An Economic Analysis of Biopesticide Use in Paddy Farms of Kerala

By

NEETHU THOMAS, B.Sc., (Agri.)
(ID. No. 13-502-007)

DEPARTMENT OF AGRICULTURAL ECONOMICS
TAMIL NADU AGRICULTURAL UNIVERSITY
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CERTIFICATE

This is to certify that the thesis entitled " AN ECONOMIC ANALYSIS OF BIOPESTICIDE USE IN PADDY FARMS OF KERALA" submitted in part fulfillment of the requirement for the degree of **MASTER OF SCIENCE (AGRICULTURE) IN AGRICULTURAL ECONOMICS**, to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out by **Ms. NEETHU THOMAS,** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship of other similar titles and that the work has not been published in part of full in any scientific or popular journal or magazine.

Place: Coimbatore **Dr. M.THILAGAVATHI**

Date: 11.06.2015 **(Chairman)**

Approved by

Chairman : (Dr. M.THILAGAVATHI)

Members : (Dr. K. R. ASHOK)

(Dr.T. RAGUCHANDER)

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ABSTRACT

AN ECONOMIC ANALYSIS OF BIOPESTICIDES USE IN PADDY FARMS OF KERALA

By

NEETHU THOMAS

Degree	**:**	**MASTER OF SCIENCE (AGRICULTURE) IN AGRICULTURAL ECONOMICS**
Chairman	**:**	**Dr. M. Thilagavathi** Professor, Department of Agricultural Economics, Agricultural college and Research Institute, Coimbatore-03
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The increased public concerns about the potential adverse environmental effects and health effects associated with the use of synthetic plant protection and production agrochemicals prompted search for the technologies and products based on biological processes to control the pests. Pesticide residues in agricultural commodities are being the issue of major concern besides their harmful effect upon human life, wild life and other flora and fauna. Equally worrying thing is about development of resistance in pest to pesticides. The only solution of all these is use of ‘Biopesticides’. More chemicals are used to protect crops in Kuttanad against the pest and diseases. The studies conducted by volunteer groups revealed that increased incidences of cancer in the Kuttanadu region is attributed to the high chemical usage in the crop production. So Government of Kerala is promoting the use of biopesticides. So it is crucial to assess the economic impact of biopesticide use on paddy farms of Kerala. The specific objectives of the study were i) to study the effect of biopesticide use on productivity, pesticide use and cost of cultivation of paddy farmers; ii) to study the level of awareness and adoption of biopesticides in paddy cultivation; iii) to analyse the environmental benefits of biopesticides, with special reference to *Pseudomonas*

fluorescens and *Trichogramma sp*.; iv) to understand the constraints in adoption of Biopesticides and to suggest policy measures to enhance the adoption of biopesticides.

Alappuzha district was purposively selected for the study as it is a major rice growing area often referred as “Rice bowl of Kerala”. Out of the fourteen districts, Alappuzha accounts for more than 18 per cent of total paddy production in Kerala during 2012-13. Considering the huge distribution of biopesticides, Alappuzha district was selected purposively for taking up a research study on economic analysis of Biopesticides use in paddy. Three stage purposive sampling method was used in the selection of study district, blocks and villages for the study. The criterias, area under paddy, awareness and usage of biopesticides for more than 4 years were used in the selection of study district, blocks and villages. The sample respondents i.e., the farmers who applied *Pseudomonas fluorescens* and Tricho cards (adopters) and others (non- adopters) were selected at random from the selected blocks and villages of the study district. From the selected two villages in each block 30 farmers were selected randomly from each village, comprising of 15 farmers each of adopters and non-adopters. Thus the total sample size was 120.

The comparative economics of paddy production for farmers under adopter category and non-adopter category were analyzed using partial budgeting technique. According to the result of partial budgeting, the adopter farmers were getting a net gain of Rs.10729 per hectare. The positive net gain value indicated the financial viability of biopesticide use in Paddy farms.

The effect of biopesticide use on yield of paddy, cost of cultivation and pesticide use were estimated through ANOVA technique. The result of ANOVA test showed that there were significant difference in yield, cost of cultivation and pesticide use between adopters and non- adopter farm categories of study area.

In order to understand the various socio-economic factors influencing the adoption of biopesticides Logistic regression was used. From the result of Logistic regression, age of the farmer, years of schooling, farm size, extension agency contact and awareness level of farmers were found to be the factors influencing biopesticide adoption decision of the farmers.

One unit increase in age would increase the probability of adoption of biopesticides by 1.09 units. Similarly one unit increase in education level of farmers and their extension agency contact would increase the probability of biopesticide adoption by 1.16 and 1.58 units respectively. One unit increase in awareness level of farmers would increase biopesticide adoption by 2.76 units. But one unit increase in farm size of the farmer would decrease the adoption of biopesticides in paddy cultivation by 0.57 units.

The environmental impact of biopesticide use was studied using Environmental Impact Quotient (EIQ). The average field use EIQ value was 12.01 and 5.15 for farmers under non-adopter and adopter category.The lower EIQ value of the adopter farmers compared to that of non-adopters indicated the environmental benefits of pest management through biopesticides. The high EIQ values of the non-adopter farmers indicated the negative environmental impact of indiscriminate pesticide use.

Through Garrett's ranking technique, the identified major constraints in the adoption of biopesticides in paddy cultivation were unavailability of quality biopesticides in time and short shelf life of biopesticides. The prophylactic action of biopesticides also found to be another major constraint.

The results of the study confirmed the hypothesis that, there were difference in the yield of paddy, cost of cultivation and pesticide use of adopter and non-adopter farmers. The environmental benefits of biopesticide use also confirmed from the result obtained through the study.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Green Revolution is milestone in the history of agriculture. Over the last few decades, intensive and extensive cultivation of high yielding varieties of crops were introduced in India with a motive to increase food grain production resulted that the fivefold increase in food grain production from 51million tonnes during 1960's to 265.57 million tonnes in 2013-14. This agricultural transformation, popularly known as "green revolution", had its impact on natural resources, environment and biodiversity. Intensive cultivation, spread of high-yielding varieties, monoculture and overlapping of cropping seasons have resulted in high incidence of pests and diseases. Increasing crop loss due to pests and diseases had been major constraint in sustaining agricultural productivity and production. The potential yield loss worldwide due to weeds, diseases and pre and post-harvest pests was estimated as 45 per cent (Gwo-Chen Li, 1999). In India, on an average, 38 percent of crop loss occurs due to pests and diseases runs to an estimate loss in value of more than Rs.250 billion further the increasing trend was observed. Pesticides are among the important agro-inputs to minimize the pest damages to crops and there by minimize the yield losses and continued to pay a significant role in enhancing the agricultural production in India. It was estimated that at globally, about 3 billion kgs of pesticide are applied each year with a value of nearly $ 40 billion per year (Pan-UK, 2008). India is the highest consumer of pesticides among the South Asian countries and it was estimated that in India pesticide consumption in 2013-14 was 54685 metric tonnes which was increasing at higher rate from 40672 metric tonnes during the year 2008-09. While the benefits of pesticide use in terms of preventing crop losses and increasing food grain production have been well recognized, its unwanted side effects on human health and environment have become a major concern (Eric Lichtenberg, 2001).The indiscriminate pesticide application led to several problems like pesticide residues in food stuff, environmental pollution, imbalance of ecological equilibrium, and resurgence of minor pests and pathogens.

The first awakening to the danger of pesticides in the West occurred when Rachel Carson's *Silent Spring* was published in 1961. In spite of the concerted efforts of the powerful pesticide lobby to denigrate her, *Silent Spring* remains the greatest classic in the field of environmental conservation. Management of pests will continue to play a pivotal role in sustaining production and productivity in Indian agriculture.

Rice “the queen of cereals” occupies 11 per cent of world’s crop area and is a staple food for above 60 per cent world’s population. Rice is the major crop that receives maximum quantity of fertilizers (40%) and pesticides (17-18%) and these practices pose major challenges in organic rice farming for nutrient and pest management (Sireesha .O,2013).

Overall pesticide use has been declining at a rate of some 1.3 per cent per year over the last decade globally. This decline is attributed to increased concerns about health and environmental effects, the rise in organic agriculture and emergence of alternatives including biopesticides. The increased public concerns about the potential adverse environmental effects and health effects associated with the use of synthetic plant protection and production agrochemicals prompted search for the technologies and products based on biological processes to control the pests. Pesticide residues in agricultural commodities are being the issue of major concern besides their harmful effect upon human life, wild life and other flora and fauna. Equally worrying thing is about development of resistance in pest to pesticides. The only solution of all these is use of 'Biopesticides.

1.1 Biopesticides

The realization of the negative effects of chemicals shifted the focus to more reliable, sustainable and environment friendly agents of pest control - the Bio-pesticides. As a result of increased concern over use of chemical pesticides in agriculture, the biological control of pests and diseases antagonistic micro-organisms remains a viable option for sustainable agriculture. Biological control is known to have a high impact on the management of soil-borne plant pathogens, less dependent on the use of high-risk chemicals and it is eco friendly since it has inherently less harmful and less environmental load also designed to affect only one specific pest or, in some cases, a few target organisms and often effective in very small quantities and often decompose quickly, thereby resulting in lower exposures and largely avoiding the pollution problems. “Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals” (US EPA Pesticides, 2008). The EPA (Environmental Protection Agency) separates biopesticides into three major classes based on the type of active ingredient used, namely microbial, biochemical, or plant incorporated protectants (GMOs). Biochemical pesticides are distinguished from conventional pesticides both by their structure (source) and by their mode of action (mechanism by which they kill or control pests). Also, the area of biopesticides is a) a rapidly growing market, b) raises both optimism and concerns and c) is a critical new issue area for anyone concerned with agriculture. There is a tremendous amount of work and research occurring in this field. Also, it is important to note that biopesticides fall along a spectrum of toxicity. At one end, they are products that are extremely narrow in focus (e.g. targeting a single species in a specific window of its life cycle). At the opposite end are biopesticide products that are wider in effect pyrethroids for example, derived from chrysanthemums, affect a relatively wide range of species and can have unintended toxic collateral effects). When highly specified, biopesticides can be almost utterly benign in their human and environmental effects. When their impact is broader, however, biopesticides raise some of the same human and ecosystem impact concerns that conventional pesticides do. (Karen Peabody et al., 2009).

1.2 Biopesticide use in World and India

The total world production of biopesticides is over 3000 tonnes per year which is increasing at a rapid rate. Worldwide there are around 1400 biopesticides are being sold. In 2005, global biopesticides sales were put at US$ 700 million, equivalent to just 2.5 per cent of the total pesticide market (Gupta and A. K. Dikshit, 2010) which was merely 0.2 per cent during 2000. This share is expected to grow to about 4.2 per cent by 2010. There is a rapid growth in the biopesticides sector with a 5 year annual compound growth rate of 16 per cent compared with 3 per cent for synthetic pesticides and an expected global market worth upto US$10 billion by 2017 (Vaishali Kandpal,2014). The biopesticides market is expected to exhibit an annual growth rate of 2.3 in the coming years (Salma Mazid, 2011) and the growth rate will be forecasted at 10-15 per cent per annum in contrast to 2.5 per cent for chemical pesticides (Vasantharaj David,2008).

1.3 Advantages of Biopesticides

The overwhelming advantages of bio-pesticides are their high selectivity to target pests and safety to non-target and beneficial organisms. In the sustainable intensification of agriculture through green economy, the bio-pesticides have an immense role. They can be tailored to IPM programmes for increased efficacy, higher yield and lower chemical load. The biopesticide development must also be targeted for integrated cropping systems. Several Presidential Green Chemistry Challenge Awards have been given for innovations in biopesticides (Karen Peabody, et al, 2009). The BCC reports indicate that in India, most pesticide / chemicals are used in the field crops like cotton (55%) followed by rice (22%). Since rice is an important staple food crop in Asia particularly in India, due to major health and environmental concerns importance was given to research on bio pesticides. The research studies revealed that a maximum of 62.10 per cent reduction in sheath blight and 47.7–56.1 per cent reduction in leaf folder incidence was noticed due to usage of the biopesticide *Pseudomonas fluorescens*. In India so far 12 types of biopesticides have been registered under Insecticide Act 1968.

They are renewable, sustainable, offer an improved impact profile, and reduce pesticide residues (NAAS, 2013). Biopesticides are best alternatives to conventional pesticides and usually inherently less toxic than conventional pesticides. Benefits of biopesticides include effective control of insects, plant diseases and weeds as well as human and environmental safety. Biopesticides play an important role in providing pest management tools in areas where pesticide resistance, niche markets and environmental concerns limit the use of chemical pesticide products (Nirakar Ranasingh, 2007). Demand for residue free crop produce is one of the key drivers of the biopesticide market. Growing organic food market and easier registration than chemical pesticides are other important driving factors for the growing biopesticides market (Kumar, 2012).

1.4 Challenges of Biopesticides

There are also some general challenges with use of biopesticides. They tend to be more slow-acting and may be very specific to the life cycle of the pest. Other attributes such as persistence in the environment have both a benefit and challenge that must be balanced. For example, a biopesticide that degrades very quickly in the environment (benefit) may also have a short shelf life or limited field persistence requiring multiple applications. Having a narrow target range and very specific mode of action can be seen as both a benefit and a challenge. While one benefit of specificity is lower impact on non-target species, one challenge is that control of the dominant pests on a given crop may require more than one product and may be more costly. Also as noted, biopesticides fall on a continuum of breadth of specificity: some active ingredients are highly specific to a particular organism at a particular window of opportunity; others have a broader mode of action.

Negative public reactions to biopesticides have been due to a lack of transparency about inert ingredients used in a product, as well as to negative side effects of some broader spectrum biopesticides on non-target species. (Karen Peabody et al, 2009).

1.5 Problem Focus

Pesticide use in India dates back to the year 1948 when DDT and BHC were imported for malaria and locust control. Currently, India is the number one manufacturer of basic pesticides in Asia and ranks 12^{th} globally. Among the predominant classes of pesticides used in India are insecticides, which accounts for 75 per cent of total consumption, followed by fungicides (at 12 per cent) and herbicides (at 10 per cent). Furthermore, in India, 54 per cent of the total quantity of pesticides used in cotton, with 17 per cent in rice and 13 per cent in vegetables and fruits. Chemical pesticide residues have often been detected in food grains, vegetables, fruits, oils, cattle feed and fodder in most parts of the country.

Pesticide poisoning in Kerala has a long history. The State became the focus of interest and research in 1958 following the death of more than 100 people who had consumed wheat flour that had been contaminated with pesticides during transportation. Pesticides used in the food crops in the state include chemicals which are banned for sale in Kerala (Endosulfan), banned for use in fruits/vegetables (Monocrotophos) and those permitted for restricted use only (Methyl Parathion, Lindane and Methoxy Ethyl Mercury Chloride). Many of the chemicals that are banned/not approved in many other countries and belong to the PAN Bad Actor Chemical group (Mancozeb, Carbendazim, Paraquat, Lambda Cyhalothrine, Diuron, quinalphos) were used by the farmers in Kerala state (Annexure 1). In contrast to the national pattern, however, the fungicide use in Kerala is much higher (at 57%) when compared with the use of insecticides. (Indira Devi. P., 2007).

More chemicals are used to protect crops in Kuttanad against the pest stem borer, brown plant hopper, the rice bug and leaf folder. Spraying is done with a knapsack sprayer and is generally not supervised. Crucially, the dose of the spray fluid used is much higher than the recommended level.

There are so many health problems associated with the indiscriminate use of pesticides. Skin problems are the most common problem linked to pesticide use in Kuttanad, itching, eye-irritation and vision problems are also very common. The studies by volunteer groups revealed that increased incidences of cancer in the Kuttanadu region is attributed to the high chemical usage in the crop production. Taking all these issues into consideration the Government of Kerala is promoting the use of biopesticides in crop production. The State biocontrol lab, Mannuthy has supplied more than 90 tonnes of biopesticides in the state. Besides that, there are so many private suppliers, NGOs, KVKs and research stations are involving in the supply of biopesticides. As far as Kerala is concerned, coconut and rice are the major crops and Pseudomonas and Trichogramma are the major biopesticides used widely. These biopesticides are widely used in the production of Rice, Vegetables, Banana and Pepper also. The farmer’s awareness and adoption of biopesticides are yet to be motivated for maximizing gains. Under these circumstances, the study on economic analysis of biopesticide use in paddy farms of Kerala was proposed with the following objectives.

1.6 Objectives

The broad objective of the study is to assess the effect of biopesticides on crop yield and pesticide use and its environmental benefits in rice farms of Kerala state. The specific objectives of the study are,

1. to study the effect of biopesticide adoption level on productivity , pesticide use and cost of cultivation of paddy farmers,
2. to study the level of awareness and adoption of biopesticides in paddy cultivation
3. to analyse the environmental benefits of biopesticides, with special reference to *Pseudomonas fluorescens* and *Trichogramma sp.* in paddy cultivation; and
4. to understand the constraints in adoption of biopesticides and to suggest policy measures to enhance the adoption of biopesticides.

1.7 Hypothesis

In order to achieve the objectives the following hypothesis was formulated:

The biopesticides are having more beneficial effects than chemical pesticides in terms of productivity of crop, cost of cultivation and environmental sustainability.

1.8 Scope of the Study

Biopesticides such as Pseudomonas and Trichogramma, as a viable intervention to solve the problems of chemical pesticides have drawn attention now a day. Aim of this intervention is to reduce the chemical load in agriculture, thereby stabilize the ecological and environmental balance. Indiscriminate use of Pesticides poses a threat to mankind. In this context, the present study aims to analyze the environmental and economic benefits of the biopesticides use. The study also looks at the important factors that influence adoption decision. This study analyses the awareness level of the farmers about the beneficial effects of biopesticides use. A socio-economic analysis of a new intervention will give an idea about the viability of such an intervention. The outcome of the study would be useful for policy makers, students, extension workers, NGOs and developmental agencies for further expansion of the area under biopesticides use and thereby promoting organic production of crops.

1.9 Limitations of the Study

Due to time and financial constraints, the study area was confined to a limited geographical area. As the farmers did not maintain any records regarding their work, income and expenditures, they had to recollect from their memory and hence there is a possibility for recall bias. However, additional efforts were taken to minimize the recall bias through cross check questions while designing the interview schedule. The results of the study is subject to these perplexes. However, adequate efforts have been taken to collect reliable data with the help of well-structured interview schedule.

1.10 Organization of the Thesis

The study is organized in the following chapters.

Chapter I Introduction: It includes introduction, problem focus, hypothesis, objectives, scope and limitations of the present study.

Chapter II Concepts and Review: In this chapter, a detailed review of important concepts used in the study along with a brief review of related past studies are presented.

Chapter III Design of the Study: It specifies the sampling design, method of investigation and tools of analysis used in the conduct of research and analyzing the data.

