price. This rate was imputed for those items which were not purchased (farm produced inputs)

c) Interest on working capital

This was charged at the rate of 8.5 per cent per annum which was the interest rate charged by commercial banks on short-term agricultural loans. It was taken only for four months that is for the crop duration only.

d) Land revenue

The actual rate paid to the Revenue Department was taken as the land revenue. It was Rs. 120 per hectare per annum in Kuttanad taluk and was considered only for the duration of the crop.

e) Depreciation of farm implements/machinery

As the respondents are not using any fixed assets in paddy cultivation depreciation was not included in the cost of cultivation. Generally the labourers will come to the field with the implements and the wages paid to them includes the rent for the implements. Ploughing was done by using tractor and tiller which were hired at a rate of Rs.250 per hour. Dewatering is done as a collective activity for the *Padasekharam* as a whole and is guarded by the *Padasekharam* committee. The motor and pumpset used was purchased by the *Padasekharam* samiti and the invidual farmers have to pay their relative share. For harvesting and threshing operations machine labour is used and was hired at the rate of Rs.250 per hour.

ii) Cost A_2

Cost A_2 is equal to Cost A_1 plus rent paid for leased in land. Based on the prevailing rent in the area, an amount of Rs 9375 per hectare per crop was accounted for as the rent for leased in land

iii) Cost B_1

It is equal to Cost A_1 plus interest on own fixed capital which includes machinery such as diesel and electric motors and farm implements etc. As the respondents were not using any fixed assets in paddy cultivation CostA_1 and Cost B_1 are the same

iii) Cost B_2

It is equal to Cost B_1 plus rental value of owned land plus rent paid for leased in land. The prevailing rent rate of Rs.9375 per hectare was apportioned as rental value of own land and rent paid for leased in land, based on the proportion of these two types of farms in each category.

iv) Cost C_1 It is equal to Cost B_1 plus imputed value of family labour.

v) Cost C_2: It is equal to Cost B_2 plus imputed value of family labour.

vi) Cost C_3: It is equal to Cost C_2 +10 percent of Cost C2 to account for the value of management input of the farmer.

vii) Cost of Production

The cost of production per quintal was worked out by dividing the various costs by the output per hectare.

viii) Income measures

The following income measures associated with different cost concepts were also used to measure the efficiency of paddy production

a) Gross Income: It represents the total value of the produce, which was valued at the prevailing market price. Those amounts taken for home consumption as well as wage payments in kind were also valued at this rate.

b) Farm Business Income: Gross Income – Cost A_1

c) Own Farm Business Income: Gross Income – Cost A_2

d) Family Labour Income: Gross Income – Cost B_2

e) Net Income: Gross Income - Cost C_3

f) Farm Investment Income: Farm Business Income – Imputed value of Family Labour

ix) Benefit Cost Ratios: It reveals the economic efficiency of production. It was calculated by dividing the total benefits by the total costs

3.2.5.2 Resource Use Efficiency

In order to study the on-farm resource productivity for IPM and Non-IPM farms

Cobb-Douglas type production function was fitted assuming that pesticide input plays a similar role as other inputs in crop production. The equation was estimated in log linear form by the method of Ordinary Least Squares (OLS)

Separate function was fitted for Non-IPM and IPM farms. The function of the Non --IPM farms was in the following form.

$$Y = a X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} e^{u}$$

Where Y = Gross income per hectare (Rs./ha)

X_1 = Expenditure on seed (Rs./ha)

X_2 = Expenditure on nutrients (N+P+K) as inorganic fertilizers (Rs./ha)

X_3 = Expenditure on plant protection chemicals (Rs./ha)

X_4 =Expenditure on labour (Rs./ha)

u = error term

a = Intercept and

b_1 to b_4 = Regression co-efficients.

The function of the IPM farms was fitted in the following form.

$$Y = a X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} e^{u}$$

Where, Y=Gross income per hectare (Rs./ha)

X_1=Expenditure on seed (Rs./ha)

X_2 = Expenditure on nutrients (N+P+K) as inorganic fertilizers (Rs./ha)

X_3 = Expenditure on plant protection chemicals (Rs./ha)

X_4 =Expenditure on labour (Rs./ha)

X_5 = Expenditure on IPM measures (Rs./ha)(only in IPM)

u = error term

a = Intercept and

b_1 to b_5 = Regression co-efficients

The above function was converted into linear form by making logarithmic transformation of all the variables.The function was estimated in the log linear form as

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + u \quad (\ldots(2)$$

The method of ordinary least squares was adopted to estimate the co-efficients. The regression coefficients so obtained were tested for their significance using the t-test.

Definition of variables

1.Gross Returns (Y): It is the total returns realized by the sale of main product. The portion of output given as kind payment of wages and that taken for home consumption was also included in the total output estimation and the farm gate price was used to estimate the Gross Income. This is converted to Rs./ha

2.Expenditure on seed: It is the amount spent by the farmer on seed, in Rs./ha

3.Expenditure on inorganic nutrients: The actual expense (cost of fertilisers, lime including the transporting costs plus any other related expenses) is expressed on per hectare basis in Rs./ha.

4.Expenditure on plant protection chemicals: The actual expenditure incurred on Plant protection chemicals is expressed on per hectare basis. This included the purchase price multiplied by quantity purchased and the related transportation expenses in Rs./ha.

5.Expenditure on human labour: The actual wages paid to the hired labourers and imputed value of family labour was taken as the total labour cost (Rs/ha)

6. Expenditure on IPM measures: It is the expenditure on IPM measures viz., use of light traps, pheromone traps, seed treatment with *Pseudomonas* and biofertilizers, arrangement of *Trichogramma* cards *etc*.

Results and Discussion

Chapter IV
RESULTS AND DISCUSSION

The results of the study are presented under the following sections.

4.1 General information about the respondents

4.2 Adoption index of IPM package

4.3 Resource use pattern in paddy production

4.4 Relative economics of IPM technology

4.5.Resource use efficiency in paddy cultivation

4.6 Farmer's adoption of IPM technology

4.1 GENERAL SOCIO ECONOMIC BACKGROUND OF THE RESPONDENTS

The characteristics of the sample respondents like age, sex educational profile and size of the land holdings are presented in the table 4.1.

The average age of the respondents in IPM group was lower (48.75 years) than the Non-IPM group (52.77 years). Majority of the respondents in both IPM and Non-IPM groups were of the age group 36-60 years. The average family size of the respondents in the IPM group was higher (2.91) than the Non-IPM group (2.77). Majority of the farmers in both the groups were in the family size group of 2-4 members.

A higher percentage of farmers in the IPM group (91.42) were having education of secondary and beyond the secondary level. The proportion of it in the Non-IPM group was 74.21 per cent. Higher education level might have acted as a tool for creating awareness and skill in IPM technology.

Table 4.1 Socio economic profile of sample farmers (Non-IPM and IPM)

S.No	Particulars	Non -IPM	IPM	Pooled
I	Age group (years)	No. of farmers	No. of farmers	No. of farmers
1	18-35	14(20.00)	22(31.43)	36(25.71)
2	36-60	49(70.00)	44(62.86)	93(66.43)
3	>61	7(10.00)	4(5.71)	11(7.86)
4	Total	70(100.00)	70(100.00)	140(100.00)
	Average age	52.77	48.75	50.76
II	Family size (number)			
1	2-4	42(60.00)	49(70.00)	91(65.00)
2	5-7	28(40.00)	21(30.00)	49(35.00)
3	Total	70(100.00)	70(100.00)	140(100.00)
	Average family size	2.77	2.91	2.84
III	Education			
1	Illiterate	0(0.00)	0(0.00)	0(0.00)
2	Primary	6(8.57)	4(5:71)	10(7.16)
3	Middle school	12(17.14)	2((2.86)	14(10.00)
4	Secondary	16(22.86)	25(35.72)	41(29.28)
5	Higher secondary	26(37.14)	27(38.57)	53(37.85)
6	Graduation and above	10(14.29)	12(17.14)	22(15.71)
7	Total	70(100.00)	70(100.00)	140(100.00)
IV	Occupation			
1	Agriculture only	42(60.00)	49(70.00)	91(65.00)
2	Agriculture as main occupation	15(21.43)	16(22.86)	31(22.14)
3	Agriculture as subsidiary occupation	3(18.57)	5(7.14)	18(12.86)
4	Total	70(100.00)	70(100.00)	140(100.00)
V	Holding Size			
1	< 1 hectare	32(45.71)	16(22.86)	48(34.28)
2	1-2 hectares	28(40.00)	38(54.29)	66(47.14)
3	2-4 hectares	10(14.29)	15(21.43)	25(17.85)
4	>4 hectares	0 (0.00)	1(1.42)	1(0.73)
5	Total	70(100.00)	70(100.00)	140(100.00)
	Average holding size (ha)	1.20	1.66	1.43

*Figures in parenthesis indicates percentages to total

It is to be noted that for 70 per cent of the respondents in IPM group, agriculture was the only occupation, and for 23 per cent it was the main occupation where as in Non-IPM group it was 60 per and 21 per cent respectively

The average size of holding of the respondents was 1.66 ha in IPM group and 1.20 ha in Non-IPM group.