Chapter IV Description of Study Area: In this chapter, description of the study area showing geographical features, biological importance and socio economic features are presented.

Chapter V Results and Discussion: The results obtained in the study are presented and discussed along with the inferences drawn.

Chapter VI Summary and Conclusion: It summarizes the findings and policy implications drawn from the findings.

CHAPTER II

CONCEPTS AND REVIEW

Review of related concepts and past studies will help in analysing and understanding the current problem in a proper perspective. For better and clear understanding of concepts, one needs to be aware of what they actually refer to and how various economists have preferred to look at it. Moreover review of related concepts and past studies will give us a holistic picture and would facilitate the focus of analysis and drawing inferences. In this chapter, a review of concepts, theories, methodologies and empirical findings were reviewed and presented under the following headings.

2.1. Review of Concepts

2.1.1 Production

2.1.2 Productivity

2.1.3 Fixed cost

2.1.4 Variable cost

2.1.5 Income

2.1.6 Net income

2.1.7 Pesticides

2.1.8 Biopesticides

2.1.9 Awareness

2.1.10 Adoption

2.2. Review of methodologies and past findings

2.2.1 Impact of pesticide use

2.2.2 Economics of pesticide use

2.2.3 Uses of Biopesticides

2.2.4 Effect of Pseudomonas on crop production

2.2.5 Analysis of Variance

2.2.6 Environmental Impact Quotient

2.2.7 Socio-Economic factors influencing adoption

2.2.8 Awareness level of farmers

2.2.9 Logistic regression

2.1. Review of Concepts

2.1.1 Production

According to Bhanage (1962) production in economics is any activity directed towards the satisfaction of other peoples want through exchange.

Nerin (1971) expressed production as the application of land, labour, capital and enterprise to the creation of new wealth.

In Hansens' view, (1972) production covers the activities of changing the form of a good at any stage from the raw material to finished product, changing the situation of a good, changing the position of a good in times and provision of some kind of services such as retailing, banking and entertaining etc.,

Chopra (1982) quoted production as a physical process in which quantities of raw materials and labour were transformed into quantities of output.

According to Dewett (1982) production is creation of utility (or) creation of want satisfying goods and services.

Sadhu and Singh (1985) observed production as a process, where in certain goods and services are used to create goods and services of different nature.

Pandey and Mithani (1990) stated production as the creation of output or goods and services and considered as essential means of transformation of one set of goods into another.

According to Nallusamy (1994) production is considered as the conversion of certain inputs or resources or factors of production into a usable form.

Johl and Kapur (1996) viewed production as a process of transformation of certain resources (or) inputs like land, labour, seeds, fertilizers, and Irrigation water into products like wheat, paddy and milk.

According to Ahuja (1997) production in economics was not merely confined to effecting physical transformation but also covered the rendering of services such as transporting, wholesaling and retailing.

Dewett and Chand (2001) defined production as the transformation of inputs to outputs.

Palalanisami *et.al.*, (2002) defined production as the process of combining resources, both implicit, and explicit, in the creation of goods or services or output.

Koutsoyiannis (2004) observed that production would indicate combination of factors needed for producing one unit of output.

Rajender Singh (2006) defined production as the process through which semifinished products or raw materials are converted to finished products.

Food and Agriculture Organization (2010) defined production as quantities of commodities harvested from the field or orchard and gardens excluding harvesting and threshing losses. Production therefore includes the quantities of the commodity sold in the market.

David, L. Debertin (2012) defined production as the process through which inputs (resources) transform to outputs (commodities).

In the present study, production is defined as a process of transformation of certain resources available with the farmers into products like paddy.

2.1.2 Productivity

Acharya and Nair (1978) described productivity as the contribution of all inputs that could be combined in some composite fashion.

According to Gowar (1980) productivity would indicate the efficiency with which the inputs are transformed into output.

Singh (1980) described productivity as an outflow per unit of resource, which is an outcome of the interaction of the mutually reinforcing forces of agrarian structure, resource endowment and technology.

Samuelson and Nardhans (1998) defined productivity as a concept measuring the ratio of total output to a weighted average of inputs.

Reddy *et.al*., (2004) defined Productivity as the efficiency with which various inputs are converted into outputs.

Mark Johnston (2007) said that agricultural productivity is the term given to the output per unit area of agriculture in terms of the inputs such as the capital and labour.

Dineshkumar (2008) stated that crop productivity as the quantitative production of a crop in terms of its main produce per unit land area and usually expressed as kilo gram or tons per hectare.

According to Julie parson (2010), productivity is the output per unit of input, usually measured either by labour productivity or total factor productivity.

Mankiw (2011) defined productivity as the quantity of goods and services produced from each unit of input.

According to Adam Jurd (2011), productivity is the ratio of the output to input.

Chad Syverson (2011) defined productivity as efficiency in production: how much output is obtained from a given set of inputs. It is typically expressed as output-input ratio.

In the present study productivity is defined as the quantity of paddy produced per hectare by the sample farmers.

2.1.3 Fixed cost

Sujit (2005) defined fixed costs are the costs that do not change as the output changes. These are independent of output and are fixed amount which must be incurred by a farm, in short run, whether the output is small or large.

Talathi and Naik (2008) defined fixed costs as those which do not vary with level of production. They classified fixed cost into fixed cash costs and fixed non cash costs.

Mankiw (2011) defined fixed costs are the costs that do not vary with the quantity of output produced.

According to William and Michael (2012), fixed costs are the payments to resources whose quantities cannot be changed during fixed period of time i.e. in short run.

Andrew and Paul (2013) defined fixed costs are costs that do not vary with level of production. They explained fixed costs are payments to factors such as land or machines that are fixed in quantities in the short run.

In the present study, fixed costs are defined as it is the payment to the fixed factors such as machine, land and permanent worker in the study area.

2.1.4 Variable cost

Sujit (2005) defined variable costs are the costs which are of recurring type and have to be incurred in every production period.

Talathi and Naik (2008) defined variable costs as those do vary with the level of production. These costs are of using the variable inputs. They do not occur when we produce nothing.

Mankiw (2011) stated variable costs as the cost vary with the quantity of output produced.

William J. Boyes and Michael Melvin (2012) mentioned variable costs are the payments for additional resources used as output increases.

Andrew and Paul (2013) defined variable cost as the cost of inputs that vary with the level of output. Author explains variable costs are payments to factors whose quantity may change in the short run. Chemicals, Labour and fuel are included in this category.

In the present study the variable cost is defined as the cost vary with level of output. The variable costs include the cost to variable inputs like seeds, chemicals, labour and fertilizer for the rice production in the study area.

2.1.5 Income

Mani (1982) defined farm income refers to income generated from sale of crop, livestock, livestock products, farm yard manure, services of farm equipment, bullock labour and non-farm income from such sources as services.

Murugadass (1990) defined gross income as the realization made by the sale of the produce and net income as the residue of gross income after deducting the cost of cultivation.

Jeyakumar (1999) conceptualized income as the sum total of income received by all members of the family working in different categories or the same kind of work. The source of income included farm, non-farm and any assistance from government programme.

Madan and Varghese (2005) defined gross returns as sum of value of main product and value of byproduct of crop. The net income is gross income minus total cost.

Thakur and Sharma (2005) defined net activities income/profit as gross income minus total cost.

Sefton and Weale (2006) defined income as the maximum amount a man can spend and still be as well off at the end of the week as at the beginning.

According to Craig, K.E (2014) income includes earnings, interest accrued, dividends from investments, pensions, social security benefits etc.

In the present study the income is defined as the total of income received through different sources like on farm, nonfarm and off farm of the sample farmers in study area.

2.1.6 Net income

Waghmane and Mandal (1972) defined net income as either net profit or net loss to the operator of land after (both in kind and cash) making provision for the depreciation charges, land rent, interest on working capital, imputed wage on family labour from the total income of the farm.

Singh *et.al.,* (1973) defined net income of the farm, as the gross income less variable cost of farm business as a whole.

According to Maurya *et.al.,* (1996) the net income would indicate the difference between input cost and output price.

Mandal (1996) arrived at the net return by deducting from the value of output all costs with the exception of family labour imputed at the market wage.

Singh *et.al.*, (2000) stated that the net income was the return pertaining to all factors of production over and above all charges for such factors in the cost analysis.

Thakur and Sharma (2005), while studying organic farming for sustainable agriculture, defined net activities income or profit as gross income minus total cost.

Smitha (2006) stated that net return as gross return minus total cost incurred in the production process.

According to Kayalvizhi (2011) net return is the difference between gross income and total cost of production.

For the present study, the net income is conceptualized as the gross income minus total cost incurred in production. The total cost included both fixed costs and variable costs.

2.1.7 Pesticides

According to Balder Singh *et.al*., (1974) Pesticide was a term used in general for the products, synthetic or natural, utilized for control of insect pests, fungi, bacteria, weeds, nematodes and rodents. It can also be used as growth regulators and defoliants.

Bhat (1985) defined pesticides as chemical or mixture of chemicals used for killing, repelling, integrating, phasing or even regulating with a view to minimize the damage by pests to the crops.

Natarajan (1985) referred pesticides as the substances which kill plant and animal species by their chemical action. Pesticides included insecticides, nematicides, fungicides, herbicides, acaricides and rodenticides.

Chattopadhyay (1991) defined pesticides as substances used to control pests and pesticides include insecticides, fungicides, weedicides, acaricides, nematicides and rodenticides.

Waxman (1998) defined pesticide as any substance used for controlling, preventing, destroying, repelling or mitigating any pest.

Muir (2002) defined pesticide as any substance or mixture of substances intended for preventing, destroying, or controlling any pest including vectors of human or animal diseases, unwanted species of plants or animals, causing harm or interfering with production, processing, storage or marketing of food, agricultural commodities and animal feedstuffs.

Milan Jokanovic (2012) defined pesticide as any chemical that kills, controls, driven away or modifies the behaviour of pest.

Lance Ching (2013) defined pesticide as any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest.

2.1.8 Biopesticides

United States Environmental Protection Agency (2008) defines biopesticides as pesticides derived from natural materials such as animals, plants, bacteria and minerals.

Karen Peabody *et.al.,* (2009) define biopesticides as a set of tools and applications that will help farmers transition away from highly toxic conventional chemical pesticides into an era of truly sustainable agriculture. They were of the opinion, bacterial biopesticides are the most common form of Biopesticides. More than 80 per cent of the biopesticides are used by the producers employing conventional farming practices.

Alastair Bailey *et.al.,* (2010) defined biopesticides as mass produced biologically based agent manufactured from living micro-organisms or a natural product and which is sold for the control of plant pests. The agents used as biopesticides are usually broken down into three categories such as micro-organisms (bacteria, fungi, oomycetes, viruses, protozoa), bio chemicals (essential oil, chitin, chitosan), semio-chemicals (insect pheromone).

Salma Mazid *et.al*., (2011) defined biopesticides as biochemical pesticides that are naturally occurring substances that control pest by non-toxic mechanisms. Biopesticides are living organisms or their products or by-products which can be used for the management of pests that are injurious to plants.

Kumar (2012) defined biopesticides as formulation made from naturally occurring substances that controls pest by non-toxic mechanisms and in eco-friendly manner.

2.1.9 Awareness

Rogers and Shoemaker (1971) defined awareness as a function or a stage of decision process when the individual was exposed to the experience of an innovation and gained some understanding of how it was functioned.

Venugopal and Perumal (1991) defined awareness as the things known to individual or presented as cognitive domain. It was considered as a pre-requisite for the adoption of innovation as it enabled farmers to completely understand the aspects behind a technology and also its relative advantage.

According to Supe (1994) awareness was the first stage of innovation decision process wherein the individual was exposed to an idea but lacked detailed information about it.

Giram and Sawarkar (1996) defined awareness as the type of social component which increased the social consciousness among the people and generated confidence in the individual to face the problems contemplatively.

According to Birbal Saha (2013), awareness means "having knowledge or cognizance".

According to Michael, S (2013), awareness means the knowledge or consciousness which facilitates a shift or change in perspective, which is pre-requisite for significant learning.

Eevi Kokkinen (2013) defined awareness as a condition of being aware or having knowledge.

Harju, P (2013) defined awareness as state of being aware of the external surroundings in which people live and work, which tend to influence peoples' development and behaviour.

2.1.10 Adoption

Rogers and Shoemaker (1971) defined adoption as the decision to make full use of an innovation as the best course of action available.

According to Mc Daniel and Darden (1987), when someone purchased a new product never tried before, he may ultimately become an adopter if he was sufficiently satisfied with his trial experience with the product.

According to Zikmund and Amico (1989), adoption process includes awareness, interest, evaluation, trial and finally make full use of an article or product..

According to Sujatha (1995), adoption is the acceptance and application of some or all the recommendation practices by the respondents in crop husbandry.

Kiruthika, N (2012) defined adoption as the decision to use the practices.

In the present study, adoption is defined as the acceptance and application of *Pseudomonas fluorescens* and *Trichogramma sp*. for pest management in paddy farms.

2.2. Review of methodologies and past findings

2.2.1 Impact of pesticide use

Antle and Pingali (1994) found that current pesticide application rate on rice in South East Asia is higher than optimal and adverse effects of pesticide use on farmers' health have in turn reduced labour productivity.

Cohen *et.al*., (1994) described increased use of pesticides has resulted in greater incidence of pesticide poisoning in developing countries.

Mullen *et.al*., (1997) studied the human health effects by overuse of pesticides which can also result in serious environmental damage to surface water, ground water and air quality which consequently harm birds, aquatic species, misuse of pesticides that could harm the predator–prey balance and result in higher levels of pest infestation and disrupt existing ecosystem balance.

Oka *et.al*., (1997) found that all pesticide formulations that are broad spectrum and applied excessively would cause various environmental problems. They were not only killed pests but also killed beneficial organisms such as parasitoids, predators, bees, earthworms, birds and fish in irrigated rice-fish ecosystems. Chemical pesticides polluted irrigation water, eventually reaching the rivers and village people who used such water for bathing, cooking and other needs, were exposed to health hazards.

Ramesh Babu and Reddy (1999) found that high input intensive farming resulted in the excessive and injudicious use of pesticides. Certain pesticides would produce serious long-term effects such as cancer, birth defects and sterility.

Eric Lichtenberg (2001) reported that, insecticides have been found to disrupt the natural habitats and the food web structures of natural enemies of rice insect pests, creating pest out breaks that can lead to increased use of and dependence on pesticides.

Das Gupta (2001) studied the incidence of pesticide damage and found that there is illness, death and contamination of livestock and food. Also observed that farmers and pesticide factory workers were exposed to danger of pesticides through lack of protective clothing and equipment.

Indira Devi (2007) reported that, the fungicide use in Kerala is much higher (57 per cent) when compared with the use of insecticides. Very frequent cases of cancer of lips, stomach, skin and brain, lymphoma, leukaemia and multiple myloma from Kuttanad rice area of Kerala link to the high pesticide use in Kerala and concluded that there is ample scope for reducing pesticide exposure in Kuttanad through training and agricultural extension services.

Konstantinos, M (2013) reported that the use of pesticides increased crop yield and helped decisively the agricultural sector. Also dealt that the rising concerns about the excessive use of pesticides and their impact on nature and health of human and aquatic organisms triggered the search for natural products as sources for new pesticides.

2.2.2 Economics of pesticide use

Latha (1999) in her study on production and marketing of hybrid cotton in Coimbatore district worked out the influence of IPM practice on cotton cultivation. She found that though the IPM incurred additional cost, it helped in better control of pests thereby improving the productivity per hectare in terms of yield. She also found that IPM practice avoided resurgence of pests and also other environmental problems.

Thakur and Pawar (1999) concluded that IPM training cum demonstrations in vegetables such as tomato, cabbage and cauliflower had significant positive impact on crop production and pesticide use. They have observed that yield increase in those crops varied from 28 to 32.1 quintals per hectare. Cost benefit ratio varied from 1:3.81 in IPM fields to 1:2.97 in non IPM fields. Reduction in input costs in IPM fields was mainly due to no use or reduced use of safer pesticides at optimum dose in appropriate time. Reduction in pesticide sprays varied from 32.33 to 50 per cent.

The study by Garg (1999) on the economics of IPM approach in Basmati rice aimed to develop an IPM system in Basmati rice that would make farmers aware about the ill effects of indiscriminate use of pesticides and benefits of IPM. Yield data showed that all IPM farmers secured higher rice yields than those using conventional chemical control tactics. It was also evinced that farmers practice of not applying pesticide or very little pesticide was better than the indiscriminate use of pesticide which might have suppressed the natural enemy population.

A study by Tamizheniyan (2001) revealed that total cost per acre on IPM farms was Rs. 10,452 compared to Rs.10,035 on non-IPM paddy farms. The gross return per acre was Rs.16,213 compared to Rs.14900 in these farms respectively. The benefit–cost ratio was 1.62 for IPM, and 1.43 for Non-IPM farms.

David Pimental (2005) studied about the environmental costs resulting from the nations’ dependence on pesticides. The result from his study showed that the major economic and environmental losses due to the application of pesticides in USA were, public health, 1.1 billion dollars/year, pesticide resistance in pests, 1.5 billion dollars, crop loss caused by pesticides, 1.4 billion dollars, bird loss due to pesticide , 2.2 billion dollars and ground water contamination, 2 billion dollars.

Indira Devi (2007) studied the health cost of pesticide use in Kuttanad region of Kerala. The average health cost from pesticide exposure was Rs.38 per day or 24 per cent of the average daily earning of the applicator.

Desalegn Begna (2014) studied the effect of pesticide use on honeybee population and economic impact on bee keepers. Field assessment was conducted on pesticide use and its economic impacts on apiculture subsector in three districts of Amhara region of Ethiopia. Three year trend analysis of honeybee colony number and honey yield indicated drastic decline mainly attributed to indiscriminate use of pesticides. The assessment revealed that indiscriminate use of pesticides caused fatalities on 22987 honeybee colonies and incurred economic loss amounting US Dollar 819291.37.

2.2.3 Uses of biopesticides

Wei *et.al.,* (1996) and Thakuria *et.al*., (2004) opined PGPR (Plant Growth Promoting Rhizobacteria) promotes the plant growth through increasing water and nutrient uptake, nitrogen fixation, production of phytohormones , phosphate solubilisation and production of antibiotics.

Lewis *et.al*., (1997) opined that the biopesticides are often designed to control a pest population to a manageable level rather than completely eradicate a target pest.

Egamberdiyeva (2003) reported that presence of PGPR increases the uptake of Nitrogen and Phosphorus from soil.

Ramarethinam *et.al*., (2003) reported that fungi like *Trichoderma* and bacteria like *Pseudomonas* are being used as disease control agent of various fungal and bacterial plant diseases.

Compant *et.al.*, (2005) opined that biological control using PGPR from the genus *Pseudomonas* is an effective substitute for chemical pesticides to suppress plant diseases.

Nirakar Ranasingh (2007) opined that the efficacy of many of biopesticides can equal that of conventional chemical pesticides. When used as a fundamental component of IPM (Integrated Pest Management) programs, biopesticides can greatly decrease the use of conventional pesticides, while crop yield remains high.

Muraleedharan *et.al.,* (2008) opined that biopesticides, when used as a component in IPM reduce the use of chemicals while crop yield remains high. These are effective in small quantity, decompose fast, lower exposure and avoid pollution caused by chemical pesticides.

Ramesh *et.al.,* (2009) found that, in recent years the focus has shifted to the control of diseases using biocontrol agents which are the safe and promising alternatives synthetic chemicals.

Sivakamasundari and Usharani (2012) were of the opinion that *Pseudomonas fluorescens* have emerged as the largest and potentially most promising group of PGPR (Plant Growth Promoting Rhizobacteria) possessing traits involved in the biocontrol of phytopathogens.

According to Khalimi *et.al.*, (2012) a large array of bacteria including species of *Pseudomonas* has been reported as PGPR to enhance plant growth.

Sonia Sethi and Saksham Gupta (2013) opined botanical pesticides, bio fungicides and bio bactericides have not only found to be increasing the fertility of soil, but also are eco-friendly non-hazardous and beneficial for crops.

2.2.4 Effect of Pseudomonas on crop production

According to Sakthivel, *et.al*., (1986) *Pseudomonas fluorescens* have been shown to inhibit the pathogens Fusarium oxysporum, Rhizoctonia solani and Sarocladium oryzae. They have observed comparatively less disease incidence in *Pseudomonas fluorescens* treated plants.

Sakthivel and Gnanamanickam (1987) found the treatment with *Pseudomonas fluorescens* reduced the severity of sheath rot by 20-42 per cent in rice cultivars. Bacterization of rice cultivars with *Pseudomonas fluorescens* enhanced plant height, number of tillers and grain yield from 3-160 per cent.

According to Mazzola, M *et.al*., (1992) *Pseudomonas fluorescens* is uniquely capable of synthesizing many of the antibiotics not only to enhance its own fitness but also to help in the maintenance of soil health and bio protection of crops from pathogens.

Vidhyasekaran, P *et.al*., (1997 and 2001) found that pre-treatment of rice leaves with *Pseudomonas fluorescens* as seed and foliar spray effectively controlled the disease and increased grain yield.

Swarnakumari, N and Lakshmanan, P.L (1999) found that seed treatment with *Pseudomonas* alone or in combination with other microbial and botanical agents such as neem cake has reduced pest and disease problem.

Vasudevan, P (2002) concluded bacterium *Pseudomonas fluorescens* applied against several rice pathogens can reduce disease severity by 20-42 per cent in green house condition as well as field condition. Such bacterization of rice plants can enhance plant height, number of tillers and grain yield by 3-160 per cent. Also found that *Pseudomonas fluorescens* have insecticidal effect on the rice tungro virus disease vector *Nephotettix virescens*. Bacterial strains can cause about 90 per cent mortality if they feed on treated rice leaves for 7 days.

Egamberdiyeva (2003) reported that winter wheat inoculated with *Pseudomonas fluorescens* increased root and shoot growth and nitrogen, phosphorus and potassium uptake. He mentioned that the use of PGPR like *Pseudomonas fluorescen*s increases plant hormones such as Cytokinin, gibberellins and auxin which also increase rice growth and yield. Presence of PGPR increases the uptake of Nitrogen and Phosphorus from soil.

Singh and Sinha (2005) reported that *Pseudomonas fluorescens* was effective in reducing disease severity, incidence and increased grain yield and weight in rice.

Rajbir Singh and Sinha (2005) found that the application of *Pseudomonas fluorescens* increased the grain yield and significantly reduced the sheath blight disease severity. They have observed that combination of application methods such as soil treatment, seedling root dip and foliar spray resulted in 56.97 per cent and 40.17 per cent reduction in the disease severity and incidence respectively. Also there were 30.59 per cent and 14.54 per cent increase in the grain yield per plant and 1000 grain weight respectively.

Gajanana *et.al*., (2006) studied the impact of IPDM technology on yield and revenue of farmers. Important indicators used were yield, cost of cultivation and net returns. Yield was higher on IPDM than non-IPDM farms. Cost of cultivation was lower and net returns was higher in IPDM adopted farms.

Duraisamy *et.al*., (2007) found that the application of Pseudomonas (group of *Pseudomonas sp*.) reduced the pest incidence compared to chemical insecticides.

Saravanakumar ,D *et.al*., (2007) reported that *Pseudomonas* increased the saline resistance in Ground nut plants hence increased yield.

Nandakumar *et.al*., (2007) observed chitinolytic activity in *Pseudomonas* applied fields which controlled the pest population in the plots.

Saravanakumar, D *et.al*., (2008) observed higher natural enemy population in *Pseudomonas fluorescens* applied plots.

Saravanakumar, D *et.al*., (2008) observed efficient control of sheath rot disease of rice plants with the use of fluorescent pseudomonas.

Vasantharaj David (2008) mentioned the *Pseudomonas* as potential nematode control agents of parasitic nematodes in many crops.

Loganathan ,K. *et.al*., (2009) found significant increase in the rice grain yield as a result of *Pseudomonas* application.

Debananda, S *et.al*., (2009) found biocontrol with beneficial bacteria as a promising alternative to chemical fungicides. Intensive research on plant growth promoting bacteria is underway worldwide for developing bio fertilizers and bio control agents as better alternatives to agro chemicals as the latter harm the environment and human health besides demanding high cost.

Alastair Bailey *et.al*., (2010) found that Pseudomonas species including *Pseudomonas fluorescens* reduce damping off and soft rots of crops.

Jeyalakshmi, C *et.al*., (2010) reported that among the different methods tried the combination of seed treatment, soil application and foliar spray with *Pseudomonas fluorescens* recorded minimum disease incidence of bacterial leaf blight with maximum yield in comparison with the chemical treatment and control.

Yaser Rahmai, K.*et.al*., (2011) studied the effect of *Pseudomonas fluorescens* on growth and yield of paddy. They found that the Pseudomonas application increases the yield of paddy.

Prakash Nathan *et.al*., (2011) were of the opinion that augmentation with Pseudomonas in rice ecosystems will ensure a healthy microclimate.

According to Shyamala, L and Shivakumar (2012) the biological control of rice blast disease with *Pseudomonas fluorescens* is effective. They mentioned that *Pseudomonas fluorescens* is one of the most effective biocontrol agents currently available and is used primarily for seed, soil, foliar treatment due to its efficient antagonistic activity against various plant pathogens.

Ramyasmruthi *et.al*., (2012) recorded the growth promoting activity of *Pseudomonas fluorescens* which is effective against wide spectrum fungal plant pathogens.

Meera and Balabasker (2012) recorded the plant growth promoting activity of *Pseudomonas fluorescens* in rice and noticed increased root and shoot length.

Sireesha, O (2013) explained *Pseudomonas fluorescens* was found to be most effective in controlling the leaf blast and neck blast incidence, also increases grain yield and number of filled grains.

Amutharaj, P *et.al*., (2013) observed that application of *Pseudomonas fluorescens* augmented the growth and yield parameters ie, plant height, shoot and root dry weight, chlorophyll content and reduced blast disease incidence. This indicates the superior characteristics of the *Pseudomonas fluorescens* treated plants.

Roy Mandipa *et.al*., (2013) reported that *Pseudomonas fluorescens* has successfully used for biological control of several plant pathogens and found blast disease of rice also can be effectively controlled by the use of Pseudomonas.

According to Shivalingaiah and Umesha (2013) *Pseudomonas fluorescens*, a major constituent of rhizobacteria encourage the plant growth through its diverse mechanisms. Effect of *Pseudomonas fluorescens* on seed germination and seedling vigour showed significant improvement over the controls. It was also found to be effective in controlling bacterial leaf blight of rice.

Usharani, G *et.al*., (2014) studied the effect of *Pseudomonas fluorescens* on growth and yield of paddy. She reported that *Pseudomonas fluorescens* increases the plant height, nitrogen content, number of tillers, leaf area index, number of panicles per hill and grain yield.

Midrarulla *et.al*., (2014) found that treatment with *Pseudomonas fluorescens* increased the grain weight of paddy by 13.8 per cent.

Kaveh Zargari *et.al*., (2014) observed the application of *Pseudomonas fluorescens* along with 100 kg nitrogen per hectare produced the highest yield (5733kg/ha) among all the treatments.

2.2.5 Analysis of Variance

Yaser Rahmai, *et.al*., (2011) studied the effect of *Pseudomonas fluorescens* on growth and yield of paddy. According to the Analysis of variance results grain yield had been significantly influenced by bacteria *Pseudomonas fluorescens*.

Ashok, K.R *et.al*., (2012) studied the impact of Bt. Technology on key variables like yield, pesticide use and profitability of cotton cultivation using Analysis of Variance Model. They found that there was significant difference between the cotton yields due to the adoption of Bt. technology.

2.2.6 Environmental Impact Quotient

Brookes and Peter (2008) studied the environmental benefits of GM soybean (Genetically Modified soybean) using EIQ index. According to them, GM crop cultivation contributed to significant reduction in the pesticide use. The use of pesticides in GM crops area was reduced by 286 million kg of active ingredient.

Doris Sande *et.al*., (2011) used EIQ to estimate the hazards from methyl bromide and proposed alternatives to workers, consumers, beneficial arthropods, birds, fishes and bees. Their findings indicate that iodo methane has the lowest EIQ value and field use rating.

Peter Kroman *et.al*., (2011) reported the superiority of IPM practices than conventional systems using EIQ value. EIQ for IPM was 40 and that for conventional system was 1235. This indicates the environmental benefits of Integrated Pest Management.

Ashok, K.R *et.al*., (2012) studied the environmental impact of the Bt. technology using EIQ methodology in the states of Gujarat, Andhra Pradesh, Maharashtra and Tamil Nadu. They reported that EIQ for Bt. cotton was lower in all the states. The decrease in EIQ value was 15 per cent in Gujarat, 19 per cent in Andhra Pradesh, 50 per cent in Maharashtra and 68 per cent in Tamil Nadu.

Diller *et.al*., (2013) reported the 40 per cent reduction in the EIQ value with the use of GM Sugar beet. According to them there was a positive environmental effect from the adoption of GM technology.

Prakashan *et.al*., (2014) used EIQ to measure the environmental benefits of Bt. adoption. According to them Bt. adoption contributes to higher environmental safety.

2.2.7 Socio-Economic factors influencing adoption

Saeeo (1989) found that adoption of innovations was more closely related to individual and farm related factors than with community and family level variables and he suggested that the expansion of local extension services, supply of technical inputs, credit and marketing facilities could increase the probability of modern practices and create incentives for innovation.

Quzi and Iqbal (1991) reported that education was an important determinant of innovation adoption. Age was observed to be inversely related to it. Older farmers tend to be more enterprising in some aspects, but generally owners of large farms were more prepared to undertake the risk of modern technology than the small farmers.

Siardos (1991) found that the farmers' personal characteristics such as the age and education did not have any significant influence on adoption behaviour and socio economic characteristics such as the scale of farming and social activities affect the farmers' adoption decision.

Jananadevan and Prakash (1992) concluded that the extent of fertilizer use was significantly related to the level of knowledge obtained by the farmers regarding fertilizer application through extension contact and information sources.

Hossain and Croach (1992) observed that the innovativeness of the opinion leaders and factors were important in influencing the behaviour of other farmers.

Changmai *et.al*., (1992) studied the factors affecting the fertilizer adoption behaviour of farmers and found out that 63.51 per cent of the sample farmers were adopters of fertilizers and 36.48 per cent of the sample farmers were non-adopters of fertilizers. It was reported that the probability of adopting fertilizer technology depends on such factors as percentage area under high yielding varieties, percentage area irrigated, total farm income, level of literacy, infrastructural facilities, access to input markets and non-farm income.

Ramasamy,C *et.al*., (1999) concluded that education, a personnel variable, farm size, a socio economic variable and irrigation, a bio physical variable, all primarily in the farmers environment would affect adoption of a technology.

Gupta and Dikshit (2010) found that the adoption of biopesticides depends on affordability, availability, efficient delivery and evidence of efficacy.

Kiruthika (2012), in her study on economic impact assessment of IPM on Onion in Tamil Nadu, found that Education level of farmer, Family size and Extension agency contact were the factors influencing adoption of IPM technology.

Kumar, S (2012) recommended that training on production and quality control to manufacturer and organizational training to extension worker and farmers to popularize biopesticides are essential for better adoption of the technology.

Vaishali Kandpal (2014) suggested that the adoption of biopesticides by farmers in India has to be motivated for maximizing gains since India has vast potential for biopesticides. The stress on organic farming and on residue free commodities would certainly warrant increased adoption of biopesticides by the farmers.

2.2.8 Awareness level of farmers

Bently (1986) studied about awareness level of traditional peasant farmers in Honduras and concluded that Honduras knew more about some aspects of the local agro-ecosystem, knew more about plants, less about insects, and less still about plant pathology.

Kalugasalamurthy (1991) found that farmers' awareness about fungal diseases, yield loss due to fungal diseases and awareness about pesticide companies were very poor.

Rajasekaran (1991) concluded the awareness about herbicides and herbicide technologies among the sample farmers were very high.

Senthilkumar (1991) found that the Economic Threshold Level (ETL) concepts were known to 71 per cent of the farmers. But only very limited number of farmers (12 per cent) had actually adopted the Economic Threshold Level (ETL).

Hayat *et.al.*, (1993) generalized on farmers' knowledge and perceptions on new varieties of wheat and concluded that 50 per cent of the farmers were growing banned varieties of wheat, which are highly susceptible to rust because they were not aware about new rust resistant varieties.

Sanzidur Rahman (2005) studied the impact of farmers' environmental awareness on resource use. He measured the impact of modern technology adoption in raising farmers' environmental awareness. The result of the study showed that farmers' environmental awareness reduces resource use including chemicals. He concluded that the efforts to raise farmers' environmental awareness are expected to enhance intangible benefits accruing from a relatively less chemical intensive environment.

Kumar, S (2012) opined that it is essential to create awareness among common men to switch over to biopesticides for their pest management requirements.

2.2.9 Logistic regression

Arellanes and Lee (2003) used Logistic regression analysis to find out the determinants of adoption of minimum tillage among resource poor farm households in Honduras. The results showed that plots with irrigation, plots cultivated by their owners and plots with steeper slopes were more likely opted for minimum tillage adoption. Farmer household characteristics were not found to have significant influence on adoption decision. Results also indicate that previous use of leguminous cover crops, soil amendments and commercial vegetable production are all associated with the minimum tillage adoption.

Adeogun *et.al.,* (2008) used Logistic regression analysis to study the adoption process of Hybrid Clarias "Heteroclarias" by fish farmers in Lagos State, Nigeria. The results showed that education, contact with extension agent, access to seed and market distance are significant variables that influence fish farmer's hybrid catfish adoption and use decisions.

Onemolease and Alakpa (2009) assessed rural youth response to improved farming practices and determinants of their adoption decisions in the Niger Delta region of Nigeria. Contact with extension agents (odd ratio = 2.39), income (2.22) and gender (1.46) were important determinants of young farmers adoption of crop-related technologies. Income (odd ratio=1.43), stock size (1.23) and gender (0.78) had a significant influence on the utilization of livestock–related technologies while extension contact (1.24), stock size (3.96), income (3.13) and gender (1.77) played important roles in their adoption of fishery technologies.

Achia *et.al*., (2010) used Logistic Regression Model to identify the determinants of poverty in Kenya using demographic and health survey data. The independent variables used were education, residence, ethnicity, region, religion, and age. Religion was found to significantly explain household socio-economic status, adjusting for various socio-cultural and demographic factors.

Kiresur and Ichangi (2011) used Logit Model to study farmer's decision on adoption of Bt Cotton in Karnataka. The estimates of the logit model revealed that the decision of a farmer on adoption of Bt technology was positively influenced by his age, education, family size and yield of Bt cotton. On the other hand, the negatively influencing factors were caste, landholding-size, plant protection chemicals and labour cost.

Li *et.al.,* (2011) studied the factors Influencing Adoption of Integrated Pest Management in Northeast Greenhouse and Nursery Production. Results of logistic regression analysis showed that IPM adoption is more likely to occur on large farms that hire more full-time workers and have more diversified crops. Greenhouse and nursery operations that face disease problems are less likely to adopt IPM and availability of biological control agents limits IPM adoption.

Awotide *et.al.,* (2012) in their study analyzed the factors that determine farmer's adoption status of improved rice varieties using Logistic Regression Technique. Among the variables; number of years of residence in the village, access to media, access to mobile phone, vocational training, livestock, access to seed and income from other crop production significantly increased the probability of adoption. However, contrary to a priori expectation, having agriculture as main occupation had a negative and significant effect on the adoption of improved rice varieties in the study area. This could be due to the fact that full time farmers are always missing out on information because of their long stay on the farm.

Akudugu *et al.* (2012) examined the factors that influence farm households' modern agricultural production technology adoption decisions in Ghana using Logit model. The results showed that farm size, expected benefits from technology adoption, access to credit and extension services are the factors that significantly influence technology adoption decisions of farm households in the study area. The study concluded that farm households' agricultural technology adoption decisions depend on their socio-economic circumstances and institutional effectiveness.

Wandji *et al.* (2012) using the univariate dichotomous LOGIT model, identified the key determinants affecting the adoption of new aquaculture technologies in western highlands of Cameroon. The results indicate that its strong commercial orientation, coupled with the positive perception of its profitability, frequent extension contact and level of education are the main determinants for the adoption of fish farming.

Idrisa *et al.* (2012) examined the determinants of adoption of improved soybean seeds among farmers in southern Borno State, Nigeria. Logit and Tobit model were used to estimate the likelihood of technology adoption among respondents and the extent of adoption of improved soybean seeds by the respondents, respectively. Yield of soybean and distance to source of improved seeds were statistically significant factors ($\rho \leq 0.01$) that influenced the likelihood of adoption of improved soybean seeds among the respondents. Farm size and distance of respondents to source of improved soybean seeds were statistically significant factors ($\rho \leq 0.01$) that influenced the extent of adoption of improved soybean seeds among the respondents.

Gregory and Sewando (2013) analyzed the determinants of probability of adopting quality protein maize (QPM) technology in Tanzania using logistic regression model. The regression results indicated that education of the household head, farmers' participation on demonstration trials, attendance to field days and number of livestock owned have positively influenced the rate of adoption of the technology. Access to credit and poor QPM marketing problem perception by farmers negatively influenced the rate of adoption. The study recommended government to ensure efficiency input-output linkage for QPM production.