4.2 ADOPTION INDEX OF IPM PACKAGE

The intensity of adoption of IPM technology can be estimated from the adoption scores of the respondents in both the categories (Non-IPM and IPM farms) presented in table 4.2. The adoption score among the IPM farmers has crossed above the minimum score of 12, which is required to differentiate the IPM farms from the Non-IPM farms, and the score was less than 12 in Non-IPM farms. The intensity of adoption was higher in IPM farms compared to Non-IPM farms

Table 4.2 Estimated adoption score of the respondents (Non-IPM and IPM)

Category	Score	No. of Respondents
Non-IPM	0-6	32 (45.71)
	7-12	38 (54.28)
IPM	13-18	15 (21.42)
	19-24	55 (78.27)

*Figures in parenthesis indicates percentages to total

These farms were under the technology for varying periods of time. 71 per cent of the farms were adopting the technology for the previous two years and 24 per cent , two to five years .the rest were adopting it for more than five years

4.3 RESOURCE USE PATTERN IN RICE PRODUCTION IN KUTTANAD

Integrated Pest Management in rice production in the study area was introduced as a programme of Department of Agriculture, Kerala during the year 1993. The department provided technical support to the programme through massive field trials, training classes and other extension tools. Financial support is also provided in the form of subsidy for various activities

The management under IPM programme starts from the very beginning of the crop calendar starting with the varietal selection, seed rate, its source and method of planting

Seed

The important varieties of paddy cultivated by the respondent farmers in the area were Jyothi (PTB 39) and Uma (MO16). Jyothi is tolerant to brown plant hopper, while Uma is resistant to gall midge and brown plant hopper. These are the commonly occurring serious pests in the Kuttanad area. Bhadra (MO4), Krishnanjana (MO 19), Karthika (MO7), Aruna, Karishma, Sabari and Panchami (MO14) are also recommended by Kerala Agricultural University, in Kuttanad area (Table 4.3.1)

While majority of IPM farmers (59 per cent) exhibited preference for Jyothi variety, 64 per cent of Non-IPM farmers preferred Uma variety. Most of the farmers in the Non-IPM group used farm saved seed (68 per cent) and only 32 per cent have purchased new seed from Krishi Bhavan. Contrarily 78.15 per cent of IPM farmers used newly purchased seed from Krishi Bhavan and National Seed Corporation and only 22 per cent used farm saved seed. The average seed rate in Non-IPM farms was 20.45 per cent higher (132.5 Kg/ha) than that of IPM farms (110 Kg/ha). This was due to increased seed rate practiced in Non--IPM farms than the recommended levels (100 to 125 Kg/ha) in anticipation of higher yield. The total expenditure on seed in Non-IPM farms was 25.44 per cent higher (Rs1060 per ha) compared to IPM group (Rs 845 per hectare).However this difference may not be perceived by the Non-IPM farmers as they are not actually effecting the payment(farm saved seed)

Table 4.3.1 Seed use pattern in paddy cultivation in Kuttanad (Non - IPM and IPM)

S.No.	Particulars	Unit	Non-IPM	IPM	Recommended level (KAU)
I	**Variety** 1.Jyothi (PTB 39) 2.Uma (Mo 16)	Percentage of farmers	36.24 63.76	59.21 40.79	Jyothi, Uma, Bhadra, Karthika, Aruna, Karishma, Sabari etc.,
II	**Source** 1. KrishiBhavan 2. NSC 3. Farm saved	Percentage of farmers	32.52 0.00 67.48	43.05 35.10 21.85	
III	Seed Rate	Kg/ha	132.5	110	100 to 125
IV	Expenditure on seed	Rs/ha	1060	845	

Plant nutrients

a) Organic sources:

Irrespective of the management system, the general practice in the area is to plough back the crop residue after harvest in the field. No other forms of organic manures are supplemented additionally.

b) Inorganic sources:

The common inorganic sources of nutrients used in the area were urea, factomphos, mussoriephos and muriate of potash (Table 4.3.2). There was considerable difference in the amount of fertilizers applied by the respondents in both the groups. A considerable deviation from that of the recommended level by KAU was found in case of Non-IPM farms as most of the farmers resorted to higher levels of application of fertilizers in anticipation of higher yields. They were applied in three splits i.e., after leveling, at tillering and at panicle initiation stages in both the groups

The application of nitrogenous fertilizer was 10.56 per cent higher (99.5 Kg/ha) than the recommended level of 90 Kg/ha in Non-IPM group and it was almost similar to that of recommendation in case of IPM group (91 Kg/ha). The phosphatic fertilizer use was 5.56 per cent higher (47.5 Kg/ha) than the recommended level of (45 Kg/ha) in Non-IPM farms but it was 16.67 per cent lower than the recommendation in IPM group (37.5 Kg/ha). Potassic fertilizers were applied at the rate of 45 Kg/ha in Non-IPM group which was on par with the recommended level (45 Kg/ha) and it was 11.11 per cent lesser (40 Kg/ha) than recommendation in IPM farms

Table 4.3.2 Inorganic nutrient use in paddy cultivation in Kuttanad

S.No	Particulars	Unit	Non-IPM	IPM	Recommended level (KAU)
I	Inorganic Nutrients				
	a) Nitrogen	Kg/ha	99.5	91	90
	b) Phosphorous	Kg/ha	47.5	37.5	45
	c) Potassium	Kg/ha	45	40	45
II	Soil ameliorants				
	a) Lime	Kg/ha	275	372	600
III	Expenditure on total plant nutrients	Rs/ha	2500	1915	

c) Soil ameliorants:

As the soils in the area were acidic in nature the application of soil ameliorants like slaked lime and calcium carbonate is a common practice. Department of Agriculture Government of Kerala through Krishi Bhavan of the concerned Panchayat provides financial support in the form of subsidy for lime ranging from 15 to 50 per cent of the cost for the paddy growers in the area. The average quantity of lime applied in the Non-IPM group was 275 Kg/ha and among IPM farms it was found to be 372 Kg/ha while the recommended level is 600 Kg/ha

The total expenditure on plant nutrients was 30.54 per cent higher (Rs.2500 Kg/ha) in Non-IPM group compared to IPM group (Rs.1915 Kg/ha). Nutrient supplement through chemical fertilizer was found to be much above the recommendation in certain nutrients in most of the crops grown in Kerala. (Devi, 1983;Mohandas, 1994 and Preeti, 1997). This is often without due regard for NPK ratios, soil nutrient status and technical or financial optimum

Plant protection chemicals

The use of plant protection chemicals has become an inevitable factor in paddy cultivation in the Kuttanad ecosystem. The major groups of agrochemicals used in the area are insecticides, fungicides and weedicides (Table 4.3.3).

Salvinia molesta, Echinochloa colonam, Panicum repens were the commonly occurring weeds in the paddy crop in the area. Among them, Salvinia is highly problematic causing disturbance for normal cultivation practices of paddy in the region. Almost all the respondents in both the groups resorted to chemical method of weed control in addition to the manual weeding The common weedicides used in the area were 2,4-D (fernoxone) and paraquat (Gramoxone). The application of fernoxone was more or less similar to the recommended level of 1 to 1.2 Kg/ha in both the groups. In Non-IPM group it was 16.82 per cent higher (1.25 Kg/ha) than IPM group (1.07Kg/ha). Paraquat was applied at less than recommended level (2 Kg/ha) in both the groups.*i.e.*, 1.20 Kg/ha in Non-IPM and 0.95Kg/ha in IPM group. However the Non-IPM farms used higher levels.

The common diseases infesting the paddy crop in the area were sheath blight (*Rhizoctonia solani*), and sheath rot (*Sarocladium oryzae*). The most common fungicides used against them are carbendazim (Bavistin) and hexaconazole (Contaf). Non-IPM farms applied carbendazim at the rate of 0.5 Kg/ha which was same as recommended level but in IPM farms it was very less (0.85 Kg/ha) than the recommended level. This reduction was due to the farmers resorting to spot spraying and need-based application in IPM group. Contaf was applied at the rate of 0.95 l /ha in Non-IPM group which is 26.67 per cent higher than recommended level (0.75 l/ha) where as in IPM group it was 0.25 l /ha which was 66.67 per cent lower than the recommended level.

Table.4.3.3 Plant Protection Chemicals in rice cultivation in Kuttanad

S.No	Name of the Chemical			Quantity used (per hectare)		Recommended level
	Chemical name	Trade name	Unit	Non-IPM	IPM	
1	2,4-D*	Fernoxone	Kg	1.25	1.07	1 to1.2
2	Paraquat*	Gramoxone	Kg	1.20	0.95	2
3	Carbendazim**	Bavistin	Kg	0.500	0.85	0.5
4	Hexaconazole**	Contaf	Litres	0.950	0.250	0.75
5	Methyl Parathion***	Metacid	Litres	1.35	0.765	0.5
6	Acephate***	Asataf	Kg	1.325	0.425	0.800
7	Carbaryl***	Sevin	Kg	1.10	0.525	2
8	Monocrotophos***	Nuvacran	Litres	1.725	0.5 75	0.600
9	Phosphamidon***	Dimecron	Litres	1.05	0.175	0.250

* Herbicide** Fungicide*** Insecticide

The common insect pests attacking Punja paddy crop were brown plant hopper (*Nilaparvata lugens*), gall midge (*Orseolia oryzae*) and rice stem borer (*Scirpophaga incertulas*). Methyl parathion, acephate, carbaryl, monocrotophos and phosphamidon were the major insecticides used against them. The total insecticide consumption was very high in Non-IPM group compared to IPM group. Only carbaryl was applied according to the recommendations in Non-IPM group and the other insecticides were applied at higher doses than recommended levels. This was due to the farmers resorting to prophylactic sprays even before the incidence of the pest. In IPM group, only methyl parathion was applied above the recommended level while other insecticides were sprayed less than the recommended levels.

The total expenditure on plant protection chemicals was 64.34 per cent lower in IPM group (Rs.1053/ha) compared to Non-IPM group (Rs.2953/ha). This was in confirmity with the study of Rakhesh (1999) where IPM farms have realized a 32 per cent reduction in plant protection chemical expenditure compared to Non-IPM farms in Kuttanad.

IPM measures

IPM measures like pest surveillance by using light traps, seed treatment with *pseudomonas fluorescence* and bio fertilizers like Azospyrillum, release of egg parasitoid *Trichogramma japonicum* and use of pheromone traps were the practices followed by the respondents in the IPM group for pest control. The average cost per hectare for each practice is given in the table 4.3.4. Seed treatment with Pseudomonas species is practiced by about 85 per cent of the farmers in IPM group. The next highly adopted practice is use of light traps for pest surveillance. The light traps were provided by the Krishibhavan at subsidized rates for the IPM trained farmers. Only 35 per cent of the respondents in IPM group used pheromone traps as it was costlier practice. The total material cost associated with the IPM was estimated as Rs. 649 per hectare. This is the expenditure incurred by the respondents in the IPM group (private cost) and does not include the subsidy component. So the actual expenditure(social cost) for these practices may be higher than this estimated cost. This cost accounted for 2.17 per cent of the total cost of cultivation. This was not accounted in case of Non-IPM group

Table 4.3.4 IPM measures adopted by the farmers in Kuttanad

S.No	IPM practice	Percentage of farmers adopting the practice	Average cost incurred by the farmer (Rs/ha)
1	Pets surveillance by light traps	75.00	168
2	Use of pheromone traps	35.00	225
3	Seed treatment with *Pseudomonas fluorescence*	85.00	196
4	Application of Azospyrillum	56.00	232
5	Release of egg parasitoid, *Trichogramma sp*	42.00	250

Labour

Paddy cultivation is a labour intensive activity. The total labour use in the crop was estimated as 128.80 man days per hectare in Kuttanad by Joseph, (1982). However, recently the human labour generally being replaced by machine labour and other technologies, as evidenced by increased dependence on weedicide and combined harvestors in the area.

The total labour use in IPM farms is given in table 4.3.5.It was estimated as 75 man days per hectare and is 5.63 per cent higher than that of Non-IPM farms (71 man days per hectare). This is primarily due to the additional labour required in IPM farms for weeding (due to lesser amount of weedicide use), land preparation (additional ploughing) and harvesting (higher yield). Obviously this resulted in a higher level of women labour engagement (weeding and harvesting operations done exclusively by women)

Irrespective of the management practice, on an average 90 per cent of the labour was hired in each farm. It may be noted that majority of the respondents in the two groups were with a family size of 2-4 members only. The family labour contribution from women labour was observed practically non-existent in the area.

It was estimated that the fertilizer application, chemical pest control operations, weeding and IPM practices had a sizeable difference in labour use between the two groups. While it was labour saving in IPM group in fertilizer and pesticide application, it was the reverse case with respect to weeding and IPM practices

The replacement of labour with technologies and machines has been a subject of debate in Kuttanad area among the strong labour unions, farmers and the general public of the state. However, IPM as a technology apart from its economical and environmental aspects has a social dimension as it improves the employment opportunities in rice cultivation. However, in the light of shrinking labour supply in agriculture this raises a potential problem as well.

The predominance of labour cost over other input costs was shown by many cost of cultivation studies on paddy in Kerala. (Samuel, 1963; Joseph, 1982; Muraleedharan, 1981 and Mohandas, 1994). In conformity with these observations the total human labour was identified as the major item of expenditure accounting for 33.77 per cent in Non-IPM group and 37.70 per cent in IPM group. Similar results were reported by Joseph (1982) who estimated labour cost in Kuttanad area as 42.51 per cent of the total cost which was the highest among the inputs.

Table 4.3.5 Total Labour use in Paddy production in Kuttanad

S.N	Operation	Non-IPM					IPM				
		Men (man days/ha)		Women (women days/ha)		Total (man days/ha)	Men (man days/ha)		Women(women days/ha)		Total (man days/ha)
		F	H	F	H		F	H	F	H	
1	Land preparation	2.50 (3.07)	8.02 (9.85)	0.00 (0.00)	8.40 (10.31)	15.28 (21.93)	2.00 (2.21)	8.70 (9.62)	0.00 (0.00)	10.39 (11.49)	16.58 (22.12)
2	Seed preparation	1.20 (1.47)	4.39 (5.39)	0.00 (0.00)	0.00 (0.00)	5.59 (7.86)	2.34 (2.59)	3.40 (3.76)	0.00 (0.00)	0.00 (0.00)	5.74 (7.65)
3	Sowing	0.00 (0.00)	4.59 (5.64)	0.00 (0.00)	0.00 (0.00)	4.59 (5.64)	0.00 (0.00)	4.25 (4.70)	0.00 (0.00)	0.00 (0.00)	4.25 (5.67)
4	Fertilizer application	0.00 (0.00)	6.12 (7.51)	0.00 (0.00)	0.00 (0.00)	6.12 (6.46)	0.00 (0.00)	3.21 (3.55)	0.00 (0.00)	0.00 (0.00)	3.21 (4.28)
5	Plant protection operations	0.00 (0.00)	10.00 (12.28	0.00 (0.00)	0.00 (0.00)	10.00 (14.07)	0.00 (0.00)	6.18 (6.80)	0.00 (0.00)	0.00 (0.00)	6.18 (8.20)
6	Liming	0.00 (0.00)	5.13 (6.30)	0.00 (0.00)	0.00 (0.00)	5.13 (7.22)	0.00 (0.00)	4.48 (4.89)	0.00 (0.00)	0.00 (0.00)	4.48 (5.89)
7	Weeding	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	9.24 (11.34)	5.23 (7.36)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	12.65 (13.98)	7.16 (9.55)
8	IPM practices	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.30 (2.54)	3.62 (4.00)	0.00 (0.00)	5.23 (5.78)	8.88 (11.84)
9	Water management	3.50 (4.30)	9.00 (11.05)	0.00 (0.00)	0.00 (0.00)	12.50 (17.59)	0.00 (0.00)	10.00 (11.05)	0.00 (0.00)	0.00 (0.00)	10.00 (13.34)
10	Harvesting	1.00 (1.23)	2.10 (2.58)	0.00 (0.00)	6.09 (7.67)	6.56 (9.34)	1.92 (2.12)	2.32 (2.50)	0.00 (0.00)	7.56 (8.36)	8.52 (11.36)
11	Total	8.2 (10.07)	49.35 (60.60)	0.00 (0.00)	23.73 (29.33)	71.00 (100.00)	8.56 (9.46)	46.13 (50.93)	0.00 (0.00)	35.83 (39.60)	75.00 (100.00)

F – Family labour H –Hired labour

Total labour use is expressed in man-days per hectare after converting the women labour as explained in the methodology

The total expenditure on human labour was 5.63 per cent higher (Rs.11250/ha) in IPM group compared to Non-IPM group (Rs.10650/ha). The expenditure on machine labour was higher in IPMgroup (Rs.1523/ha) compared to Non-IPM group (Rs.1571/ha) due to additional rounds of ploughings and additional cost of harvesting in IPM farms

4.4 RELATIVE ECONOMICS OF IPM TECHNOLOGY

The difference in resource use between the IPM and Non-IPM farms was reflected in the total cost of cultivation also. The total cost of cultivation at Cost C_3 in IPM farms was estimated as Rs.29841/ha which was 5.37 per cent lesser than the Non-IPM group (Rs.31536/ha). Thus, the cost saving in IPM technology was Rs.1695 per hectare. The operation wise cost of cultivation and input wise cost of cultivation was estimated for both the farms (Non-IPM and IPM). The former is presented in Table 4.4.1 and the latter as Appendix IV.

The expenditure on harvesting along with post harvest operations (winnowing, cleaning etc.,) was higher in IPM farms, due to higher yield realized. These expenses were mainly the payment towards the rent for combined harvester (machine labour) and wages paid to women labourers (kind payment). Usually the kind payment is given as one seventh of the grain yield obtained in the farm. Land preparation and weeding also demanded higher investments in IPMfarms compared to other group.

Plant protection operation (chemical, cultural, physical and biological) amounted to Rs.4453/ hectare in Non-IPM farms where as it was Rs.3961/ha in the IPM group with a clear margin of Rs.497/ha. While the whole expenditure of Rs.4453/ha in Non-IPM farms is on chemical pesticides, IPM farms use only chemicals worth Rs.1980/ha highlighting the environmental and social dimension of the issue.