CHAPTER III

DESIGN OF THE STUDY

In order to fulfil the objectives of the study, an appropriate methodology which describes sampling design, data collection and specification of the empirical model and tools of analysis is necessary. This chapter provides a detailed outline of the methodology followed for the study as follows

3.1. Choice of the Study Area

3.2. Sampling Design

3.3. Period of the Study

3.4. Collection of Data and Method of enquiry

3.5. Tools of Analysis

3.1. Choice of the study area

The study was conducted in Alappuzha district of Kerala. Alappuzha district was purposively selected for the study as it is a major rice growing area often referred as "Rice bowl of Kerala". The productivity level was higher in Alappuzha (2890 kg/ha), next to Thrissur (2925kg/ha) and Kottayam (2904 kg/ha) districts. The details are shown in Table 3.1. i.e., More than 18 per cent of total area under paddy was in Alappuzha district. According to the sources (State Biocontrol Lab, Mannuthy) almost 10 per cent of the total production of *Pseudomonas fluorescens* was used by the paddy farms in Alappuzha district. An NGO called Gandhi Smaraka Seva Kendram supplied 15 tonnes of *Pseudomonas fluorescens* to the farmers at Alappuzha district during last year. The farmers in the Alappuzha region are using *Pseudomonas fluorescens* and Tricho cards (*Trichogramma sp*.) in paddy cultivation over 4 years. Krishi Vigyan Kendra (KVK) Kayamkulam also supplied *Pseudomonas fluorescens* to the farmers in Alappuzha district. Considering the huge distribution of biopesticides, Alappuzha district was selected purposively for taking up a research study on economic analysis of Biopesticides use in paddy. Data regarding the Area, Production, Productivity of Rice in different districts of Kerala is given in the Table 3.1.

FIGURE 1. MAP OF KERALA STATE

FIGURE 2. MAP OF ALAPPUZHA DISTRICT

Table 3.1. District wise area, production, productivity of rice in Kerala in 2012-13

Sl.No	District	Area (in Ha)	Production (000'MT)	Productivity (Kg/Ha)
1	Thiruvananthapuram	1816 (0.92)	4096	2256
2	Kollam	1387 (0.73)	2928	2111
3	Pathanamthitta	2280 (1.11)	6041	2650
4	Alappuzha	36195 (18.34)	104593	2890
5	Kottayam	17571 (8.90)	51015	2904
6	Idukki	1176 (0.59)	3183	2707
7	Ernakulam	3940 (1.99)	8533	2166
8	Thrissur	23098 (11.70)	67569	2925
9	Palakkad	79201 (40.14)	189229	2389
10	Malappuram	6674 (3.38)	15377	2304
11	Kozhikkod	3511 (1.77)	5326	1517
12	Wayanad	10203 (5.17)	28052	2742
13	Kannur	6684 (3.38)	14237	2130
14	Kasargod	3514 (1.78)	8116	2310
STATE		197277	508299	2577

(Figures in the parentheses indicate per cent to total)

Source: Agricultural Statistics 2012-13, Department of Economics and Statistics, Thiruvananthapuram

3.2. Sampling design

The study area was chosen purposively for the present study. Three stages purposive sampling method was used in the selection of study district, blocks and villages for the study. The criteria like area under paddy, awareness and use of biopesticides for more than 4 years were used in the selection of study district, blocks and villages. The sample respondents i.e., the farmers who applied *Pseudomonas fluorescens* and Tricho cards (adopters) and others (non- adopters) were selected at random from the selected blocks of the study district. From the selected two villages in each block 30 farmers were selected randomly from each village, comprising of 15 farmers each of adopters and non-adopters. Thus the total sample size was 120. The details are given in Table 3.2 and Table 3.3.

Table 3.2. Block wise area under paddy in Alappuzha district during 2012-2013

Sl.No	Block Name	Area (Hectare)	Production (Tonnes)
1	Thycattussery	164.63	280.78
2	Pattanakkadu	173.29	261.23
3	Kanjikkuzhy	110.96	170.43
4	Aryad	90.45	85.31
5	Ambalappuzha	3023.11	8534.31
6	Veliyanadu	10120.64	30653.20
7	Champakkulam	15239.53	44936.75
8	Chengannur	873.68	2701.25
9	Mavelikkara	1595.58	4403.97
10	Bharanikkavu	307.67	572.95
11	Harippadu	2976.04	8088.61
12	Muthukulam	158.86	196.81
	Municipalities	1360.19	3707.17
Total		36195	104593.45

Source: Agricultural statistics 2013-2014, Department of Economics and Statistics, Thiruvananthapuram

Table 3.3. Distribution of sample farmers in the selected villages

(Numbers)

Sl. No	**Name of the blocks**	**Name of the villages selected**	**Farmers**	
			Adopters	**Non adopters**
1.	Chambakulam	Chambakulam	15	15
		Kainakary	15	15
2.	Veliyanadu	Muttar	15	15
		Nilamperoor	15	15
	Total		60	60

Chambakulam and Veliyanadu are the blocks having maximum area under biopesticides use (Annexure 2).

FIGURE 3. MAP OF CHAMBAKKULAM BLOCK

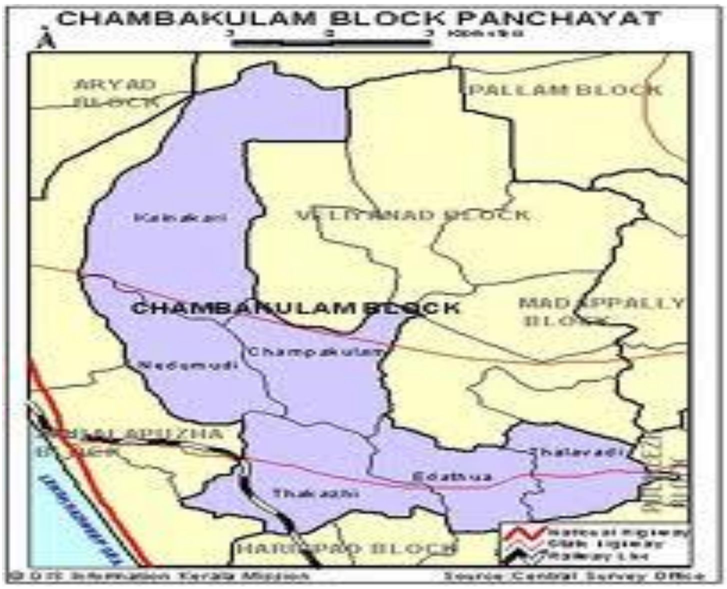
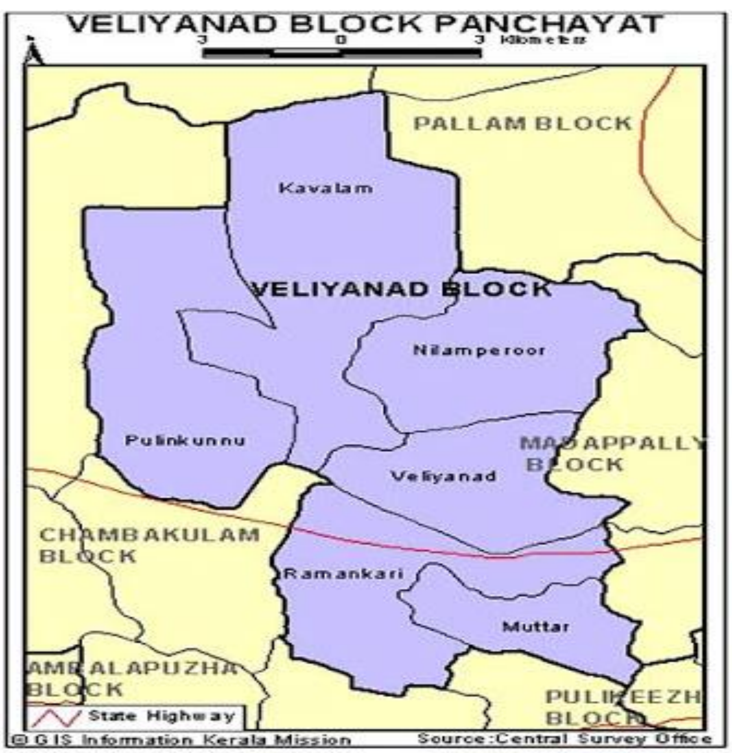


FIGURE 4. MAP OF VELIYANADU BLOCK



3.2.1. Paddy cultivation method in study area

The study district is lying the 1-2 meter below Mean Sea Level. The paddy fields in this area are divided into contiguous blocks called Padasekharams bound by waterways, rivers and other natural partitions. Farming operations were taken up by the farmers jointly. The farmers meet out the expenses on individual basis. The fields were flooded with water for 10-15 days and it was drained out to maintain the soil quality by reducing the salt content in the soil.

The Puncha Special Office in the Alappuzha district will auction the contract for draining the water from the paddy fields. The Puncha Special Office will pay Rs.400 per acre to regulating water level in the paddy fields. The water from the field will be drained 20 days before the harvest. The cost for this will be paid by the farmers at the rate of Rs.2500 per hectare. Combined harvester is used for the harvesting process. Most of the farmers are using machines for the land preparation and harvesting. It was observed in the study area that Uma is the major variety used for cultivation in Alappuzha region by more than 95 per cent of the farmers. Uma (MO.16) is a high yielding Gall midge resistant variety, released from Rice Research Station, Moncompu. The biopesticide adopter farmers were following seed treatment with Pseudomonas at the rate of 10g/kg of seed and foliar spray at 0.2 per cent (1 kg/ha).

3.3. Period of the study

The primary data were collected from the selected sample respondents during the month of September 2014 to February 2015. The data regarding area, production, productivity of rice pertaining to the agricultural year 2012-13 because the year 2013-2014 was recorded as drought year.

3.4. Collection of data and method of enquiry

3.4.1. Secondary data

The relevant secondary data for the study, were collected from the records of the State Biocontrol Lab Mannuthy, Department of Economics and Statistics, Office of Principal Agricultural Officer Alappuzha, Agricultural Statistics, Panchayat Level Statistics, etc., in the respective years. This included the features of study area such as rainfall pattern, demography, cropping pattern, crop rotation and communication facilities, etc. By using collected information the questionnaire was developed and it was pretested at the farm level during pilot survey.

3.4.2. Primary data

In order to fulfil the objectives of the study, the primary data were collected from the sample respondents by personal interview method, using a well-structured interview schedule. The method of personal interview was adopted to ensure that the data obtained from the respondents were relevant, comprehensive and reasonably correct and precise. The data included general information of the respondents like age, educational level, family size, land holding pattern, source of irrigation, cropping pattern and animal husbandry. Detailed information on production aspects like area of rice, cultivation aspects, cost and returns, adoption and non-adoption of biopesticides in pest and disease control by farmers, factors associated with adoption and non-adoption decisions of farmers were comprehensively collected from the selected sample respondents during field survey.

3.5. Tools of analysis

3.5.1. Conventional analysis

The conventional methods of analysis viz., percentages, averages and frequency tables were developed to estimate the level of distribution of agro-socio-economic variables such as age, education, experience in farming, size distribution of sample holdings, cropping pattern, sources of technical information, awareness level of farmers about benefits of biopesticides, natural enemy population, input use, cost and returns etc., of the sample farm households.

3.5.2. Effect of biopesticide adoption on productivity of rice and cost of cultivation:

ANOVA model

Dummy variables are variables that assume values 0 and 1. Dummy variables can be incorporated in regression models just as easily as quantitative variables. As a matter of fact, a regression model may contain regressors that are all exclusively dummy, or qualitative in nature. Such models are called Analysis of Variance (ANOVA) models (Gujarati, 2009).

The impact of biopesticide adoption on key variables like yield per ha, and pesticide use were estimated through the following Analysis of Variance model.

Model is

$$Y \ = \alpha + \beta \, P + u \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Where,

Y= variable for which impact is estimated

P = 1 for adoption of biopesticides

0 for non-adoption of biopesticides

This model is estimating whether biopesticide adoption makes any significant difference in the yield, and pesticide use assuming that all other factors are held at constant. The intercept α gives the mean productivity of non-adopters and the slope β tells by how much the mean productivity of adopters, differs from the mean productivity of non-adopters. α+β gives the mean productivity of biopesticide adopters.

Since the independent variable, being binary variable, adoption of biopesticides assumes values of 1 and 0. The Yield of Paddy, Cost of Cultivation of Paddy and Expenditure on plant protection were considered as dependent variables.

3.5.3. Factors influencing the adoption of biopesticides by the farmers: Logit Model

Binary choice models are appropriate when the decision making choice between two alternatives depends on the characteristics of the problem. Three types of models have been proposed in the econometric literature for estimating binary choice models: the linear probability model, Probit, and Logit models represented by linear probability function, normal distribution function and logistic distribution function respectively (Gujarati, 1995). These models are used to approximate the mathematical relationships between explanatory variables and the adoption decision that is always assigned qualitative response variables.

Following Maddala (1992), Gujarati (2003) and Green (2008) and the logistic distribution for the adoption decision of biopesticides can be specified as:

$$p_i = \frac{1}{1+e^{-z(i)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, Pi is a probability of adoption of biopesticides and ranges from 0 to 1. 'e' represents the base of natural logarithms and Z (i) is the function of a vector of n explanatory variables and expressed as

$$z_i = \beta_0 + \sum \beta_i X_i \quad \text{...................................... (3)}$$

Where β0 is the intercept and βi is a vector of unknown slope coefficients.

The relationship between p_i and X_i, which is non-linear, can be written as follows:

$$= \frac{}{1+} \quad p_i = \frac{1}{\beta_i + x_i + ...+ \beta_n x_n} \quad \text{...................................... (4)}$$

The slopes tell how the log-odds in favour of adoption of biopesticides changes as independent variables change. If p i is the probability of adopting biopesticides then 1- p i represents the probability of not adopting and can be written as:

$$1 - p_i = \frac{1}{(1+e^{-zi})} = \frac{e^{-zi}}{(1+e^{-zi})} = \frac{1}{(1+e^{-zi})} \quad \text{.............................. (5)}$$

Dividing equation (2) by equation (5) and simplifying gives:

$$\frac{p_i}{1-p_i} = \frac{1+e^{zi}}{(1+e^{-zi})} = e^{-zi} \quad \text{................................(6)}$$

Equation (6) indicates simply the odd-ratio in favour of adoption of biopesticides. It is the ratio of the probability that the farmer will adopt the technology to the probability that he will not adopt it. Finally, the logit model is obtained by taking the logarithm of equation (6) as follows.

$$L_i = L_n \left[\frac{p_i}{1-p_i} \right] = z_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ...+ \beta_n x_n \quad \text{............................(7)}$$

Where L_i is log of the odds ratio, which is not only linear in X, but also linear in the parameters:

This econometric model is estimated using the iterative Maximum Likelihood Estimation (MLE) procedure due to the nonlinearity of the logistic regression model. The MLE procedure yields unbiased, asymptotically efficient, and normally distributed regression coefficients (parameters). The analysis was done using Stata software.

The empirical model used in the study is

$Y= a+\beta_1 AGE+\beta_2 EDU+\beta_3 FWR +\beta_4 FZE+ \beta_5 LTK+ \beta_6 INC+ \beta_7 FXT+ \beta_8 AL+\beta_9 DST+ e_i$

Where,

Y = Adoption/Non-adoption (Dichotomous variable)

Explanatory variables

AGE	=	Age of the farmer (in years)
EDU	=	Number of schooling years
FWR	=	Number of farm workers in the household
FZE	=	Farm size (in ha.)
LTK	=	Number of livestock owned
INC	=	Annual income (in Rs.)
FXT	=	Frequency of contact with the extension agent (Not at all = 0, Occasionally=1,quarterly= 2,fortnightly=3 monthly =4, weekly =5)
AL	=	Awareness Level on beneficial effects of biopesticides. The awareness level represents how many environmental benefits the farmer knows. It was measured on a 3 point scale and classified the respondents into high(5-7 benefits), medium(4 benefits) and low(less than 4 benefits) awareness categories.
DST	=	Distance to nearby market in kilo metres (availability)

In this study the factors influencing adoption decision are studied using Logistic Regression analysis. Since dependent variable, Adoption assumes the values of 1 and 0, the most appropriate tool for analysis will be Logit Analysis. Using this this analysis, we can identify the factors influencing biopesticide adoption decision.

3.5.3.1. Definition of variables and working hypothesis

Adoption of biopesticides is a dichotomous type represented by a value of 1, if a farmer adopts and a value of 0, otherwise. Based on apriori assumptions the expected sign for each variable is discussed below.

Table 3.4. Definition and expected sign for each variable included in the model

Variable	Definition	Expected sign
Dependent Variable Adoption or Non-adoption	If farmer adopts means 1 otherwise 0	
Explanatory variables		
Farmers' age (AGE)	Age in years. As farmers advance in age, risk aversion increases and adopting a new technology seems less likely.	-
Education (EDU)	Number of schooling years. Variable indicating that education should increase a farmer's ability to obtain process and use information relevant to the adoption of a new method.	+
Number of farm workers in the household (FWR)	Labour is measured in number of adult farm workers in the family. Large households will be able to provide the necessary labour required for timely operation	+
Farm size(FZE)	Farm size in hectares. It is an indicator of wealth and perhaps a proxy for social status. As the farm size increases technology adoption level also increases.	+
Number of livestock owned(LTK)	Number of livestock. If more number of livestock means organic manure availability will be increased which will positively influences the adoption of less chemical inputs in paddy cultivation	+
Annual income (INC)	Annual income in Rupees. Higher income enables the farmer to adopt new technologies.	+
Frequency of contact with the extension agent(FXT)	Better contact with the extension workers result in households making better farming decisions including the adoption of a new practise Not at all = o, occasionally = 1, quarterly = 2, fortnightly = 3 monthly = 4 , weekly = 5	+
Awareness Level (AL)	AL will positively influence the adoption of biopesticides	+
Distance to nearby market in kms.(DST)	Distance will negatively influence the adoption	-

3.5.4. Environmental benefits of biopesticides: Environmental Impact Quotient (EIQ)

There are different approaches to quantify the environmental impact of pesticide use. Kovach *et.al.,(*1992) developed Environmental Impact Quotient(EIQ) to measure environmental impact of different pesticides. EIQ value of individual pesticide refers to the average of its effect on farm worker, consumer and environment.

$$EIQ=\{C[(DT*5)+(DT*P)] + [(C*((S+P)/2)*SY)+(L)] + [(F*R)+(D*((S+P)/2)*3)+(Z*P*3)+(B*P*5)]\}/3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

Where,

DT=dermal toxicity
C=chronic toxicity
SY=systemicity
F=fish toxicity
L=leaching potential
R=surface loss potential
D=bird toxicity
S=soil half life
Z=bee toxicity
B=beneficial arthropod toxicity
P=plant surface half life

To account for different formulations of the same active ingredient and different use patterns, a simple equation called EIQ Field use rating was developed.

EIQ Field use rating=EIQ* per cent of active ingredient* Rate of application of chemical

With this method comparisons of environmental impact between pesticides and different pest management programmes can be made.