IPM farms enjoyed cost saving in chemical fertiliser application also. It was higher by 36.42 per cent in Non-IPM farms (Rs.4187/ha) compared to IPM farms (Rs.3069/ha). Cost saving was observed in seeds and sowing operations too.

Table 4.4.1 Operation wise cost of cultivation in paddy production in Kuttanad

S.No	Particulars	Non-IPM (Rs/ha)	IPM (Rs/ha)
1	Land Preparation	3083 (9.77)	3247 (10.88)
2	Seeds and Sowing	2588 (8.20)	2343 (7.85)
3	Fertiliser and application	4187 (13.27)	3069 (10.28)
4	Weeding	785 (2.49)	1074 (3.59)
5	Plant protection Operations	4453 (14.12)	1980 (6.63)
6	IPM measures	0 (0.00)	1981 (6.63)
7	Water management	1875 (5.94)	1500 (5.02)
8	Harvesting	1762 (5.58)	2041 (6.83)
9	Land Revenue	30 (0.10)	30 (0.10)
10	Interest on working Capital	531 (1.68)	488 (1.64)
11	Rent on leased in land	1205 (3.82)	1339 (4.49)
12	Rental value of own land	8170 (25.91)	8036 (26.93)
13	Imputed value of management input (10%of cost C_2)	2867 (9.09)	2713 (9.09)
14	Total	31536 (100.00)	29841 (100.00)

*Figures in parenthesis are percentages to total

Yield and Returns

The average yield of paddy in Kuttanad (3190 Kg/ha) is reported to be much higher than that of the crop for the state as a whole. (Directorate of Economics and Statistics, Govt. of Kerala, 2002) This is attributed to the specialty of soil and other agronomic conditions in the area. The yield and returns of the crop under IPM and Non-IPM situations are furnished in table 4.4.3

Table 4.4.2 Yield and Returns in paddy cultivation (per hectare)

S.No	Particulars	Non-IPM	IPM
1	Average Yield (kg/ha)	4446	4523
2	Gross Income (Rs/ha)	33345	33922
3	Gross Expenditure (Rs/ha)	31536	29841
4	Cost of production per quintal (Rs)	709	660

Relatively higher yield was achieved in IPM farms (45.23 quintals/ha) compared to Non-IPM farms (44.46quintals/ha). The usual practice of the farmers in the area was to burn and plough back the crop residue (straw) in the field itself. So income from bye product was not accounted in gross income estimation. The produce was sold directly to the co-operative society soon after harvesting and cleaning. The average yield, gross income and cost of production per quintal are summarized in table 4.4.3.The gross income was 1.73 per cent higher in IPM group (Rs.33922/ha) compared to Non-IPM group (Rs.33345/ha). The cost of production per quintal was worked out at Cost C_3 and it was Rs709 per quintal in Non-IPM group where as in IPM group it was estimated as Rs 660 per quintal

4.4.3 Income measures and benefit cost ratios

Various income measures derived from gross income such as Farm Business Income, Family Labour Income, Net Income and Farm Investment Income were estimated for both the groups and are presented in table 4.4.4. The Farm Business Income was Rs17453/ha in IPM group which was 14.21 per cent higher than Non-IPM group (Rs15281/ha). Net Income, which is the most suitable income measure to judge the profitability of crop production, was higher (Rs.4081/ha) in IPM group compared to Non-IPM group (Rs 1809/ha). Though the difference in Gross Income is Rs.577/ha, the Net Income shows a sizeable difference of Rs.2272/ha.

Table 4.4.3 Income measures and Benefit Cost Ratios in paddy production

S.No.	Income measures	Non-IPM	IPM
1	Gross Income (Rs/ha)	33345	33922
2	Farm Business Income (Rs/ha)	15281	17453
3	Own farm Business Income (Rs/ha)	14076	16114
4	Family Labour Income (Rs/ha)	5906	8078
5	Net Income (Rs/ha)	1809	4081
6	Farm Investment Income (Rs/ha)	14051	16169
7	B-C Ratio at Cost A_1	1.85	2.06
8	B-C Ratio at Cost A_2	1.73	1.90
9	B-C Ratio at Cost B_1	1.85	2.06
10	B-C Ratio at Cost B_2	1.22	1.31
11	B-C Ratio at Cost C_1	1.73	1.91
12	B-C Ratio at Cost C_2	1.16	1.25
13	B-C Ratio at Cost C_3	1.06	1.14

Benefit cost ratio indicates the value of the output per rupee of input cost. This ratio will serve as a measure which would indicate as to whether the costs incurred commensurate with the returns obtained. The benefit cost ratio of paddy production computed in relation to various cost concepts is presented in table 4.4.4.The IPM farms were having higher benefit cost ratio at all cost levels compared to Non-IPM farms .The benefit cost ratio at cost A_1 for Non-IPM farms was estimated as 1.85 and it was 2.06 for IPM farms. The ratio at Cost C_2 was 1.16 for Non-IPM farms and 1.25 for IPM farms and at Cost C_3 level it was 1.06 and 1.14 respectively. The enterprise tends to turn uneconomical at Cost C_3 level at a slight disturbance (reduction in crop yield or increase in input price) in Non-IPM farms. IPM farms were found to be more risk tolerant in that respect. From the results we can infer that rice cultivation under Integrated Pest Management was more beneficial than traditional chemical based cultivation and more risk tolerant.

4.4.4 Partial Budgeting Analysis

The rationale of any new technology is judged by the financial aspects of it. IPM technology warrants additional investment in certain activities like land preparation, weeding, pest control measures and harvesting. This additional cost per hectare of land cultivated was estimated at Rs.2714/ha (Table 4.4.4). Simultaneously the technology effected some cost savings in seeds and sowings, fertilizers and plant protection chemicals, amounting to Rs.3836/ha

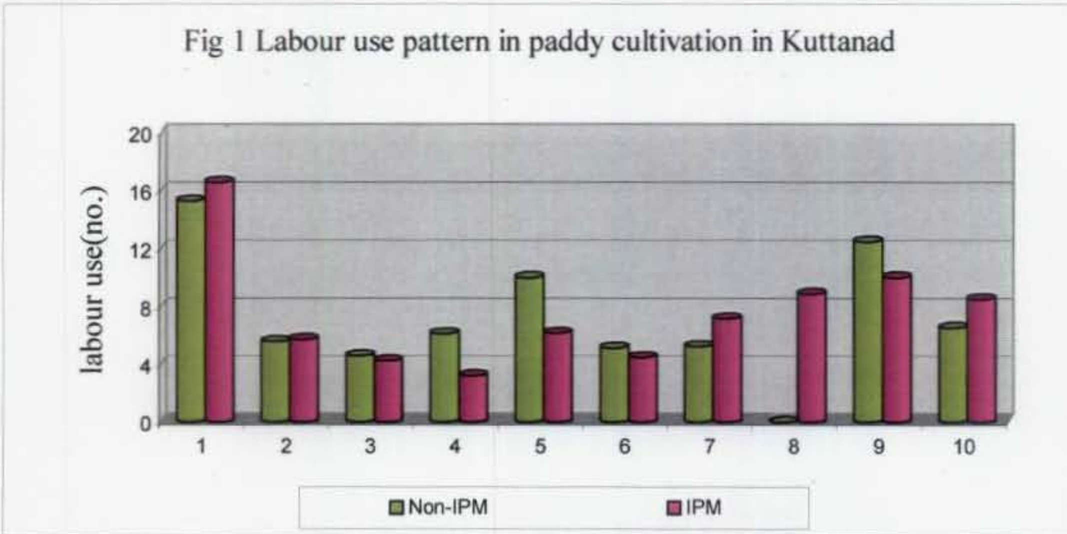
Similarly, the additional returns realized through better yields from the IPM farms were found to be Rs 1702 per hectare. Thus the net gain due to the technology adoption was estimated at Rs 2824 per hectare, which justifies the economic rationale of the technology. (Table 4.4.5). This was also reported by Tamizhenian (2001) who assessed the net gain of IPM practice as Rs 1731.76 per acre in paddy cultivation in Tiruvarur district of Tamil Nadu.

The IPM technology ensures better environmental quality compared to conventional practice. They include reduced damage on ecosystem (air, soil, water), human health (the pesticide applicators, agricultural laboureres, farm managers etc.,) and the health of the consuming population (human beings, livestock, fish and other aquatic life forms). This analysis has not attempted the qualitative dimensions of the IPM technology. Hence this estimate can be considered as the lowest bound of the value of net gain through the technology adoption.

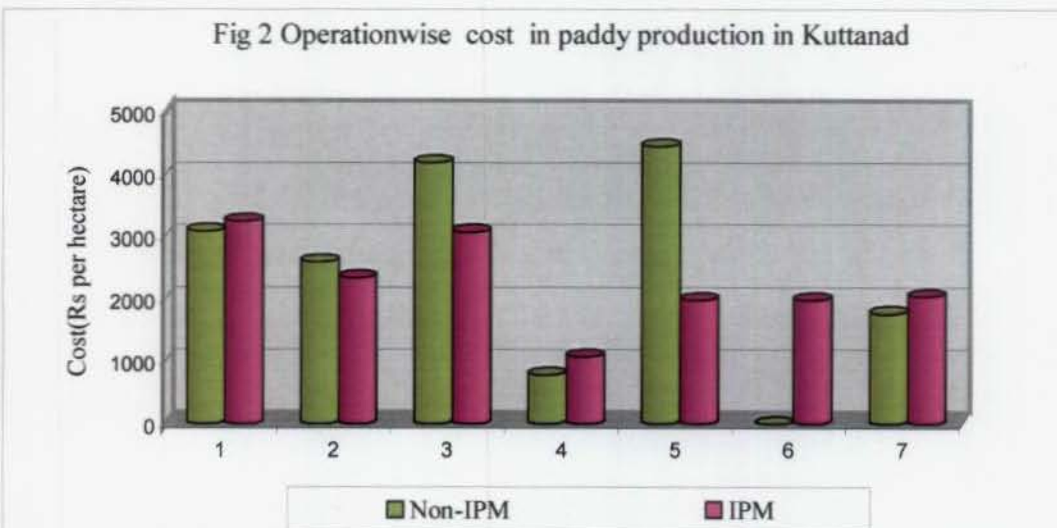
Partial Budgeting Analysis

Table 4.4.4 Economics of paddy cultivation per hectare by adoption of Integrated Pest Management Technology v/s Traditional practice (Rs/ha)

Debit	Credit
A) Additional cost per hectare 1. Land preparation = Rs 164 2. Weeding = Rs 290 3. IPM measures = Rs 1981 4. Harvesting = Rs 279	C) Reduced Costs per hectare 1. Seeds and sowing = Rs 244 2. Plant protection = Rs 2473 3. Fertiliser and application = Rs 1119
B) Reduced returns per hectare (Rs)= nil	D) Added Returns per hectare=Rs 1702
X = Total added costs and reduced returns (A + B) Rs 2714	Y = Total reduced costs and added returns (C + D) Rs 5538
Net change in Income (gain) Y –X = Rs 2824	



1.Land preparation
2.Seed preparation
3.Sowing
4.Fertiliser application
5.Plant protection operation
6.Liming
7.Weeding
8.IPM practices
9.Water management
10.Harvesting



1.land preparation
2.seeds and sowing
3.Inorganic nutrient application
4.Weeding
5.Plant protection
6.IPMmeasures
7.Harvesting

4.5 RESOURCE USE EFFICIENCY IN IPM AND NON-IPM FARMS

Cobb-Douglas Production function is seen employed in an array of studies to estimate the efficiency of each resource used in crop production (Azad and Garg, 1974;Balishter, 1983;Srikanthamurthy; 1986;Preeti, 1997 *etc.*) Earlier studies on paddy cultivation in Kuttanad have also adopted the model (Joseph, 1982;Mohandas, 1994;Rakhesh, 1999 *etc.*,). The same method is followed and the results are furnished in table 4.5

In conventional farms (Non-IPM) labour and seed cost were the major determinants of gross returns in paddy farming. The expenditure on chemical inputs (fertilizers and plant protection chemicals) were having a negative impact, though not statistically significant

The chemical pest control expenses in IPM farms were found to have a positive influence on gross returns though statistically not significant. It was negative in the case of Non-IPM farms. IPM technology has a strong positive influence on the profitability of paddy and one per cent increase in this, is capable of increasing the returns by 0.28 per cent. Similarly labour cost also exerted a positive influence on profitability, which was statistically significant at 1 per cent level. Moreover all the other productive input costs were having a positive effect, which shows an economically justifiable resource use pattern in these farms. It can be concluded that IPM farms are economically more efficient in resource utilization than the Non-IPM counter parts.

4.6 FARMERS ADOPTION OF IPM TECHNOLOGY

The study also tried to generate an idea on the farmer's perception of IPM technology. Adoption by fellow farmers and its demonstration effect were reported as the strongest motivation for adoption of the technology. The cost savings and resultant

4.5.Resource use efficiency under Non-IPM and IPM farms

S.No	Independent variable	Non-IPM		IPM	
		Regression Co-efficient	t-value	Regression Co-efficient	t-value
1	Expenditure on seed (Rs/ha)	0.44	3.70**	0.06	1.17
2	Expenditure on inorganic nutrients (Rs/ha)	-0.07	-1.26	0.04	1.49
3	Expenditure on plant protection chemicals (Rs/ha)	-0.03	-1.23	0.01	1.39
4	Expenditure on labour (Rs/ha)	0.35	4.72**	0.29	4.17**
5	Expenditure on IPM measures (Rs/ha)			0.27	6.80**
6	Constant	4.21	4.34	4.55	7.33
7	R^2	0.35		0.73	
8	Adjusted R^2	0.31		0.71	

Dependant variable: Returns (Rs/ha)

** Significant at one per cent level

profitability were other points of attraction. As the farmers were literate they were also concerned of the negative effects of pesticide on the ecosystem.

Table 4.6.1 Duration of training on IPM attended by the farmers

S.No	Duration	Number of farmers	
		Non-IPM	IPM
1	15 days to 2 months	27	23
2	3 to 4 months	0	47

Almost all the farmers in the IPM group have undergone training in IPM, organised by the Department of Agriculture for a period ranging from 15 days to 4 months. About 38.57 per cent of Non-IPM farmers have also attended IPM training classes but only for a lesser period (Table 4.6.1).

Table 4.6.2 Effect of IPM on costs and Returns

S.No	Percentage	Reduction in yield (No. of farmers)	Cost of cultivation (No. of farmers)
1	<10	39 (55.71)	16 (25.71)
2	10-20	31 (44.28)	54(74.28)

*(Figures in parenthesis indicates percentage to total)

All the farmers (IPM) reported that they experienced reduction in crop yield in the initial period of adoption of IPM. It was upto 10 per cent in majority of the farms, while in 44 per cent of the cases the yield loss was reported to be to the extent of 20 per cent compared to the condition before the adoption (Table 4.6.2). However, in most cases the farmers expected the yield to get stabilized within a span of 1 to 2 years (Table 4.6.3). Moreover, the cost savings on account of the adoption of the technology was perceived to be to the extent of 10 to 20 per cent by most of the respondents (Table 4.6.2). Actual estimates have shown it as 8.82 per cent at Cost A_1 level

It seems that the cost saving attribute of the technology is perceived by majority of the farmers than its yield reduction aspects. The latter is also accommodated on account of the short-term expression.

Table 4.6.3 Yield stabilisation after the adoption of IPM

S.No	Yield stabilisation (years)	IPM (No. of farmers)
1	1 to 2	55
2	3 to 4	15

Benefits of IPM technology are not confined to the individual farmers alone. Use of safe chemicals and scientific practices ensure a safe environment which has got a social dimension. Owing to perhaps the high literacy level as well as the past experiences in the area all the farmers were well aware of at least one aspect of negative externalities associated with pesticide use. Majority of the farmers in two groups highlighted the effect on human health (Table 4.6.4). But the choice of chemical for pest control was mainly based on the dealer's suggestion or own decision in Non-IPM category, which often resulted in the use of highly toxic chemicals at higher dose at inappropriate time. On the contrary the chemical pest control in IPM group was mostly based on scientific consultation (71 per cent of respondents)(Table 4.6.5). This ensures a safe and scientific use causing minimum damage to the ecosystem.

Table 4.6.4 Farmers awareness regarding the adverse effects of pesticides

S.No	Effects perceived by the farmer	Non-IPM (No of farmers)	IPM (No of farmers)
1	Contamination of water bodies	12	8
2	Destruction of natural enemies	9	18
3	Effects on human health	26	29
4	Destruction of aquatic life	13	10
5	Contamination of Food	10	5

Table 4.6.5 Source of information for chemical pest control

S.No	Basis for selection	Non-IPM (No of farmers)	IPM (No. of farmers)
1	Consulting KrishiBhavan	11	27
2	Deciding yourself	24	13
3	Dealer's suggestion	34	7
4	Consulting research station	1	23

Table 4.6.6 Farmers perception of the major problems associated with the adoption of IPM technology

S.No	Problems in the adoption of the IPM practice	No. of farmers
1	Difficulty in management of water	20
2	Unavailability of bio agents	9
3	Higher labour charges.	26
4	Lack of proper guidance from department officials.	4
5	Lack of Co-operation from neighbouring farmers	7
6	Non availability of bio-Fertilisers	4

The major problems in the adoption of IPM technology as expressed by the farmers are high labour cost and difficulties in water management (Table 4.6.6). These aspects are to be addressed in detail by conducting a focussed study.

Plate 1.Rice field in Kuttanad

Plate 2.Harvesting of paddy using combined harvester

Plate 3. Spraying of paddy fields in Kuttanad

Summary

SUMMARY

With the advent of green revolution, chemical pest control has gained importance and consumption of pesticides has increased enormously over the years. The global concern on the adverse effects of pesticides in the environment led to re-orient the policy on plant protection.