In this study, the environmental benefits of biopesticide use are assessed using Environmental Impact Quotient Analysis. Since the farmers in the study area are using chemical pesticides, it was essential to assess the beneficial effects of Biopesticide use. The continuous application of chemical pesticides will reduce the quality and beneficial microbial population of the soil. The reduction in the natural enemy population will result in pest resurgence also. The previous studies under taken in the study area revealed the indiscriminate use of pesticides and its' health effects and environmental problems (Indira Devi, 2007). There are several benefits of Biopesticide use like environmental safety, safety of the applicator, beneficial to the Natural enemy population. But through this analysis we can assess the environmental impacts of different pest management methods. In the study area the some of the adopter farmers are using chemicals also, but in recommended dosage only. But, the non- adopter farmers are applying the plant protection chemicals indiscriminately.

3.5.5. Constraints in the adoption of biopesticides: Garrett's ranking technique

This method was suggested by Garrett for converting the ranks into scores, when number of items ranked differed from respondent to respondent. A set of factors restricting the adoption of biopesticides in paddy cultivation has been listed out and respondents were asked to rank them in the order of their importance. Then it was converted to the ranks by using the following formula

$$\text{Per cent position} = 100 - (R_{ij} - 0.5)/N_j \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Where,

R_{ij}=rank given for i^{th} factor by j^{th} individual

N_j=number of factors ranked by j^{th} individual

By referring the table given by Garett, the per cent positions obtained were converted into scores, then for each factor the scores of various respondents were added and mean is calculated. The mean scores were arranged in a descending order. The reason with the highest mean score was considered to be most important.

In this study also, the constraints in the adoption of biopesticides are ranked using Garrett's ranking technique. Through this ranking method I could find out the major constraints in the adoption of biopesticides in Paddy farms in the study area.

CHAPTER IV

DESCRIPTION OF THE STUDY AREA

A proper perspective of the study region is absolutely essential to have a better understanding of the results of the study and in turn to draw meaningful conclusions. With this in view, a detailed profile of the study area is presented in this chapter.

4.1. Location and general description

The State of Kerala is a small, narrow strip of land having an area of 38.86 lakh ha (1.185% of the national land area), on the extreme west coast of India. With a coastline of 590 Kms it does not exceed 100 Kms at its widest point. It is situated west of Western Ghats in the humid tropics between the latitudes of 8°18’ and 12° 48’N and longitudes of 74°28’ and 77°37’E. Kerala named as “Gods own country” and the “Gateway of monsoon in India” is well known for its natural beauty, rich biodiversity and tropical rainforests. The name of the State “Kerala” is derived from “Kera” meaning coconut. The state is bordered by Karnataka to the north and northeast, Tamil Nadu to the east and south and the Arabian Sea on the west. Kerala is divided into 14 revenue districts.

Constituted on November 1, 1956 it comprised of the erstwhile Malabar district in the North, the whole of the former Cochin, part of the former Travancore-Cochin State in the centre and the major part of the Travancore State in the South. Among the three, Travancore was the largest accounting for more than half of the area. In terms of its physical features, the land is divided into four distinct types: (i) the highlands vouching the Western Ghats (ii) the midlands (iii) the lowland plains and (iv) the coastal belt. Over 40 rivers feed it. The undulating topography of the state, the tropical climate (high incidence of sunlight, rainfall and warm temperature) as also the cool temperature of the hills generate variety of agro-climatic conditions which lead to growth of a range of crop species.

Alappuzha is a district of immense natural beauty with the Arabian sea on the west, a vast network of backwaters, lagoons and fresh water rivers crisscrossing the land. The district was formed on 17th August 1957. Alappuzha (Alleppey) is one of the well-developed coastal districts in southern part of Kerala State covering an area of 1,414 sq.km. It is the smallest district accounting 3.64 per cent of the area of the State. The district lies between 9 ^{0} 5 ' north latitude, 76 ^{0} 17 ' and 76 ^{0} 44 ' east longitudes. It is surrounded by Lakshadweep sea on the west, Kottayam and Pathanamthitta districts in the east, Kollam district in the south and

Ernakulam district in the north. The district has 6 taluks viz. Cherthala, Ambalappuzha, Kuttanad, Karthikapally, Chengannur and Mavelikara which comprises 12 blocks, 71 panchayats and 5 municipalities. The district head quarter is well connected by good roads and rail. The National Highway NH-47, the Main Central road and the Delhi - Mumbai - Trivandrum broad-gauge line are passing through this district. Alappuzha town is criss-crossed by navigable canals that are connected to Cochin in the north and other important towns in the east. A singularity of this land in the region called **'Kuttanad'** a land of lush paddy fields referred to as the **`Rice Bowl of Kerala'** which is one of the few places in the world where farming is done below sea level.

4.2. Administration

The District is divided into two Revenue Divisions, six Taluks and 91 Villages. Revenue Division Alappuzha comprising of Cherthala, Ambalappuzha and Kuttanad Taluks and Chengannur Revenue Division consisting of Karthikapally, Chengannur and Mavelikkara Taluks. Alappuzha Revenue Division covering 47 Villages and Chengannur Revenue Division covering 44 Villages. The District has twelve Block Panchayats which are divided into seventy three Grama Panchayats. The urban bodies in the District are Kayamkulam, Mavelikkara, Chengannur, Alappuzha and Cherthala Muncipalities. The total geographical area of the District is covered by 91 villages spread over 12 blocks, 73 panchayaths and 5 muncipalities. The details are given in Table 4.1.

Table 4.1.Taluks and number of villages

Sl.No	Name of Taluk	No. of Villages
1	Ambalapuzha	13
2	Chengannur	11
3	Cherthala	20
4	Karthikappally	18
5	Kuttanad	14
6	Mavelikkara	15
	Total	91

Source: Records of the Office of Principal Agricultural Officer, Alappuzha,2014

4.3. Human resources

4.3.1. Demographic details

Demographic details of the district as per 2011 census are furnished in Table 4.2.

Table 4.2. Demographic details of Alappuzha district and Kerala state -2011

(Numbers)

Sl.No.	Particulars	Alappuzha District	Kerala state
1.	Total Population	2127789 (100.00)	3,34,06,061 (100.00)
	a. Male	1013142 (47.61)	1,60,27,412 (47.98)
	b. Female	1114647 (52.38)	1,73,78,649 (52.02)
2	Rural Population	979643 (46.04)	1,74,71,135 (52.30)
3.	Urban Population	1148146 (53.95)	1,59,34,926 (47.70)
4.	Percentage Decadal Growth 2001-2011	0.61	4.86
5.	Total Literacy	1852797 (87.07)	2,81,35,824 (84.22)
	a. Male	890552 (41.85)	1,37,04,903 (41.03)
	b. Female	962245 (45.22)	1,44,30,921 (43.20)
6.	Sex ratio	1100	1,084
7.	Density of Population(per sq.km)	1501	859

(Figures in the parenthesis shows percentage to total)

Source: Census-2011, Panchayat Level Statistics 2011-Alappuzha District, Directorate of Economics and Statistics, Thiruvananthapuram

The district has a population of 2127789 persons which was accounted for 6.3 per cent of the total population of the state according to the 2011 census. Out of 21.28 lakhs population, 9.79 lakhs persons (46.04 per cent) from rural area and urban population is 11.48 lakhs (52.38 per cent). The density of the population is 1501 per sq.km. Decadal growth rate for the period 2001 - 2011 is 0.61 per cent in comparison with the state figures of 4.86 per cent. The sex ratio of the district is 1100 females for 1000 males. This is in consonance with the unique pattern of the state, which is contrary to the all India figure of 940 females per 1000 males. The total literacy rate was 87.07 per cent. The level of literacy was found to be higher among females than males.

4.3.2. Occupational distribution of workers

The main workers are classified into four categories viz. cultivators, agricultural labourers, household industrial workers and other workers as per the Census 2011. The other workers category includes the primary sector workers like fishermen, workers engaged in mining and plantation workers also. Occupational distribution of workers as per 2011 Census is shown in Table 4.3.

Table 4.3. Distribution of main workers in Alappuzha district and Kerala state-2011

(Numbers)

Sl. No.	Category	Alappuzha District	Kerala State
1.	Agricultural Labourers	39491 (6.62)	9,19,136 (9.85)
2.	Cultivators	17805 (2.98)	5,44,932 (5.84)
3.	Household Industry workers	25155 (4.21)	1,98,281 (2.13)
4.	Other Workers	513936 (86.17)	76,67,398 (82.18)
5.	Total Workers	596387 (100.00)	93,29,747 (100.00)

(Figures in the parenthesis indicate percentage to total)

Source: Census-2011, Panchayat Level Statistics 2011- Alappuzha district, Directorate of Economics and Statistics, Thiruvananthapuram.

Among the main workers in the district, agricultural labourers were contributed 6.62 per cent followed by cultivators (2.98 per cent). Both of them were accounted for only 9.60 per cent of the main workers, where as in the state, their contribution was 15.69 per cent. The major share of the main workers (86.17 per cent) belongs to other workers category.

4.4. Physiography

A major part of the district is coastal plains. The general elevation of the area is less than 6 m above mean sea level with some parts of the area below mean sea level in the range of 1-2 m. Typical coastal geomorphic features such as beaches, shore platforms, spit and bars, beach ridges etc. are seen. A small part of the district in the southeast forms part of mid land hard rocks. The area east and southeast of Alappuzha town comprising 409 sq.km is known as Kuttanad region. It represents low-lying deltaic region characterised by wet lands. The beach ridges are suggestive of marine regression. Beach is very narrow and straight. The absence of extensive tidal plain and the intensive coastal erosion may be indicative of neo-tectonic activity. The beach between Purakkad and Trikkunnappuzha is undergoing active erosion.

Alappuzha district consists of 3 sub-micro region namely (1) Alleppey Coast (2) Kuttanad Low -lying Plains and (3) Chengannur Rolling Plains. Alleppey Coast is a low lying land having marshy areas in some places along the coast of the District comprising the whole of Cherthala taluk and part of Ampalappuzha, Karthikappally and Mavelikkara Taluks. The height of the land is very low-even below the sea level in some areas. Maximum height recorded is 18 m. in Vallikunnam Village of Mavelikkara Taluk. Kuttanad Low-lying Plains comprises of the whole of Kuttanad Taluk and parts of Ampalappuzha, Chengannur, Mavelikkara and Karthikappally Taluks. The height of this region in many places is lower than the sea level and the maximum height recorded in Kunnamangalam Village is 6 m. Chengannur- Rolling Plain lies in the eastern portion of the District comprising parts of Mavelikkara and Chengannur Taluks. Average height of this region is between 80 and 90 m. The District has a flat unbroken sea coast of 82 km. length which is 13.9 per cent of the total coastal line of the State.

4.5. Climate and rainfall

The district has a tropical humid climate with an oppressive summer and plentiful seasonal rainfall. The period from March to the end of May is the hot season. This is followed by the southwest monsoon season, which continues till the end of September. During October and major part of November southwest monsoon retreats giving place to the northeast monsoon, and the rainfall up to December is associated with northeast monsoon season.

Generally March and April months are hottest and December and January months are coldest. At Alappuzha the maximum temperature ranges from 28.8 to 32.7ºC whereas the minimum temperature lies between 22.6 to 25.5ºC. The average annual maximum temperature is 30.7ºC and the average annual minimum temperature is 23.9º C. The wind is predominantly from east and northeast during morning hours and during the evening hours the predominant wind direction is from west and northwest. The wind speed is low in Kayamkulam. The wind speed is high during May (13.6 kmph) at Alappuzha. The humidity is higher during the monsoon period, June to September. It is around 87 per cent at Alappuzha and 84 per cent at Kayamkulam. All through the year, the humidity is high during the morning hours.

The details of rainfall distribution are presented in Table 4.4. From the Table 4.4, it was clear that the district received an average of 2840.5 mm as the normal rainfall. Out of this, southwest monsoon contributed the major part of the annual rainfall. The southwest monsoon season from June to September contributed nearly 69 per cent of the annual rainfall. This is followed by the northeast monsoon season from October to December, which contributed about 12.70 per cent of the annual rainfall, and the balance 18.3 per cent is accounted for January to May months. The study district received less than the state level rainfall. The deviation per cent was also higher in study district than the state.

Table 4.4. Rainfall distribution of Alappuzha district and Kerala state for the year-2012-13

Sl .No.	Month	Alappuzha (mm)	Kerala (mm)
1	July	271.5 (13.3)	362.5
2	August	407.1 (19.9)	504.1
3	September	195.4 (9.5)	239.9
4	October	151.0 (7.4)	188.1
5	November	105.2 (5.1)	114.4
6	December	5.5 (0.2)	9.7
7	January	51.5 (2.5)	3.7
8	February	88.4 (4.3)	39.1
9	March	49.8 (2.4)	50
10	April	40.3 (1.9)	50.2
11	May	137.4 (6.7)	118.6
12	June	535.8 (26.2)	1041.1
13	Actual	2038.9	2706.4
	Normal	2840.5	2936.7
	Deviation (per cent)	-28.2	-7.8

(Figures in the parenthesis indicate percentage to total)

Source: Agricultural Statistics, 2012-13, Directorate of Economics and Statistics,

4.6. Operational holdings

The distribution of operational holdings in Alappuzha district is given in Table 4.5.

On an average 98.43 per cent operational holdings were coming under marginal type category which accounts for 75.60 per cent of the area. Average holding size under this category was 0.10 ha. Large holdings were less in number, which comes around 0.01 per cent of the total operational holdings. Small and marginal famers dominate in the study area.

Table 4.5. Distribution of operation holdings in Alappuzha district -2011-12

(Hectare)

Sl. No.	Size category	Numbers	Area	Average holding size
1.	Below 1 ha	469853 (98.43)	50771.85 (75.60)	0.10
2.	1-2 ha	5285 (1.10)	8214.03 (12.23)	1.55
3.	2-4 ha	1712 (0.35)	4861.87 (7.24)	2.83
4.	4-10ha	408 (0.08)	2243.08 (3.33)	5.40
5.	Above 10 ha	85 (0.01)	1670 (2.48)	19.64
	Total	477343 (100.00)	67160.83 (100)	

(Figures in parentheses indicates per cent to total)

Source: Records maintained in the office of Principal Agricultural Office, Alappuzha

4.7. Livestock resources

Cattle wealth is of considerable importance to the people of the district whose main occupation is agriculture. The predominance of the cattle population with 53.10 per cent as evident from the table could be correlated with the prevalence of paddy cultivation in the district. The availability of organic manure will influence the adoption of organic methods in paddy cultivation. The straw can be utilized as feed for the cattle. Similarly, the organic manure like cow dung can be used in paddy cultivation. Since the study area is a major paddy producing district, obviously the cattle population must be high.

The total animal wealth of the district is furnished in Table 4.6.

Table 4.6. Distribution of animal wealth in Alappuzha district

Sl.No.	Particulars	Numbers	Percentage to total
1.	Cattle	64805	53.10
2.	Pig	472	0.003
3.	Buffaloes	2736	0.02
4.	Dog	46363	37.99
5.	Rabbit	10399	8.52
	Total livestock	122039	100.00

Source: Panchayat Level Statistics Report 2011, Directorate of Economics and Statistics, Thiruvananthapuram.

4.8. Irrigation pattern

Alappuzha district is mainly drained by Pamba river and its tributaries viz. Achancovil and Manimala rivers. The Pamba river drains over an area of 804 sq.km of the district and form a deltaic region skirting the south eastern, southern and south western fringes of Vembanad lake. The Manimala river enters the Kuttanad area at Thondara and confluences with Pamba river at Neerettupuram. Achancovil river enters Kuttanad at Pandalam and joins Pamba river at Veeyapuram. Vembanad lake, the largest back water in the State lies on the north eastern part of the district separating Alappuzha from Kottayam district.

There are no major irrigation projects in Alappuzha district. However, about 19 sq.km. in the south-western part of the district is benefited by the Pamba Irrigation Project. Minor and lift irrigation projects irrigate an area of about 181 sq. km.

The details of the crop-wise area irrigated are given in Table 4.7. The district had a gross area of 46375 ha under irrigation in 2012-13 which was found to be 44.46 per cent of the gross cropped area in the district. Paddy occupied 76.50 per cent of the gross irrigated area. Coconut occupied next position with 14.44 per cent of the gross irrigated area in the district. Inverse pattern is seen in the state with 35.92 per cent for coconut and 32.08 per cent of the gross irrigated area for Paddy. Vegetables and Tuber crops are the next most irrigated crops in the district with 2.87 per cent and 0.50 per cent of the gross irrigated area respectively. Also 1.14 per cent of the gross cropped area in the study district is occupied by Banana.

Table 4.7. Crop-wise gross area under irrigation in study area during 2012-13

(Hectare)

Sl.No.	Crop	Alappuzha District	Kerala State
1.	Paddy	35477 (76.50)	1,46,938 (32.08)
2.	Tubers	231 (0.50)	619 (0.13)
3.	Vegetables	1333 (2.87)	21,019 (4.59)
4.	Coconut	6700 (14.44)	164491 (35.92)
5.	Nutmeg	82 (0.18)	15468 (3.37)
6.	Other spices & Condiments	7 (0.02)	496 (0.11)
7.	Banana	530 (1.14)	44,336 (9.68)
8.	Sugarcane	11 (0.02)	1697 (0.37)
9.	Other crops	1945 (4.19)	26,202 (5.72)
	Total	46375 (100.00)	457896 (100.00)

(Figures in parentheses indicates per cent to total)

Source: Agricultural Statistics 2012-2013, Directorate of Economics and Statistics, Thiruvananthapuram

Source wise net area irrigated under the district and state in 2012-13 was 40130 ha and 395868 ha respectively. The source wise details of irrigated area is furnished in Table 4.8. Tube wells are major irrigation source, followed by government canals in the district each contributing to 15.15 per cent and 6.03 per cent of the net irrigated area in the district. Whereas in the state, contribution of private wells and government canals were 30.79 per cent and 20.39 per cent respectively. Tube Wells account for 6.60 per cent net area irrigated in the state.

Table 4.8. Source-wise net area under irrigation in study area during 2012-13

(Hectare)

Sl.No.	Source	Alappuzha District	Kerala State
1.	Government Canal	2420 (6.03)	80718 (20.39)
2.	Private Canal	-	2457 (0.62)
3.	Government Tanks	-	1275 (0.32)
4.	Private ponds	449 (1.12)	42283 (10.68)
5.	Government Wells	5 (0.01)	417 (0.10)
6.	Private Wells	839 (2.09)	121921 (30.79)
7.	Minor Irrigation	-	6772 (0.16)
8.	Other Sources	34 (0.08)	34404 (8.69)
9.	Tube wells	6081 (15.15)	26148 (6.60)
10	Rivers	30302 (75.50)	79473 (20.07)
	Total	40130 (100.00)	395868 (100.00)

(Figures in parentheses indicates per cent to total)

Source: Agricultural Statistics 2012-2013, Directorate of Economics and Statistics, Thiruvananthapuram

4.9. Land utilization pattern

The particulars on land utilization pattern of the district are presented in the Table 4.9. The total geographical area of the district is 141011 hectares. Though the area covered by forest in the state was 27.83 per cent, it was nil in the study district. The share of current fallows, cultivable waste, fallow land other than current fallows, land put to non-agricultural use, net sown area and total cropped area to total geographical area of the district were found greater than that of the State. Net area sown accounted for 60.53 per cent, which was higher than the State's average of 52.70 per cent. But the cropping intensity in the district (122.17 per cent) was lesser than that of the State (126.54 per cent).