In paddy growing regions of Kerala, Kuttanad stands first in pesticide consumption. This had led to serious problems like pest resurgence, secondary pest infestation, and environmental pollution and health hazards. In view of these ill effects, Integrated Pest Management approach was introduced in the area. Though lot of research on scientific and technical aspects of the technology was attempted in this area, little information is available on the financial aspects of the programme. It was in this background this study entitled *Integrated Pest management in rice production-resource: use efficiency and relative economics* was conducted during the period March to July 2005 pertaining to the summer crop in Kuttanad (Nov 2004-Feb 2004). The specific objectives of the research project were:

1) To assess the relative economics of IPM technology in rice production
2) To estimate the resource use efficiency under IPM and Non-IPM packages.

The study was carried out based on information on a sample of 70 farms each from the group of farms managed under the IPM technology and those which were not following the technology, in the *Kayal* lands of Kuttanad, in Kerala. The categorization as IPM adopters and non-adopters were done by constructing an adoption index based on a preliminary survey. The data was collected by personal interview method using structured questionnaire, direct observation and secondary data sources.

It was found that the farmers practicing IPM technology were younger than their counterparts and majority were of better educational qualification. Majority of the farmers (93 per cent) in the IPM group depended on agriculture as the major source of their livelihood, while it was 81 percent in non IPM group. When agriculture forms the basis of income, there can be a tendency to protect the resource, adopting sustainable technologies.

The management under IPM programme starts from the very beginning of the crop calendar, starting with the varietal selection, its source, seed rate and method of planting. Though both types of farms were sowing only recommended varieties, IPM farms preferred Jyothi while Non IPM preferred Uma. But the seed rate was much above the recommended levels in the case of non IPM group and they primarily relied on farm saved seeds.

Though both groups did not follow the recommended levels in the application of fertilizers and soil ameliorants, the level of application was lower in the case of IPM farms. Among the various inputs in crop production, labour was the most important single item of expenditure in paddy production. The total labour use in IPM farms was found to be 75 man-days per hectare i.e., 5.63 per cent higher than that of Non-IPM farms (71 man days per hectare). This is primarily due to the additional labour required in IPM farms for weeding (due to lesser amount of weedicide use), land preparation (additional ploughing), harvesting (higher yield) and IPM measures. Obviously this resulted in a higher level of women labour engagement (weeding and harvesting operations done exclusively by women). IPM measures like surveillance by using light traps, seed treatment with *pseudomonas* and bio-fertilizer, release of egg parasitoid *Trichogramma japonicum* and use of pheromone traps were the additional practices undertaken in IPM group.

The total expenditure on seeds and sowing, fertilizer application and plant protection charges were 67.15 per cent higher in the Non-IPM group. About 64 per cent reduction was observed in expenditure on plant protection chemicals alone in IPM group. Contrary to this, the expenditure on land preparation, weeding and harvesting operations were 11.93 per cent higher in IPM group. Total cost of cultivation was estimated as 5.07 per cent higher in Non-IPM group (Rs31536/ha) compared to IPM group (Rs 29841/ha)

A part from the cost saving, relatively higher yield (45.23 quintals per hectare) was obtained in IPM farms compared to the other group. (44.46 quintals per hectare). Correspondingly, the gross income was 17.30 per cent higher. The partial budgeting analysis have revealed that the cost saving coupled with higher yield realization in IPM farms has resulted in an additional net private gain in income to the tune of Rs 2824 per hectare

Benefit cost ratio at Cost A_1 was estimated as 1.85 (Non-IPM) and it was 2.06 for IPM farms inferring rice cultivation under IPM, as more beneficial than chemical based cultivation. At cost C_3 level, the non IPM groups were more prone to risk as the BC Ratio was very close to unity. Even a small change in cost –price ratio may result in uneconomic situation.

Cobb-Douglas production function was fitted to assess the efficiency of resource use in paddy cultivation for both IPM and Non-IPM farms. Confirming the results of earlier studies in this area, expenditure on labour and seed were revealed to be the important items which positively and significantly contributed to the gross income, in non IPM farms. Expenditure on plant protection chemicals and fertilizers in these farms were indicated to be at uneconomic levels, as they had expressed a negative influence on gross income, though not significant

On the other hand, in IPM farms, apart from labour cost, the expenditure on IPM measures also showed a significant positive impact on gross returns. Contrary to Non IPM farms, the chemical pest control expenditure showed a positive effect, justifying its adoption under an integrated system. Moreover all the other productive input costs were having a positive effect, which shows an economically justifiable resource use pattern. It can be concluded that IPM farms are economically more efficient in resource utilization than the Non-IPM counter parts.

Though most of the farmers were aware of the potential hazards of excessive chemical use in agriculture, and got exposed to adequate training, the spread of the technology is constrained by factors like, the perception of a yield loss, difficulties in water management and labour problems. But those who have adopted the technology was found to be aware of the short-term nature of yield reduction and cost saving aspects of the technology.

Policy suggestions.

1. The adoption of any technology is primarily influenced by financial considerations, especially when it is aimed at a population whose main stay is agriculture. In this aspect the results of this study can be effectively used in the dissemination of the technology highlighting the cost saving and yield advantage aspects of the same.
2. The resource use efficiency in the farms highlighted the need for a rescheduling of the inputs especially in Non IPM farms. There should be efforts to streamline the use of productive inputs, considering the economic aspects of efficiency.
3. A large majority of farmers in the Non IPM farms were found to be depending on the dealers in the choice of chemical pesticides which is to be regulated. Programme for regulating the functioning of the dealers by proper implementation of the Insecticide Control Order may be prioritized.

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Future line of work

1. This study was conducted by concentrating on the private benefits of the IPM technology. But the effects of chemical use are manifested as damages in the ecosystem, which will not be captured in a study of this sort. The benefits of IPM technology thus will be more pronounced in a wider dimension of environmental valuation. So a holistic study assessing and valuing the environmental benefits is strongly recommended.

2. This study was confined to a particular geographic location and crop. Similar studies are to be initiated in crops like vegetables and fruits and in other parts of the state.

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Appendices

Appendix I
Department of Agricultural Economics
College of Horticulture
Vellanikkara
Integrated Pest Management in Paddy Production- Resource Use Efficiency and Relative Economics

Questionnaire for categorizing the Farms Under IPM and Non -IPM Categories

1.Name of the KrishiBhavan

2. Name of the *padasekharam*

3.Name of the respondent

4.Address

	Full Adoption	Partial Adoption	No Adoption
a] Cultural Control			
1. Use of resistant varieties			
i) Makom (MO 9) ii) Jyothi (PTB 39) iii) Uma (MO 16)			
2. Recommended seed rate			
i) 100 Kg /ha to 125 Kg / ha			
3.Synchronized time of planting October -November			
4.Recommended dose of fertilizers			
i) Nitrogen - 90 Kg/ha ii) Phosphorous - 45 Kg/ha iii) Potassium - 45 Kg/ha			
5.Conservation of natural enemies			
Collection of egg masses of stemborer in perforated polythene bags Keeping them in field			

	Full Adoption	Partial Adoption	No adoption
6. Removal and destruction of Crop residues			
7. Bund trimming			
b] Physical control methods			
8. Pest surveillance by light traps			
9. Use of pheromone traps			
c] Chemical control			
10. Seed and seedling treatment by			
a). Bio fertilizers			
1. Azospyrillum-500 g/5-10 Kg seed			
2. Azolla – 4t/acre			
3. BGA-10Kg/ha			
b} Fungicides			
i) Carbendazim-2 gm / Kg of seed			
ii) Tricyclazole-2 gm/Kg of seed			
11. Whether followed ETL based Pesticide application on main crop			
1.. Acephate- 800 g of 75 SP / ha			
2. Monocrotophos 600 ml of EC/ ha			
3. DDVP- 500 ml of 100 EC/AF / ha			
4. Carbaryl- 625 g of 85 S / ha			
d] Biological control			
12. Release of bio control agents			
a} **Parasitoids**			
i) *Trichogramma sp.*			
b} **Predators**			
i) Spiders			
ii) Ladybird beetles			
iii) Grasshoppers			

Appendix II
Department of Agricultural Economics
College of Horticulture
Vellanikkara
Integrated Pest Management in Paddy Production- Resource Use Efficiency and Relative Economics

Interview schedule (For IPM farms)

1 Name of the Krishibhavan

2. Name of the *padasekharam*

3.Name of the respondent

5. Landmark for identification

4.Address

6.Household information

S.No	Relation with head (code)	Sex	Age in years	Education	Primary occupation
1					
2					
3					
4					
5					
6					
7					

Sex: 1.Male 2. Female
Education: 1.No schooling; 2.Primary school; 3.Middle school; 4.Secondary; 5.Higher secondary 6.Graduate; 7.Post Graduate; 8.Others (specify)
Occupation: 1.Agriculture 2.Government employee; 3.Private employee; 4.Own business; 5.Agricultural labourer; 6.Non agricultural Labourer; 7.Not working; 8.House wife; 9.Student
Relation with head: 1.Head 2.wife 3. Son 4.Daughter 4.Son in law 6.Daughter in law 7.Sister 8.Brother 9.Grandson 10.GrandDaughter 11.Others

Land particulars

(acres)

Sl.No	Particulars	Wetland	Garden land	Dry land	Total
1	Area owned				
2	Area leased in				
3	Area leased out				
4	Net sown area				
5	Area sown more than once				
6	Net irrigated area				

8.Details of the land under study

Sl.No	Crop season	Year	Area (acres)	Variety sown	Period under IPM	
					No. of seasons	Years(Number)

9. Implements and machinery owned by the farmer

S.No	Particulars of the machinery/implement	Number	Year of purchase	Subsidy if any(Rs/unit)	Original value	Present value	Whether used in paddy cultivation

10 Live stock owned by the farmer

Type	Number	Breed	Year of purchase	Age in years	Value at present	Whether used in paddy cultivation
1.Bullock 2.He buffaloes 3.Shebuffaloes 4.Cows 5.Goat						

11.Bullock /Machine labour used

SL.No	Farm Operation	Bullock/machine labour		Duration (hrs)	Prevailing rate (Rs/acre)	Payment in kind (if any)	Value of Kind payment
		BL	ML				
1							
2							
3							
4							

12. Labour use pattern in paddy cultivation (human labour)

S. No	Particulars	Family labour(hrs)		Hired labour(hrs)		Prevailing wage rate/hrs of work			Contract payment (Rs/acre)	Wage in kind	Value of kind payment
		Men	Women	Men	Women	Hrs of work	Wage rate				
							Men (Rs)	Women (Rs)			
1	Dewatering										
2	Ploughing										
3	Repair of inner bunds										
4	Levelling										
5	Seed Preparation										
6	Sowing										
7	Gap filling										
8	Application of soil ameliorants										
9	Manure application										
10	Fertilizer application										
	a) I application										
	B II application										
	c) III application										
11	Weed control										
12	Pest control operations										
13	Water management										
14	Harvesting										
15	Post harvest operations a) Threshing b) Winnowing										
16	Marketing										

Inputs used	Time of application (DAS)	Source of purchase	Quantity applied		Rate	Subsidies if any		Transportation cost	Other expenses If any
			Unit	Quantity		Rate/unit	Total amount		
1 Seed									
2 Manures									
3. Fertilizers 3.I application 1.Urea 2.SSP 3.MOP 4.Complex									
3.2) II application 1.Urea 2.SSP 3.MOP 4.Complex fertilizers									
3.3) III application 1.Urea 2.SSP 3.MOP 4.complex									
4) Soil ameliorants 4.1 Lime 4.2 Calcium carbonate									
5.Weedicides 5.1 5.2 5.3									
6.Insecticides/fungicides 6.1 6.2 6.3 6.4 6.5									

14.Pest control measures adopted

SL.No.	Stage of the crop (DAS)	Type of infestation	Method adopted	Material cost involved(except chemical pesticides)	
				Material	Cost (Rs)
1					
2					
3					
4					
5					

15.Pesticide use pattern in paddy crop

Application no. (1)	Period/stage of the crop (DAS) (2)	Type of infestation # (3)	Pesticide used ## (4)	Perceived toxicity ### (5)	Quantity used (6)	Quantity of water used (7)

(Rice stem borer 2. Gall midge 3.Rice bug 4.Leaf folder, 5.BPH, 6.Rice case worm, 7.Rice swarming caterpillar, 8.Rice hopper, 9.Rice thrips, 10.Whorl maggot, 11.Leaf hopper, and 12. Rice mealy bug, 13.Rice root nematode, 14.Rice cyst nematode, 15.Blast, 16.Brown spot, 17.Narrow brown leaf spot, 18.Sheath blight, 19.Stalkburn, 20.Leaf scald, 21.BLB, 22.Black leaf streak, 23.Foot rot, 24.Sheath rot, 25.Viral diseases, 26.Tungro 27.yellow dwarf28.grassery stunt29. Ragger stunt, 30.False smut31.udbatta, 32.others specify 33.Prophelyctic

##1.2,4,D 2.Dimecran, 3.Ekulex, 4.Metacid, 5.Nuvacron, 6.Bavistin, 7.Hinosan, and 8.others specify

1. Low 2. medium.3. High

16. Yield and Product use pattern

SL.no	Item	Output (Kg)	Qty given as wages (Kg)	Home consumption (Kg)	Seed purpose (Kg)	Quantity Sold (Kg)	Others(Specify) (Kg)
1.	Grain						
2	Straw						

17.Marketing particulars

Item	Method (code)	Price (Rs/Kg)	Marketing cost if any (Rs)
1.Grain			
2.Straw			

1 Co-op society 2. Private party 3. Local market

18.Other information

1) What was your motivation to adopt IPM?

2) Have you undergone any training in IPM? Yes/No

If yes, a) Duration. (Days)
b) Organized by

3) Do you think IPM adoption reduces crop yield than chemical approach? Yes/No

If yes by how much
1)<10% 2)10-20% 3)20-30% 4)30-40% 5)40-50% 6)>50%

4) In your assessment how many years will it take for the yield to get stabilized after the adoption of IPM?
1) 2 yrs 2) 2-4 yrs 3) 4-6 yrs 4) >6 yrs

5) What was the average yield of paddy in your field before the adoption of IPM?

6) Have you experienced any fall in the crop yield after the adoption of IPM? Yes/No

If yes give the details

Crop	% Of Fall in yield
I Crop	
II Crop	
III Crop	
IV Crop	

7). How much, in your estimate is the

1. Cost of production of paddy
2. Cost of cultivation of paddy

8) Do you think that there is reduction in the total cost of cultivation if IPM is followed? Yes/ No

If yes by how much

1). 10% 2).10-20% 3).20% 4)20-30% 5)30-40% 6)>40%

9) When you decide to apply the pesticide, what is the basis for selection of the same?

1.Consulting krishibhavan
2.Deciding your self
3.The dealer suggests
4.Company representative's suggestion
5.Friend's suggestion
6.Applicator Suggested
7.Any other (specify)
8.Consulting research station

10). Are you aware that the chemical pesticides cause many adverse effects on the environment? Yes/No

If yes, what are they?

1.
2.
3.

11). In your opinion what are the important problems in the adoption of IPM practice?

12) How do you rate the performance of Department of Agriculture with respect to the dissemination of IPM technology?

1.Excellent 2.Satisfactory 3.poor 4.Inefficient

13) What are the best methods to popularize IPM?

1.
2.
3.

Appendix III
Department of Agricultural Economics
College of Horticulture
Vellanikkara
Integrated Pest Management in Paddy Production- Resource Use Efficiency and Relative Economics

Interview schedule (For Non-IPM farms)

1.Name of the Krishibhavan

2. Name of the *padasekharam*

3.Name of the respondent

5. Landmark for identification

4.Address

6.Household information

S.No	Relation with head (code)	Sex	Age in years	Education	Primary occupation
1					
2					
3					
4					
5					
6					
7					

Sex: 1.Male 2. Female
Education: 1.No schooling; 2.Primary school; 3.Middle school; 4.Secondary; 5.Higher secondary 6.Graduate; 7.Post Graduate; 8.Others (specify)
Occupation: 1.Agriculture 2.Government employee; 3.Private employee; 4.Own business; 5.Agricultural labourer; 6.Non agricultural Labourer; 7.Not working; 8.House wife; 9.Student
Relation with head: 1.Head 2.wife 3. Son 4.Daughter 4.Son in law 6.Daughter in law 7.Sister 8.Brother 9.Grandson 10.GrandDaughter 11.Others

7
Land particulars (acres)

Sl.No	Particulars	Wetland	Garden land	Dry land	Total
1	Area owned				
2	Area leased in				
3	Area leased out				
4	Net sown area				
5	Area sown more than once				
6	Net irrigated area				

8 Details of the land under study

Sl.No	Crop season	Year	Area (acres)	Variety sown	Period under IPM	
					No. of seasons	Years(Number)

9. Implements and machinery owned by the farmer

S.No	Particulars of the machinery/implement	Number	Year of purchase	Subsidy if any(Rs/unit)	Original value	Present value	Whether used in paddy cultivation

10. Live stock owned by the farmer

Type	Number	Breed	Year of purchase	Age in years	Value at present	Whether used in paddy cultivation
1. Bullock 2. He buffaloes 3. Shebuffaloes 4. Cows 5. Goat						

11. Bullock /Machine labour used

SL.No	Farm Operation	Bullock/machine labour		Duration (hrs)	Prevailing rate (Rs/acre)	Payment in kind (if any)	Value of Kind payment
		BL	ML				
1							
2							
3							
4							

12. Labour use pattern in paddy cultivation (human labour)

S. No	Particulars	Family labour(hrs)		Hired labour(hrs)		Prevailing wage rate/hrs of work			Contract payment (Rs/acre)	Wage in kind	Value of kind payment
		Men	Women	Men	Women	Hrs of work	Wage rate				
							Men (Rs)	Women (Rs)			
1	Dewatering										
2	Ploughing										
3	Repair of inner bunds										
4	Levelling										
5	Seed Preparation										
6	Sowing										
7	Gap filling										
8	Application of soil ameliorants										
9	Manure application										
10	Fertilizer application										
	a) I application										
	B II application										
	c) III application										
11	Weed control										
12	Pest control operations										
13	Water management										
14	Harvesting										
15	Post harvest operations a) Threshing b) Winnowing										
16	Marketing										