Table 4.9. Land utilization pattern in the district and the state

(Hectares)

Sl.No.	Particulars	Area	
		Alappuzha	**Kerala**
1.	Total Geographical area	1,41,011 (100.00)	38,86,287 (100.00)
2.	Forest	0 (0.00)	10,81,509 (27.83)
3.	Barren and uncultivable land	23 (0.016)	16,354 (0.42)
4.	Land put to non agricultural uses	22,522 (15.97)	4,02,577 (10.35)
5.	Cultivable waste	12,829 (9.09)	96,596 (2.48)
6.	Permanent pastures and other grazing lands	1 (0.0007)	118 (0.003)
7.	Land under miscellaneous tree crops	64 (0.04)	2799 (0.07)
8.	Current Fallow	2898 (2.05)	76,744 (1.97)
9.	Fallow other than current fallow	1928 (1.36)	55,835 (1.43)
12.	Water Logged Area	328 (0.23)	2840 (0.07)
14.	Net area sown	85,361 (60.53)	20,48,109 (52.70)
15.	Area sown more than once	18,926 (13.42)	5,43,625 (13.98)
16.	Total cropped area	1,04,287 (73.95)	25,91,734 (66.68)
17.	Cropping intensity	1.22	1.26

(Figures in the parenthesis shows percentage to total)
Source: Agricultural Statistics,2012-13, Directorate of Economics and Statistics, Thiruvananthapuram

4.10. Soil

On the basis of morphological and physico-chemical properties, the Soil Survey Division of Department of Agriculture, Govt. of Kerala have classified the soils of the district into four types viz. (1) Coastal alluvium (Entisols), (2) Riverine Alluvium (Inceptisols) (3) Brown hypidimorphic soil (Alfisols) and (4) Lateritic soil (Oxisols).

Coastal Alluvium (Entisols)

These soils are seen along the western parts of the district all along the coast and have been developed from recent marine and estuarine deposits. The texture is dominated by sand fraction and is extensively drained with very high permeability. These soils have low content of organic matter and of low fertility level. This soil is ideal for the cultivation of Coconut.

Riverine alluvium (Inceptisols)

These soils occur mostly in the central pedi-plains and eastern parts of the area along the banks of Pamba river and its tributaries and show wide variation in their physico-chemical properties depending on the nature of alluvium that is deposited and characteristics of the catchment area through which the river flows. They are very deep soils with surface textures ranging from sandy loam to clayey loam and moderately supplied with organic matter like nitrogen and potassium. Paddy is the major crop that can be cultivated in this type of soil.

Brown hydromorphic soil (Alfisols)

These are mostly confined in the western low-lying areas of the district along the coast. These soils have been formed as a result of transportation and sedimentation of material from the adjoining hill slopes and also through deposition by rivers and exhibit wide variation in their physical and chemical properties. They are moderately supplied with organic matter like nitrogen, potassium and deficient in lime and phosphate. This soil is used for the cultivation of Paddy and sugarcane.

Lateritic soil (Oxisols)

The laterite soil is the resultant of weathering process of Tertiary and Crystalline rocks under tropical humid conditions and is seen in the south-eastern part of the district. Heavy rainfall and temperature prevalent in the area are conducive to the process of formation of this soil type and have been formed by leaching of base and silica from the original parent rock with accumulation of oxides of iron and Aluminium. They are poor in nitrogen, phosphorous, potassium and low in bases. The organic content is also low and is generally acidic with pH ranging from 5.0 to 6.0. This soil is ideal for the cultivation of coconut, arecanut and fruit trees.

4.11. Ground water

Alappuzha district consists of Coastal alluvium comprising of sand and clay along the coastal region and flood plain deposits in Kuttanad region. Residual laterite formations are encountered in south-eastern parts of the district and Granites are encountered in and around Chengannur area. The Charnockite, Khondalite and Granites form the basement. Charnockites and Khondalites are encountered at depth. They are overlain by Tertiaries. The laterite/alluvial sediments overlay the Tertiaries. Alappuzha is the only district in Kerala where domestic water requirement is met from groundwater source on a large scale. Requirements for drinking water supply source are met with from a large number of tube wells. The major abstraction of groundwater is from Tertiary sedimentary formation.

4.12. Rivers, Lakes and Backwaters

The Manimala, the Pamba and Achancovil River are the important rivers flowing through the district. The Manimala River flowing through the Thalavady, Edathua and Champakulam Village in Kuttanad Taluk. The Pampa River enters the District at Chengannur and flows through Pandanad, Veeyapuram,Thakazhi and Champakulam. The Achacovil River passess through Venmony, Cheriyanad, Puliyoor, Chengannur Villages and Chennithala in Mavelikkara Taluk. The Vembanad lake and the Kayamkulam lake are the two important backwaters of the District. The Vembanad lake has a length of 84 km. and average breadth of 3.1 km. The District has a flat unbroken sea coast of 82 km. length which is 13.9 per cent of the total coastal line of the State.

The Alappuzha town is full of man- made canals and bridges designed for promoting trade by water and road designed by Sri.Raja Kesavadas former Divan of State of Travancore. With the development of Cochin port and road transport, the importance of Alappuzha port diminished. Recently Government has taken action to rennovate Alappuzha port. Alappuzha district is mainly drained by Pamba river and its tributaries viz. Achankovil and Manimala rivers. The Pamba river drains over an area of 804 sq.km of the district and form a deltaic region skirting the south eastern, southern and south western fringes of Vembanad lake. The Manimala river enters the Kuttanad area at Thondara and confluences with Pamba river at Neerettupuram. Achancovil river enters Kuttanad at Pandalam and joins Pamba river at Veeyapuram. Vembanad lake, the largest back water in the State lies on the north eastern part of the district separating Alappuzha from Kottayam district.

4.13. Specific features of paddy cultivation in Kuttanad

Kuttanad region which represents the low- lying lands measuring 25 kilometers east west and 60 kilometers north south is one of the two major rice producing areas in Kerala. Originally it was part of the coastal area of the Arabian Sea, which became a shallow bay due to a geological uplift. The incessant inflow of silt carried by the rivers Meenachil, Pamba, Achencovil and Manimala over thousands of years accumulated in this shallow bay and gradually made it an extensive brackish water lagoon and backwater system extending from Alapuzha in the south to Kochi in the north. In course of time the shallow parts of the lagoon further silted up by the river systems became wet lands while the deeper parts of it still remain as backwaters.

Compared to other paddy growing areas in Kerala, paddy cultivation in Kuttanad region has certain unique characteristics. Paddy lands in this region are divided into contiguous blocks called ‘Padasekharams’ bound by waterways, rivers and other natural partitions. Many of such padasekharams are man- made in the sense that they are reclaimed lands from the bed of backwaters. Hence it is said that ‘while god created earth, man created Kuttanad’. The size of padasekharams ranges from less than one hectare to more than 1000 hectares.

As *puncha* crop (summer crop) is the traditional crop in Kuttanad during which 80 per cent of the paddy fields are sown, from early days paddy cultivation in this region is called puncha cropping. The season begins from October-November when the operation of bailing out water from padasekharams starts. The other season is the *virippu* season (autumn or varsha crop) in which 40 per cent of the paddy lands are cultivated. Padasekharams where the second crop is not raised are submerged under water for most part of the year. Before the completion of the Thanneermukkom Salt water Barrier, the low lying areas in this region were periodically inundated with saline water by the tidal inflows from the Arabian Sea.

Compared to the other rice producing areas in the state, productivity of paddy crop is higher in Kuttanad region. Similarly, the per hectare cost of cultivation is also found to be higher in this region. The wetland eco system of the region is helpful to the excessive growth and spread of weeds and insects. The incidence of plant diseases and rate of crop failures are relatively higher in this area. Leaf blight, leaf blast, sheath rot etc. are the major diseases of rice in the study area. Stem borer, leaf roller, leaf folder, Gall midge etc. are the major insect pests in the study area. The high degree of human intervention in the natural endowment of the region coupled with the indiscriminate use of pesticides and chemical fertilizers over the past several years has caused irrevocable damage to the ecosystem of Kuttanad (Thomas, 2002).

4.14. Efforts to increase intensity and productivity of paddy crop

It was rather impossible to raise a second crop in this region due to the flood submergence during the monsoon months and saline intrusion during the summer months. In order to tackle this problem the state government undertook three major construction projects viz., Thottappally spillway, R Block-Holland project and Thanneermukkom salt-water barrier during the period 1950 to 1975 as part of the Kuttanad Development Scheme which detailed below.

4.14.1. Thottappally spillway

Due to the accumulation of flood waters from the river systems in Kuttanad water level used to rise beyond manageable limits soon after the onset of the southwest monsoon. The entire low lying areas of the region used to remain flooded till the end of north east monsoon making it impossible to raise a second crop during the autumn season. Detailed hydraulic surveys conducted from the early thirties had shown that this problem could be mitigated by diverting the floodwaters directly to the Arabian sea at the extreme south of the flood limit itself.

Accordingly, the construction of a spillway was started in 1951 at Thottappally located 20 kilometers south of Alappuzha town. The maximum monthly dispatch of floods entering the Kuttanad region during the monsoon months was estimated as 69000 cusecs and the spillway was designed to discharge more than 90 per cent of it directly to the sea. However, while designing the spillway the problem of piling up of water due to the raising sea level during the monsoon months and the consequent formation of sand bar on the seaward side of the spillway was not taken into account. Therefore after the spillway was completed in 1955, the realized capacity of it is found to be less than one - thirds of the estimated capacity and hence fails to serve its purpose to some extent.

4.14.2. R Block - Holland project.

The construction of permanent outer bunds around the R Block kayal lands under the R Block - Holland Project that was started in 1961 is a landmark in the history of paddy cultivation in Kuttanad. The embankments built earlier as part of reclamation were made of mud and were not strong enough to withstand the incessant wave action. Most of them were submersible under floodwaters during the monsoon months. Under the R Block - Holland Scheme permanent and non-submersible bunds that stood six feet above the MSL with a top width of ten feet and a total length of 10.4 kilometers were erected around the R Block kayal lands. Later in the 1970’s the Kerala Land Development Corporation (K L D C) initiated a Bund Improvement Scheme for the repair and strengthening of ring bunds in kayal lands. However, the project had been dropped half way due to the paucity of sufficient funds.

4.14.3. Thanneermukkom salt water barrier.

From the early days of reclamation, destruction of puncha crop due to the ingress of saline water had been a recurring phenomenon in the kayal lands of Kuttanad area. Thanneermukkom Salt Water Barrier was envisaged to mitigate the problem of saline water intrusion in to the Kayal lands located in the south of Thanneermukkom during the summer months when the fresh water inflow of the feeder river systems becomes weak. The project in addition to protect the summer crop from water salinity also aimed to facilitate a second crop soon after the puncha season. Eventhough the construction of the Bund had begun in 1958 it was commissioned only in 1975. The Barrier is built across the Vembanad kayal connecting Vechoor in the east to Thanneermukkom in the south. Every year regulators of the Bund are lowered in December to prevent the entry of saline water in to Vemband lake and remain closed till May when the discharges from feeder rivers improve with the pre monsoon rains. After the construction of this Barrier it is possible to raise a second crop in most of the puncha lands.

4.15. Cropping pattern in the study area

The cropping pattern of the study district (Table 4.10) showed that in Alappuzha district, paddy, coconut, tapioca were the major crops cultivated. In food crops, paddy is the major crop which accounted for about 34.70 per cent of total cropped area of the district and 7.6 per cent of total paddy area of the State. Coconut which constituted about 35.46 per cent of the total cropped area of the District. Rice production in the District is 36195 tonnes during the year 2012-13. Out of the total rice production in the District nearly 63.76 per cent is from summer crop. Champakulam, Veliyanad and Ambalappuzha blocks together produced 82.79 per cent of rice in the District.

Table 4.10. Area under major crops in Alappuzha and Kerala during 2012-13

(Hectare)

Sl.No.	Crop/ Crop category	Alappuzha	Kerala
1	Paddy (Gross area)	36,195 (34.70)	1,97,277 (7.6)
2	Total Cereals/Millets	36,195 (34.70)	1,97,792 (7.63)
3	Banana	631 (0.60)	61,011 (2.35)
4	Total Fruit crops	9976 (9.56)	3,61,795 (13.95)
5	Tapioca	2545 (2.44)	69,586 (2.68)
6	Total Tubers	1337 (1.28)	19,789 (0.76)
7	Total Vegetables	1798 (1.72)	4083 (0.15)
8	Total food crops	57,111 (54.76)	9,66,954 (37.30)
9	Coconut	36,986 (35.46)	7,98,162 (30.79)
10	Total oilseed crops	37,168 (35.64)	8,00,220 (30.87)
11	Total Spices and Condiments	3027 (2.90)	2,69,546 (10.40)
12	Rubber	4420 (4.23)	5,39,561 (20.81)
13	Total non-food crops	5465 (5.20)	155501 (5.99)
14	Total cropped Area	1,04,287 (100.00)	2591734 (100.00)

(Figures in the parenthesis shows percentage to total)

Source: Agricultural Statistics,2012-13, Directorate of Economics and Statistics, Thiruvananthapuram

4.16. Paddy area under High Yielding Varieties (HYV)

Area under High Yielding Varieties of paddy is furnished in Table 4.11. From the Table 4.11, it was noticed that 99.56 per cent of the total area under paddy was under High Yielding Varieties which was higher than the HYV coverage of the state. Compared to other seasons, HYV coverage was more in summer season i.e.,100 per cent.

Table 4.11. Area under HYV paddy in the study district during 2012-13

(Hectare)

Sl.No.	Season	Alappuzha District		Kerala State	
		Area under HYV	Total area	Area under HYV	Total area
1.	Kharif	10665 (98.88)	10785 (100.00)	61764 (97.67)	63232 (100.00)
2.	Rabi	5076 (99.29)	5112 (100.00)	75551 (87.08)	86751 (100.00)
3.	Puncha	20325 (100.00)	20325 (100.00)	47169 (99.73)	47294 (100.00)
	Total	36066 (99.56)	36222 (100.00)	184484 (93.51)	197277 (100.00)

(Figures in parentheses indicates percentage to total area)

Source: Agricultural Statistics 2012-13, Directorate of Economics and Statistics, Thiruvananthapuram

4.17. Production and productivity of rice in Alappuzha District

The details of production and productivity of paddy are presented in Table 4.12. Production was highest in summer season. Puncha crop is the major crop contributing to the total rice production of the study area. On an average 54.53 per cent of the rice production of Alappuzha district is provided by summer crop. Uma is the variety used by more than 95 per cent of the farmers in Alappuzha district. Average productivity was 2.93 t/ha in Alappuzha district which was higher than the state average of 2.61 t/ha.

Table 4.12.Production and productivity of rice in Alappuzha and Kerala

(tonnes per hectare)

Sl.No.	Season	Production		Productivity	
		Alappuzha District	Kerala State	Alappuzha District	Kerala State
1.	Kharif	32362 (30.94)	161083 (31.69)	3.00	2.54
2.	Rabi	15188 (14.52)	212607 (41.82)	2.97	2.45
3.	Summer	57043 (54.53)	134609 (26.48)	2.80	2.84
	All seasons	104593 (100.00)	508299 (100.00)	2.93	2.61

(Figures in parentheses indicates per cent to total production of all seasons)

Source: Agricultural Statistics 2012-13, Directorate of Economics and Statistics, Thiruvananthapuram

4.18. Infrastructural facilities

a. Transport and communication

The district has a total road length of 2964.66 km of which 86.78 per cent are village roads. The details are furnished in Table 4.13.

Table 4.13. Details of transport facilities in Alappuzha -2011

Sl.No.	Particulars	Length (kms)	Percentage to total
1.	National Highways	24.1	0.008
2.	State Highways	43.7	1.47
3.	PWD Roads	289.96	9.78
4.	Other District Road	34	1.14
5.	Village Road	2572.9	86.78
	Total	2964.66	100.00

Source: Panchayat level Statistics Report-2011, Department of Economics and Statistics, Thiruvananthapuram

b). Banking and Cooperation

There are 640 Banking and Co-operative institutions in the district. Details are furnished in Table 4.14. Service Co-Operative Banks and Credit Societies ranks first with a total number of 159.

Table 4.14. Banks & Co-operative Institutions in the district

Sl.No.	Category	Total Number
1.	State Bank of India associates	98
2.	Nationalised Commercial Banks	146
3.	Scheduled Commercial Banks	121
5.	District Co-Op Bank Branches	55
6.	Service Co-Op Banks & Credit Societies	159
7.	Urban Co-Op Banks	4
8.	Employees Credit Societies	47
9.	Kerala State Agricultural & Rural Development Banks	10
	Total	640

Source: Panchayat level Statistics-2011, Department of Economics and Statistics, Thiruvananthapuram

4.19. Input supply firms

Input supply firms in the study area comprises of both public and private sector firms that supply major farm inputs such as seeds, seedlings, fertilizer, plant protection chemicals etc.

Table 4.15. Details of farm input supply firms in Alappuzha district

Sl. No.	Particulars	Number
1.	Fertilizer	
	Private	131
	Co-operative society	73
	FACT outlet	3
2.	Organic Manure	
	Private	2
	Co-operative society	1
3.	PPC	
	Private	114
	Co-operative society	44
4.	Seed farms	3
5.	Soil Testing Laboratories	1
6.	Fertilizer Testing Laboratories	1
7.	Seed Testing Laboratories	1
8.	Parasite Breeding Stations	1
9.	Sources of Technical Information	
	Rice Research Station	1
	Krishi Vigyan Kendra	1
	Agricultural Officers	78

Source: Records maintained in the office of the Principal Agricultural Officer,2014, Alappuzha

CHAPTER V

RESULTS AND DISCUSSION

To fulfil the objectives of the study, the data collected from the selected sample paddy farmers (adopters and non-adopters) of Alappuzha district were tabulated and analysed using suitable tools described in the study. The results are presented and discussed in this chapter for the adopter and non-adopter farmers under the following headings:

5.1. General characteristics of the sample respondents

5.2. Impact of bio pesticides use on crop yield, cost of cultivation and pesticide use

5.3. Factors influencing the adoption of bio pesticides for pest and disease management

5.4. Environmental benefits of bio pesticides use in pest and disease management

5.5. Constraints faced by the farmers in the adoption of bio pesticides

5.1. General characteristics of the sample respondents

General characteristics of the sample households like the family composition, age, educational status, farming experience, size of farm holdings, occupational pattern, sources of information, various chemical pesticides used, natural enemy population in rice fields, awareness level on benefits of bio pesticides use and personal characteristics play an important role in the decision-making process and adoption of environment friendly pest management practices.