Inputs used	Time of application (DAS)	Source of purchase	Quantity applied		Rate	Subsidies if any		Transportation cost	Other expenses If any
			Unit	Quantity		Rate/unit	Total amount		
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2.Manures									
3. Fertilizers 3.1 application 1.Urea 2.SSP 3.MOP 4.Complex									
3.2) II application 1.Urea 2.SSP 3.MOP 4.Complex fertilizers									
3.3) III application 1.Urea 2.SSP 3.MOP 4.complex									
4) Soil ameliorants 4.1 Lime 4.2 Calcium carbonate									
5.Weedicides 5.1 5.2 5.3									
6.Insecticides/fungicides 6.1 6.2 6.3 6.4 6.5									

14.Pest control measures adopted

SL.No.	Stage of the crop (DAS)	Type of infestation	Method adopted	Material cost involved(except chemical pesticides)	
				Material	Cost (Rs)
1					
2					
3					
4					
5					

15.Pesticide use pattern in paddy crop

Application no. (1)	Period/stage of the crop (DAS) (2)	Type of infestation # (3)	Pesticide used ## (4)	Perceived toxicity ### (5)	Quantity used (6)	Quantity of water used (7)

(Rice stem borer 2. Gall midge 3.Rice bug 4.Leaf folder, 5.BPH, 6.Rice case worm, 7.Rice swarming caterpillar, 8.Rice hopper, 9.Rice thrips, 10.Whorl maggot, 11.Leaf hopper, and 12. Rice mealy bug, 13.Rice root nematode, 14.Rice cyst nematode, 15.Blast, 16.Brown spot, 17.Narrow brown leaf spot, 18.Sheath blight, 19.Stalkburn, 20.Leaf scald, 21.BLB, 22.Black leaf streak, 23.Foot rot, 24.Sheath rot, 25.Viral diseases, 26.Tungro 27.yellow dwarf28.grassery stunt29. Ragger stunt, 30.False smut31.udbatta, 32.others specify 33.Prophelyctic

##1.2,4,D 2.Dimecran, 3.Ekulex, 4.Metacid, 5.Nuvacron, 6.Bavistin, 7.Hinosan, and 8.others specify

1. Low 2. medium 3. High

16. Yield and Product use pattern

SL.no	Item	Output (Kg)	Qty given as wages (Kg)	Home consumption (Kg)	Seed purpose (Kg)	Quantity Sold (Kg)	Others(Specify) (Kg)
1.	Grain						
2	Straw						

17. Marketing particulars

Item	Method (code)	Price (Rs/Kg)	Marketing cost if any (Rs)
1. Grain			
2. Straw			

1 Co-op society 2. Private party 3. Local market

18) **Other information**

1) Have you undergone any training in IPM? Yes/No

If yes, a) Duration. (Days)
b) Organized by

2) Do you think IPM adoption reduces crop yield than chemical approach? Yes/No

If yes by how much

1)<10% 2)10-20% 3)20-30% 4)30-40% 5)40-50% 6)>50%

3) In your assessment how many years will it take for the yield to get stabilized after the [illegible]

1) 2 yrs 2) 2-4 yrs 3) 4-6 yrs 4) >6 yrs

4) How much, in your estimate is the

1. Cost of production of paddy
2. Cost of cultivation of paddy

5) Do you think that there is reduction in the total cost of cultivation if IPM is followed? Yes/ No

If yes by how much

1). 10% 2).10-20% 3).20% 4)20-30% 5)30-40% 6)>40%

6) When you decide to apply the pesticide, what is the basis for selection of the same?

1.Consulting krishibhavan
2.Deciding your self
3.The dealer suggests
4.Company representative's suggestion
5.Friend's suggestion
6.Applicator Suggested
7.Any other (specify)
8.Consulting research station

7). Are you aware that the chemical pesticides cause many adverse effects on the environment? Yes/No

If yes, what are they?

1.
2.
3.

8). In your opinion what are the important problems in the adoption of IPM practice?

9) How do you rate the performance of Department of Agriculture with respect to the dissemination of IPM technology?

1.Excellent 2.Satisfactory 3.poor 4.Inefficient

10) What are the best methods to popularize IPM?

1.
2.
3.

Appendix IV

Table 4.4.2 Input wise Cost of Cultivation in Paddy Production in Kuttanad

(Rs Per hectare)

S.No	Particulars	Non-IPM	IPM
1	Hired Human Labour	9420 (29.87)	9966 (33.40)
2	Hired Machine Labour	1571 (4.98)	1523 (5.10)
3	Seeds	1060 (3.36)	845 (2.83)
4	Inorganic Nutrients	2500 (7.93)	1915 (6.42)
5	Plant protection chemicals	2953 (9.36)	1053 (3.53)
6	IPM Practices (material cost)	0 (0.00)	649 (2.17)
7	Land Revenue	30 (0.10)	30 (0.10)
8	Interest on working capital	531 (1.68)	488 (1.64)
	Cost A_1	18064 (57.28)	16469 (55.19)
9	Rent on leased in land	1205 (3.82)	1339 (4.49)
	Cost A_2	19269 (61.10)	17808 (59.68)
	Cost B_1	18064 (57.28)	16469 (55.19)
10	Rental value of own land	8170 (25.91)	8036 (26.93)
	Cost B_2	27439 (87.01)	25844 (86.61)
11	Imputed value of family Labour	1230 (3.90)	1284 (4.49)
	Cost C_1	19294 (61.18)	17753 (59.49)
	Cost C_2	28669 (90.91)	27128 (90.91)
12	Imputed value of management Input (10%of Cost C2)	2867 (9.09)	2713 (9.09)
	Cost C3	31536 (100.00)	29841 (100.00)

*Figures in parenthesis denotes percentages to total

INTEGRATED PEST MANAGEMENT IN RICE PRODUCTION: RESOURCE USE EFFICIENCY AND RELATIVE ECONOMICS

By

SAIJYOTHI. D

ABSTRACT OF THE THESIS

submitted in partial fulfilment of the requirement for the degree of

Master of Science in Agriculture

(AGRICULTURAL ECONOMICS)

Faculty of Agriculture

Kerala Agricultural University, Thrissur

Department of Agricultural Economics

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

2005

ABSTRACT

The present study entitled **Integrated Pest Management in rice production: resource use efficiency and relative economics**, was conducted in Kuttanad region of Kerala, India with the specific objectives of evaluating the economics of IPM technology over the traditional practice and to assess the resource use efficiency. The study pertaining to the summer crop in the area (November 2004 to February 2005) was undertaken during March to July 2005

A sample of 70 farmers each from IPM and Non-IPM category were selected by conducting a preliminary survey to categorise the farmers under each group. The production details of paddy were gathered from both the groups using a pretested structured questionnaire by personal interview method.

The management under IPM programme starts from the very beginning of the crop calendar, starting with the varietal selection, its source, seed rate and method of planting. Though both types of farms were sowing only recommended varieties, seed rate was much above the recommended level in the case of non IPM group and they primarily relied on farm saved seeds. It was the reverse in the case of IPM farms. The level of application of fertilizers and soil ameliorants was lower in the case of IPM farms. Among the various inputs in crop production, labour was the most important single item of expenditure in paddy production. The total labour use in IPM farms was found to be 75 man-days per hectare i.e., 5.63 per cent higher than that of Non-IPM farms (71 man days per hectare). This is primarily due to the additional labour required in IPM farms for weeding (due to lesser amount of weedicide use), land preparation (additional ploughing), harvesting (higher yield) and IPM measures.

Thus the total expenditure on seeds and sowing, fertilizer application and plant protection charges were 67.15 per cent higher in the Non-IPM group. Contrary to this, the expenditure on land preparation, weeding and harvesting

operations together, were 11.93 per cent higher in IPM group. Total cost of cultivation was estimated as 5.07 per cent higher in Non-IPM group (Rs31536/ha) compared to IPM group (Rs 29841/ha)

Apart from the cost saving, relatively higher yield (45.23 quintals per hectare) was also there in IPM farms compared to the other group.(44.46 quintals per hectare). The partial budgeting analysis have revealed that the cost saving coupled with higher yield realization in IPM farms has resulted in an additional net private gain in income to the tune of Rs 2824 per hectare

Benefit cost ratio at Cost A_1 was estimated as 1.85 (Non-IPM) and it was 2.06 for IPM farms inferring rice cultivation under IPM, as more beneficial than chemical based cultivation. At cost C_3 level, the non IPM groups were more prone to risk as the BC Ratio was very close to unity

Cobb-Douglas production function was fitted to assess the efficiency of resource use in paddy cultivation for both IPM and Non-IPM farms. It could be concluded that IPM farms were economically more efficient in resource utilization than the Non-IPM counter parts.

Though most of the farmers were aware of the potential hazards of excessive chemical use in agriculture, and got exposed to adequate training, the spread of the technology is constrained by factors like, the perception of a yield loss, difficulties in water management and labour problems. But those who have adopted the technology was found to be aware of the short-term nature of yield reduction and cost saving aspects of the technology.

The policy suggestions are made based on the findings and future line of work is also suggested.