5.1.1. Family composition of sample farmers

The size of the family and its composition determines the contribution of family labour and use of hired labour for various farming activities such as ploughing, puddling, seed sowing, transplanting, fertilizer application, weeding, irrigation and harvesting. Hence understanding of family composition is essential one. The family composition could be understood from Table 5.1, the average size of the family was 4.2 and 4.4 respectively for adopters and non-adopters farm categories. The average number of earners per family was 1.7 and 1.8 respectively in both categories. The earner-dependent ratio of the sample farm categories were 0.74:1 and 0.75:1 which implied that the number of dependents were more in both categories which necessitated for higher income and sustainability of paddy farms. It was observed that in study area, most of the people in the age group of 18-25 years were doing their higher studies. So the number of dependents were higher in the study area.

Table 5.1. Family composition of sample farmers

(Numbers)

Sl. No	Particulars	Adopters	Non-adopters
1	Average size of the family	4.2	4.4
2	Males	2.2	2.2
3	Females	2.0	2.2
4	Children	0.8	1.0
5	Earners	1.7	1.8
6	Dependents	2.3	2.4
7	Earner-Dependent ratio	0.74:1	0.75:1

5.1.2. Age of the sample farmers

Age of the farmers indirectly helps us to know about their experience and knowledge level in decision making.

Table 5.2 Age wise distribution of the sample farmers

(Numbers)

Sl. No	Age in years	Adopters	Non-adopters
1	Up to 40	6 (10.0)	7 (11.6)
2	41-50	14 (23.3)	15 (25.0)
3	51-60	24 (40.0)	21 (35.0)
4	More than 60	16 (26.6)	17 (28.3)
5	Total	60 (100.0)	60 (100.0)
6	Average age of the sample farmers (years)	55.4	54.0

(Figures in parenthesis indicate per cent to total)

From the Table 5.2, it was observed that, on an average 40 per cent of the adopter farmers and 35 per cent of the non-adopter farmers were in the age group of 51-60 years. Sixty six per cent of the farmers, under the category of adopters were in the age group of above 50. Average age for farmers, under the category of adopters was 55.4 and that for non-adopters was 54. Thirty three per cent of adopter farmers and 36.6 per cent non-adopter farmers were under the age less than or equal to 50. It showed that in study area, aged people are involving in agriculture. Under these age group the farmers were in a position to take decision wisely to manage and maintain the quality of natural resources.

5.1.3. Educational status of sample farmers

The level of education helps the farmer to understand the technicality of any new technology in a better way, which influences in adoption or in experimentation the new things in agriculture. The educational statuses of sample respondents are presented in Table 5.3.

It was observed from Table 5.3 that, on an average 63 and 22 per cent and 52 and 20 per cent of sample farmers had education up to secondary and higher secondary level respectively, both in adopted and non-adopted farm categories. Seventeen per cent of the non-adopter farmers had primary education level, whereas 3.3 per cent of the farmers in adopter category had education up to primary level. Proportions of collegiate were same for adopters and non-adopters.ie., 7 per cent. It implied that the education level was higher in adopted category of farms.

Table 5.3. Educational status of sample farmers

(Numbers)

Sl. No.	Educational status	Adopters	Non-adopters
1.	Primary	2 (3.3)	10 (16.6)
2.	Secondary	38 (63.3)	31 (51.6)
3.	Higher secondary	13 (21.6)	12 (20.0)
4.	Collegiate	7 (11.6)	7 (11.6)
	Total	60 (100.0)	60 (100.0)
	Average years of schooling	10	9

(Figures in parenthesis indicate per cent to total)

5.1.4. Farming experience of sample farmers

Farming experience is an important factor influencing the adoption decision of biopesticides in paddy farms. As the experience in paddy cultivation increases, farmers' ability to assess the impact of various practices followed in the paddy cultivation and their subsequent impact on environment and natural resources. The details of farming experience of selected sample farmers are presented in Table 5.4.

It could be inferred from the Table 5.4 that, about 62 per cent of the farmers under adopter category were having farming experience more than 20 years. Only 57 per cent of the non-adopter farmers were having farming experience more than 20 years. Fifteen per cent of the non-adopter farmers were having farming experience less than 10 years. But only 10 per cent of the adopter farmers were having farming experience less than 10 years.ie., Almost 90 per cent of the farmers under adopter category were having better farming experience. Nearly 28 per cent of the farmers under adopter as well as non-adopter category were having 10-20 years of farming experience. Thirty and 43 per cent of the sample farmers in the adopter and non-adopter category had farming experience more than 30 years. It showed that farming experience was higher for the farmers those who are in the adopter category.

Table.5.4. Farming experience of sample farmers

(Numbers)

Sl. No	Years	Adopters	Non-adopters
1	< 10 years	6 (10.0)	9 (15.0)
2	10-20 years	17 (28.3)	17 (28.3)
3	20-30 years	19 (31.6)	8 (13.3)
4	>30 years	18 (30.0)	26 (43.3)
5	Total	60 (100.0)	60 (100.0)

(Figures in parenthesis indicate per cent to total)

5.1.5. Occupational status of sample farmers

The occupational pattern of farmers helps us to know about the standard of living of farm households. The occupational status of sample farmers is presented in Table 5.5. From Table 5.5, it was observed that nearly 53 per cent of the adopter farmers are depending on agriculture as the main source for their livelihood. But only 44 per cent of the non-adopter farmers were depending on agriculture as their major source of income. Nearly 56 per cent of the non-adopter farmers were obtaining income from sources other than agriculture. For the farmers in the adopter category the agriculture is not only the source of income, but also a way of life. For farmers in the non- adopter category agriculture is just a source of income. Some of the family members of farmers under the non-adopter category are working in abroad. Farmers whose major source of income is from agriculture will have more opportunity to attend the various training programmes organised by KVKs and Krishi bhavan. Farmers depending on other sources of income may not be interested in attending the trainings organised by various resource persons and institutions.

Table.5.5. Occupational status of sample farmers

(Numbers)

Sl. No	Particulars	Adopters	Non-adopters
1	Primary	32 (53.13)	26 (43.75)
2	Secondary	28 (46.88)	34 (56.25)
3	Total	60 (100.00)	60 (100.00)

(Figures in parenthesis indicate per cent to total)

5.1.6. Size distribution of sample holdings

The size of the holding is a measure of wealth. Financial soundness of the farmers also influences the adoption of new technology. The farmers those who are having a safe financial position may be interested in experimenting new technology in agriculture.

Table 5.6. Size distribution of sample holdings

(Hectares)

Size group	Adopters			Non-adopters		
	Numbers	Total area	Average area	Numbers	Total area	Average area
Marginal (< 1.0 ha.)	7 (11.60)	5.82 (4.09)	0.83	8 (13.30)	6.95 (4.27)	0.87
Small (1.01 - 2.0 ha.)	26 (43.30)	36.41 (25.60)	1.40	15 (25.00)	22.6 (13.80)	1.50
Semi-medium (2.01 - 4.0 ha.)	24 (40.00)	75.41 (53.00)	3.14	27 (45.00)	75.24 (46.24)	2.78
Large (> 4.0 ha.)	3 (5.00)	24.59 (17.28)	8.19	10 (16.60)	57.92 (35.60)	5.79
Total	60 (100.00)	142.23 (100.00)	2.37	60 (100.00)	162.71 (100.00)	2.71

(Figures in parentheses indicate per cent to the total)

It was inferred from Table 5.6, that, more than 55 per cent of the adopter farmers were coming under small and marginal category. Only 5 per cent adopter farmers were large farmers, whereas almost 17 per cent of farmers under non-adopter category were large farmers. More than 60 per cent of the non-adopter farmers were medium and large farmers. In small farms, the family labourers are involving in agriculture intensively which motivates them to get aware and adoption of new (or) low cost technology at higher level.

5.1.7. Asset position of the sample farmers

Table 5.7. Average value of asset position of the sample farmers

(in Rupees)

Sl. No	Types of assets	Average value of assets	
		Adopters	**Non-adopters**
I	**Land asset**		
	Average land asset value	474100 (59.66)	571000 (59.83)
II	**Farm asset**		
A	Electric motor	19083 (2.40)	7350 (0.77)
B	Pump set	1000 (0.12)	633 (0.06)
C	Tractor	17500 (2.20)	33333 (3.49)
D	Farm implements	1633 (0.20)	7758 (0.81)
	Total farm assets	39216 (4.93)	49074 (5.14)
III	**House hold asset**		
A	House	250750 (31.55)	290800 (30.47)
B	Cattle shed	5545 (0.69)	7630 (0.79)
C	Vehicles	25035 (3.15)	35780 (3.74)
	Total house hold asset	281330 (35.40)	334210 (35.02)
	Total asset value	794646 (100.00)	954284 (100.00)

(Figures in parentheses indicate per cent to the total)

The average asset position of the sample households is presented in Table 5.7. It was assessed from Table 5.7 that, land and household assets form more than 95 per cent of the total value of farm households respectively both in adopters and on-adopters farm category.

Since majority of farmers in adopters category were small and marginal farmers, hence average value of their farm assets was lower (4.9 per cent) than non-adopter farm category (5.13 per cent).

5.1.8. Income distribution of sample households

The income level of farm households paves way for better consumption expenditure and expenditure towards adoption of new technologies in crop cultivation. The income distribution of sample farmers in study area is given in Table 5.8. It was observed from Table 5.8 that, on an average 56.16 and 39.03 per cent of total income was shared by on-farm activities followed by 38.48 and 58.80 per cent of total income was earned through non-farm sources. It was also noticed that the off-farm income contributed 5.34 per cent in adopter farm category and it was 1.76 per cent in non-adopter category, which revealed that most of the farmers in adopter category were involved in agriculture intensively. Average annual farm income for adopter farmers was 147000 rupees and that for non- adopters was 111571 rupees. Non- farm income for non -adopter farmers was higher than that of adopter farmers, which implies the dependence of non -adopter farmers on activities other than agriculture for their livelihood.

Table 5.8 Annual average income distribution of the sample farmers

(Rs/annum)

Sl. No	Sources of income	Annual house hold income	
		Adopters	Non-adopters
1	On farm	147000 (56.16)	111571 (39.03)
2	Off farm	14000 (5.34)	5033 (1.76)
3	Non farm	100740 (38.48)	168250 (58.80)
	Total	261740 (100.00)	285854 (100.00)

(Figures in the parenthesis indicate per cent to total)

5.1.9. Cropping pattern of the study area

The cropping pattern of the sample farms is given in Table 5.9. From the Table 5.9 it was understood that the sample farmers in both the categories allocated 35.95 and 36.23 per cent (0.87 and 1 ha) of their land area to staple food crop followed by 30.57 and 31.15 per cent (0.74 and 0.86 ha) and 28 and 30 per cent (0.67 and 0.83 ha) in vegetable and coconut crop which are commercial crops. Smaller proportion of land area was allotted to banana crop. The average area under paddy for adopter farmers was 0.87 ha and that for non-adopter farmers was 1 ha. The average area under coconut for adopter farmers was 0.67 ha and that for non -adopters was 0.83 ha. The average area under banana for adopter farmers was 0.14 ha and that for non- adopter farmers was 0.07 ha. The average area under vegetables for adopter farmers was 0.74 ha and that for non-adopter farmers was 0.86 ha.

From this we came to know that, the selected sample farmers in study area cultivated food crops to satisfy their food needs and commercial crops to increase their level of income to meet out their family expenditure. Since most of the farmers in adopter category belong to small and marginal farmers category their livelihood depending only on agriculture. Hence these farmers would like to maintain the quality of resources through adoption of technologies which sustains the quality of resources.

Table 5.9.Cropping pattern of the sample farms

(Average area in ha.)

Sl. No	Crop	Adopters	Non-adopters
1	Paddy	0.87 (35.95)	1.00 (36.23)
2	Coconut	0.67 (27.68)	0.83 (30.07)
3	Banana	0.14 (5.70)	0.07 (2.53)
4	Vegetables	0.74 (30.57)	0.86 (31.15)
5	Average area under cultivation	2.42 (100.00)	2.76 (100.00)
6	Average size of holding	0.83	1.35
7	Cropping intensity	2.91	2.04

(Figures in the parenthesis indicate per cent to total)

5.1.10. Sources of technical information to sample farmers

Rice Research Station, Block Technology Managers, Krishi bhavan and Krishi Vigyan Kendra were providing timely technical information to the farmers in the study area. Apart from these farmers in the selected study block were utilising the sources like television, and newspaper for their information. The selected sample respondents in both categories have attended training, exposure visits and field days conducted by institutions to update their technical knowledge on crop production. The Table 5.10 provides the details on number of sample respondents using different sources of information for their knowledge.

From the Table we came to know that only 73 and 53.3 per cent of the non-adopter farmers were utilising the services of Krishi bhavan and KVK. While 100 per cent of the sample respondents in adopter category were utilising these sources for their information. Nearly 87 and 62 per cent of the adopter and non- adopter farmers were contacting RRS (Rice Research Station), Moncombu, for technical information and guidance. All the farmers, both adopter as well as non -adopters were using Television and Newspaper for gaining technical knowledge in crop production.

Table 5.10. Sources of Information to Sample Farmers

(Numbers)

Sl. No	Sources	Adopters	Non-adopters
1	Krishi bhavan	60 (100.0)	44 (73.3)
2	Krishi Vigyan Kendra	60 (100.0)	32 (53.3)
3	Rice Research station	52 (86.6)	37 (61.6)
4	Block Technology Managers	48 (80.0)	36 (60.0)
5	Television	60 (100.0)	60 (100.0)
6	Newspaper	60 (100.0)	60 (100.0)
7	Training programme	53 (88.3)	21 (35.0)
8	Exposure visits	52 (86.6)	10 (16.6)
9	Field days	60 (100.0)	15 (25.0)
	Total	60 (100.0)	60 (100.0)

(Figures in the parenthesis indicate per cent to total)

It was interesting to note that 88.3, 86.6 and 100 per cent of selected sample farmers in adopter category were attended training programmes, exposure visits and field days, which makes them to follow the technologies as recommended. But it was seems to be lesser in non-adopter category.

5.1.11. Natural enemy population in the sample paddy fields

Natural enemy population in the field shows the stability and health of the particular ecosystem. In the absence of natural enemies, the resurgence of pests will occur. It's obvious that the natural enemy population are higher in the field where minimum of chemicals in use. The population of various natural enemies per acre is given in the Table 5.11. From the observation it was clear that the natural enemy population was higher in the fields of bio pesticide adopters than non-adopter paddy fields. The data on natural enemy population were obtained from farmers based on their observation.

Table 5.11. Average Natural enemy population in the sample paddy fields

(Numbers per acre)

Sl. No	Natural enemy	Adopters	Non-adopters
1	Beetles	22	12
2	Dragon flies	21	13
3	Mirid bugs	22	13
4	Spiders	20	14
5	Frogs	1.5	1.3

5.1.12. Pesticides use pattern in sample farms

In study area, since the paddy crop was infected with weeds, insects and diseases different types of chemicals were used by the sample farmers in both the category. In the study area, chemical pesticides were used by all the non-adopter farmers and some of the adopter farmers. The adopter farmers were following chemical pesticide application in the recommended rate and the application is need based. But the non-adopter farmers were applying chemical pesticides indiscriminately. They were following the words of pesticide dealers and various chemical suppliers. They had less contact with the Agricultural officers and Block Technology Managers. Many scientists have studied about the indiscriminate use of chemical pesticides in the Kuttanadu region (Indira Devi, 2007). According to them the

Table 5.12. Pesticide use pattern in sample farms

(Numbers)

Sl. No	Pesticides	Pesticide category	Toxicity	Adopters		Non-adopters	
				Frequency	Application rate	Frequency	Application rate
1	Fame (Flubendiamide)	Diamide	Slightly	18	37.5 ml/ha	60	50ml/ha
2	Acetaf (Acephate)	Organo phosphate	Slightly	20	500g/ha	60	1.25 kg/ha
3	Bartriz (Cartap hydrochloride)	Nereis toxin analougue	Highly	6	10 kg/ha	60	20kg/ha
4	Takumi (Flubendiamide)	Diamide	Slightly	8	150g/ha	60	300g/ha
5	Chemidor (Imidacloprid)	Neonicotinoid	Moderately	4	4kg/ha	60	10 kg/ha
6	Nominigold (Bis-pyribac sodium)	Pyrimidinyl Oxybenzoic	Highly	28	300ml/ha	60	300ml/ha
Biopesticides						**Frequency of application**	
1	*Pseudomonas fluorescens*	Bacteria	Safe	60	3 kg/ha	Seed treatment and foliar spray	
2	Trichocards	Parasitoid	Safe	60	8 no./ha	4 times at 20 days interval	

increased incidence of cancer and other diseases in the study area is due to the indiscriminate use of chemical pesticides. In adopter farm category, farmers came to know about the ill-effects of chemicals through training, exposure visits etc. Also they have started to use biopesticides and followed this practice on an average of 4.7 years.

The pesticide use pattern of the sample farmers is presented in Table 5.12. It was noticed that the usage of chemicals and number of farmers using chemicals seems to be very low in sample farms of adopter category. They were using *Pseudomonas fluorescens* (2.5kg/ha) and Trichocards (8 no./ha) which were stimulating the plant growth, reduces weeds and pest and disease incidences.

5.1.13.(a) Awareness level of sample farmers on benefits of biopesticides

The awareness about a technology is pre-requisite for its adoption. The various beneficial effects of biopesticide on crop growth and environment grouped into 7 items and the farmers were asked about their knowledge on these beneficial effects of biopesticides and details are presented in Table 5.13.

Table 5.13. Awareness level of sample farmers on benefits of biopesticides

(Numbers)

Sl.No.	Benefits of biopesticides	Adopters	Non-adopters
1	Increases crop yield	48 (80.00)	1 (1.67)
2	Effectively controls plant diseases	59 (98.30)	8 (13.30)
3	Effectively controls insect pests	24 (40.00)	0 (0)
4	Safe to farmer	60 (100.00)	27 (45.00)
5	Safe to natural enemies	60 (100.00)	30 (50.00)
6	Increases nutrient uptake	13 (21.60)	0 (0.00)
7	Low residual effect	36 (60.00)	0 (0.00)
	Total	60 (100.00)	60 (100.00)

(Figures in the parenthesis indicate percentages to total)

From the Table 5.13, it was clearly understood that the adopter farmers were having higher level of awareness regarding the beneficial effects of bio pesticides. It is because of the fact that adopter farmers were having more contacts with the technical persons. All the adopter farmers knew about that biopesticide use is safe to the farmer and natural enemies. About 98.3 per cent of the farmers believed that biopesticides effectively controls plant diseases. Eighty per cent adopter farmers were aware about yield promoting nature of biopesticides. Only 40 per cent of the farmers in adopter category were known about the effect of biopesticides on insect pests. The awareness levels of non-adopter farmers were comparatively less. All the farmers in the adopter category and some of the non-adopter farmers knew that the bio pesticide application is safe to the natural enemy as well as farmer.

5.1.13.(b).Frequency distribution of farmers based on awareness level

The frequency distribution of farmers based on their awareness level is presented in Table 5.14.

Table 5.14. Frequency distribution of farmers based on awareness level

(Numbers)

Sl.No	Awareness category	Adopters	Non-adopters
1	Low	12 (20.00)	59 (98.33)
2	Medium	13 (21.66)	1 (0.01)
3	High	35 (58.33)	0 (0.00)
	Total	60 (100)	60 (100)

From Table 5.14, it was noted that, almost 98.33 per cent of non-adopter farmers were under low awareness category. But only 20 per cent of the sample farmers in the adopter category were under low awareness category. It showed that the higher awareness level of farmers under adopter category than farmers in non-adopter category. The adopter farmers were getting knowledge on new technologies through various sources like trainings, exposure visits, field days and extension agency contacts.

5.1.14. Economics of paddy cultivation in sample farms of study districts

5.1.14. (a). Input wise pattern in paddy farms of sample households

Input wise expenditure on paddy cultivation incurred by the adopters and non - adopters are given in the Table 5.15.

From the Table, it could be understood that the farmers in non-adopter category were using higher seed rate, pesticides and fertilisers than adopter farmers. The significant difference in input pattern of plant protection chemicals was noted as Rs. 1500 and Rs.4600 in adopter and non-adopter farm categories implied that the heavy incidences of pest and diseases which reduces yield potential.

Table 5. 15. Input wise expenditure incurred by adopters and non-adopters

(per hectare)

Sl.No	Inputs	Adopter		Non-adopter	
		Quantity (kg)	Value (Rs.)	Quantity (kg)	Value (Rs.)
1	Seeds	80	2800	85	2975
2	FYM	150	750	150	750
3	Fertilizers				
	Urea	100	500	125	625
	Phactumphos	75	1350	75	1350
	Potash	75	1200	80	1280
4	Plant protection				
	Chemicals	14	1500	32.35	4600
	Pseudomonas	3	210	-	-
	Trichocards (Number)	8	480	-	-
5	Irrigation	-	2500	-	2500
6	Human labour (Man days	62	24000	68	25840
7	Machine labour	5 hours	4500	5 hours	4500
	Total		40790		44389

(Figures in parentheses indicate per cent to the total)

5.1.14 (b). Returns obtained by adopters and non-adopters

Returns obtained by the sample farmers are furnished in Table.5.16.

From the table, we came to know that adopters were getting a higher yield (6191 kg) and income (Rs.117629) compared to non-adopter farmers (5870 kg and Rs.111530). So it was noted that the adoption of biopesticides for pest management will not reduce the yield. In short run the effect of biopesticides may not be visible. But a continuous use of bio pesticides in the field will increase the soil health as well as natural enemy population. In study area, the farmers were practising the application of biopesticides for more than four years. Hence, the farmers are achieving higher yield.

Table 5.16. Returns obtained by adopters and non-adopters

Sl. No.	Particulars	Adopters	Non-adopters	Difference
1.	Grain yield (Kg/ha)	6191	5870	321
2.	Price of output (Rs/kg)	19.00	19.00	-
3.	Gross income (Rs./ha.)	117629	111530	6099

5.1.15. Partial budgeting technique on adoption of biopesticides over traditional method in selected sample paddy farms of study area

Partial budgeting was used to estimate effect of biopesticides in adopter farms over non-adopter farm category. The results are presented in table 5.17. There was a net gain of Rs.10729 for the farmers under adopter category. So it is evident from the table that sample farmers under adopter category were getting higher returns than non-adopter category. The operational expenditure was less for adopter category farms. The positive net income showed the financial viability of the adoption of biopesticides.

The additional expenditure in non-adopter category of paddy farms was higher due to usage of more quantities of plant protection chemicals.

Table 5.17. Partial budgeting analysis

Sl.No	Debit	Value(Rs/Ha)	Sl.No	Credit	Value(Rs/ha)
1	Added costs		1	Reduced costs	
	Biopesticides	690		a) Seeds	175
				b) Fertilizer	205
				c) Plant protection chemicals	3100
				d) Human labour	1840
	Total	690			5320
2	Reduced returns	-	2	Added returns	
				a)Grain yield	6099
	Total added costs and reduced returns	690		Total reduced costs and added returns	11419
	Net gain = 11419-690 = Rs.10729				

5.2. Impact of biopesticides use on crop yield, cost of cultivation and pesticide use

The effect of biopesticide use on crop yield, cost of cultivation and pesticide use were analysed using ANOVA (Analysis of Variance) model. The farmers under the category of adopters in the study area were using Pseudomonas and Trichogramma for the management of pest and disease for the last 4 years. It is essential to find out whether there was any significant effect on yield, cost of cultivation and pesticide use due to continuous use of biopesticide in paddy farms. The qualitative variable, adoption level was taken as the independent variable in ANOVA. Adoption level indicated the level of adoption of technology by the farmers as recommended.

5.2.1. Effect of Biopesticide use on yield of paddy

In order to find out whether there is any significant difference in the paddy yield of farmers under adopter category and non -adopter category, the ANOVA test was used. Adoption level was taken as the independent variable and yield per hectare was taken as the dependent variable. The result is presented in Table 5.18.

Table 5.18. Effect of biopesticide use on yield of paddy

(Yield in kg/ha)

Sl. No	Variable	Intercept (Mean yield of non adopters)	(Coefficient) Yield difference	Mean yield of Adopters	t value	P value
1	Yield	5870.60	321.50***	6192.10	3.13	0.002

*** indicates one per cent level of significance

From Table 5.17**, it was observed that the mean paddy yield for the farmers under adopter category was found to be higher than that of non- adopter farmers. The yield difference was statistically significant, which implied that continuous application of biopesticide enhances the soil quality and natural enemy population in paddy farms of study area, which leads to increase in productivity of paddy crop.**

5.2.2. Effect of biopesticide use on cost of paddy cultivation

In order to find out whether there is any significant difference in the cost incurred in production of paddy the ANOVA test was used by taking the adoption level of technology by the farmer as independent variable and per hectare cost of cultivation as the dependent variable. The result of the analysis is given in Table 5.19.

Table 5.19. Effect of biopesticide use on cost of paddy cultivation

(Cost in Rs/ha)

Sl. No	Variable	Intercept (cost of production for non adopters)	(Coefficient) Cost difference	Cost of cultivation for Adopters	t value	P value
1	Cost of Cultivation	44330.20	-4960.83***	39369.37	6.20	0.000

*** indicates one per cent level of significance

From Table 5.19, it was opined that the cost of cultivation was found to be lower in paddy farms of adopter category. The observed difference in cost of cultivation was found to be statistically significant. The cost difference was might be due to lesser usage of chemical inputs like fertilizers, plant protection chemicals and reduced use of human labour as stated by several studies (Thakur and Pawar, 1999). Biopesticides effectively controlled pest and disease infestation in the paddy farms of adopter category.

5.2.3. Effect of biopesticide adoption on pesticide use in paddy cultivation

In order to assess whether there is any significant difference between the pesticide use of farmers under adopter category and non- adopter category, the ANOVA test was conducted by taking the level of adoption as independent variable and per hectare expenditure on pesticides as dependent variable. Since the farmers were used different types of chemicals in different quantities, the expenditure on pesticides was taken as the proxy for estimating pesticide use. The result of the analysis is presented below in Table 5.20.

Table 5.20. Effect of biopesticide adoption on pesticide use in paddy cultivation

(Value in Rs./ha)

Sl. No	Variable	Intercept (Cost of pest management for non-adopters)	(Coefficient) Difference in Expenditure	Cost of pest control for Adopters	t value	P value
1	Expenditure on pesticides	4976.06	-1631.56	3344.50	7.04	0.000

*** indicates one per cent level of significance

From the Table 5.20, it was observed that the expenditure on pesticides was found to be less for farmers using biopesticides in paddy farms than farmers following only chemical method of pest control. The difference in the expenditure on pesticide was found to be statistically significant. From the results of Analysis of Variance, it was clear that the adopter farmers were getting higher yield with lesser cost of cultivation.

5.3. Factors influencing the adoption of biopesticides in paddy cultivation

The factors influencing the adoption of biopesticides were analysed using Logistic regression. The descriptive statistics of variables are given in Table 5.21.

Table 5.21. Descriptive Statistics of Variables

Sl. No	Variable	Mean	Standard Deviation
1	Age (Years)	54.99	11.03
2	Education (Number of schooling years)	9.73	3.18
3	Farm size (in ha)	0.91	0.66
4	Workers in family (Numbers)	3.4	1.04
5	Number of Livestock owned (Numbers)	0.36	0.48
6	Income (in lakhs)	3.16	1.04
7	Extension agency contact (Numbers)	2.72	1.06
8	Awareness level (Scores)	2.88	2.12
9	Distance to market (in km.)	3.85	1.44

The result of logistic regression is presented in Table 5.22.

Table 5.22. Parameter estimates of logistic regression

Sl. No	Variable	coefficient	Odds ratio	P value	Z statistic
1	Intercept	-5.698**		0.017	-2.400
2	Age (Years)	0.093***	1.09	0.001	3.25
3	Education (years of schooling)	0.218**	1.16	0.030	2.170
4	Farm size (in ha)	-1.412**	0.57	0.026	-2.220
5	Workers in family(Numbers)	-0.488	0.57	0.163	-1.390
6	Livestock (Numbers)	0.158	1.22	0.788	0.270
7	Income (in lakhs)	-1.99e-06	0.99	0.553	-0.590
8	Extension agency contact (Numbers)	0.781***	1.58	0.008	2.630
9	Awareness level (Scores)	1.058***	2.76	0.000	3.540
10	Distance to market (in km.)	-0.029	1.58	0.884	0.150

*** 1 per cent significance level, ** 5 per cent significance level

Log pseudo likelihood = - 40.061

Chi square value = 37.50

From the result obtained through logistic regression analysis, it was understood that, the Age of the farmer, Years of schooling, Farm size, Extension agency contact and Awareness level of farmers were found to be the factors influencing the biopesticide adoption decision of the sample farmers.

It could be observed from the table, as the age of the famer increased, they found to be more participated in the training programmes and various extension activities, since they had more time to spend for gaining knowledge from various sources. It seems to be that in study area most of the young people were working in different sectors which may affect their involvement in technology development programme. Aged farmers, through their farm experience had become aware about the importance of sustaining natural resources.

Education level of the farmer will help him to understand the technicality of the new technology. It could be observed from the result that farmers with more years of schooling were found to be using biopesticides in paddy cultivation. Also farm size found to be another factor influencing the adoption of biopesticides in paddy cultivation. From the result it was understood that smaller the farm, more likely the adoption of biopesticides in the paddy cultivation since the farm size had negatively influenced the adoption of biopesticides. Less labour requirement and easy monitoring made the smaller farms to adopt biological control of pest and diseases, because of their awareness on importance of biopesticides.

We came to know that, if the farmers had more contact with extension personnel, that positively influence the adoption decision of the sample farmers. The farmers were able to get knowledge timely due to the frequent contact with extension agencies. The awareness level of the farmers also found to be positively influencing the use of biopesticides in their paddy farms.

From the odds ratio, it can be inferred that one unit increase in age would increase the probability of adoption of biopesticides by 1.09 units. Similarly one unit increase in education level of farmers and their extension agency contact would increase the probability of biopesticide adoption by 1.16 and 1.58 units respectively. One unit increase in awareness level of farmers would increase biopesticide adoption by 2.76 units. But one unit increase in farm size of the farmer would decrease the adoption of biopesticides in paddy cultivation by 0.57 units.

5.4. Environmental benefits of bio pesticides use in pest management

Environmental benefits of biopesticide use were analysed using EIQ (Environmental Impact Quotient). The EIQ values and Field use EIQ obtained are presented in Table 5.23. and Table 5.24. Since both the adopter as well as non- adopter farmers were using same chemicals but in different rates, Field Use EIQ value gives a better picture of environmental impact of pesticide usage.

Table 5.23. EIQ values for Non adopter farmers

Sl. No	Trade Name	Active ingredient	% Active ingredient	Application rate	EIQ	Field Use EIQ
1	Fame	Flubendiamide	48%	50ml/ha	19.4	0.4
2	Acetaf	Acephate	75%	1.25kg/ha	24.9	20.8
3	Bartriz	Cartap hydrochloride	4%	20kg/ha	47.2	16.8
4	Chemidor	Imidacloprid	10%	10 kg/ha	36.7	32.8
5	Nominigold	Bis-pyribac sodium	10%	300ml/ha	11.5	0.3
6	Takumi	Flubendiamide	20%	300g/ha	19.4	1
	Average					12.01

Table 5.24.EIQ value for Adopter farmers

Sl.no	Trade Name	Active ingredient	% Active ingredient	Application rate	EIQ	Field Use EIQ
1	Fame	Flubendiamide	48%	37.5ml/ha	19.4	0.3
2	Acetaf	Acephate	75%	500g/ha	24.9	8.3
3	Nominigold	Bis-pyribac sodium	10%	300ml/ha	11.5	0.3
4	Bartriz	Cartap hydrochloride	4%	10kg/ha	47.2	8.4
5	Chemidor	Imidacloprid	10%	4 kg/ha	36.7	13.1
6	Takumi	Flubendiamide	20%	150g/ha	19.4	0.5
	Average					5.15

From the Table 5.23 and 5.24, it was observed that Field use EIQ values were found to be higher for farmers under non adopter category. It was because of the fact that the sample farmers coming under the non- adopter category were applying the Pesticide chemicals at higher rate than the adopter farmers. The average Field use EIQ value were 12.01 and 5.15 for non- adopter farmers and adopter farmers. The sample farmers in adopter famer category were using the chemicals in recommended rate only. The sample farmers under the adopter category in the study area were not following complete organic paddy production. They were also using plant protection chemicals on need based. But the sample farmers under non adopter farmer category were using plant protection chemicals at a rate higher than recommended.

5.5. Constraints faced by the farmers in the adoption of bio pesticides

The reasons for non-adoption of biopesticides in the study area were identified through the survey and sample respondents were asked to rank the reasons for non-adoption of biopesticides according to their order of preference. The constraints were identified and ranked based on the merit of their importance felt by the farmers using Garrett's ranking technique. The result of Garrett ranking technique is given in Table 5.25.

Table 5. 25. Constraints in the adoption of biopesticides in paddy cultivation

Sl. No	Constraints	Rank	Mean Score value
1	Non-availability of biopesticides	I	67
2	Quality of the biopesticides	II	65
3	Biopesticides are not curative measures	III	46
4	Short shelf life of the product	IV	43
5	Biopesticides are slow in action compared to chemical pesticides	V	38

It was evident from the result of Garrett ranking technique that, non-availability of biopesticide at required quantity in needy time was the major constraint identified by the sample respondents, in the adoption of biopesticides in paddy cultivation (Mean score value, 67). In the study area, since only a few sources (Gandhi Smaraka Seva Kendram, KVK, RRS and Krishi bhavans) were supplying biopesticides with less than 10 per cent share of total demand for biopesticides, non- availability was identified as the major constraint . Quality of the biopesticide was second major constraint in the adoption of biopesticides according to the farmers response (Mean score value, 65). Since biopesticides are not a curative measure in short term, it was identified as a constraint in adoption of biopesticides by sample farmers in the study area. It is only a prophylactic measure. Once the pest attack occurred, we can't rely on biopesticides alone. Short shelf life of the biopesticide was found to be another constraint (Mean score value, 43) restricting the adoption of biopesticides. In farmers' opinion the least important constraint was that biopesticides are slow in action compared to chemical pesticides.

CHAPTER VI

SUMMARY AND CONCLUSION

In this chapter, a brief report of work undertaken and the results obtained are summarized along with conclusions and policy options.

The Green Revolution, spanning the period 1967-1977 transformed India from a food deficient nation to self-sufficient nation. Due to their ability to respond with higher yields to increasing application of fertilizer and, in part, to their ability to produce two, sometimes even three, crops a year, HYV (High Yielding Variety) seeds have brought real and substantial increase in production. Crop protection has immensely contributed to the success of Green Revolution and sustained production of food, fiber, fodder and feed. Last a few decades of chemicalisation in agriculture, helped managing many pests and diseases. While the benefits of pesticide use in terms of preventing crop losses and increasing food grain production have been well recognized, its unwanted side effects on human health and environment have become a major concern. The indiscriminate pesticide application led to several problems like pesticide residues in food stuff, environmental pollution, imbalance of ecological equilibrium, and resurgence of minor pests and pathogens.

Rice "the queen of cereals" occupies 11 per cent of world's crop area and is a staple food for above 60 per cent world's population. Rice is the major crop that receives maximum quantity of fertilizers (40 per cent) and pesticides (17-18 per cent) and these practices pose major challenges in organic rice farming for nutrient and pest management. In Kerala, even though the food habits had changed over past few decades, Rice continues to be the staple food.

Pesticide residues in agricultural commodities are being the issue of major concern besides their harmful effect upon human life, wild life and other flora and fauna. Equally worrying thing is about development of resistance in pest to pesticides. The only solution of all these is use of 'Biopesticides'.

Biopesticides are a set of tools and applications that will help our farmers' transition away from highly toxic conventional chemical pesticides into an era of truly sustainable agriculture. Very frequent cases of cancer of lips, stomach, skin and brain, lymphoma, leukaemia and multiple myloma from Kuttanad rice area of Kerala link to the high pesticide use in Kerala and concluded that there is ample scope for reducing pesticide exposure in Kuttanad through training and agricultural extension services. So the Kuttanadu region of Kerala was selected purposively for the study on 'Economic analysis of Biopesticide use in paddy farms of Kerala'.

The broad objective of the study was to understand the effect of biopesticides on crop yield and pesticide use, its environmental benefits. The specific objectives were i) to study the effect of biopesticide adoption level on productivity, pesticide use and cost of cultivation of paddy farmers, ii) to study the level of awareness and adoption of biopesticides in paddy cultivation, iii) to analyse the environmental benefits of biopesticides, with special reference to *Pseudomonas fluorescens* and *Trichogramma sp.* and iv) To understand the constraints in adoption of Biopesticides and to suggest policy measures to enhance the adoption of biopesticides.

The Hypothesis was that biopesticides are having more beneficial effects than chemical pesticides in terms of productivity of crop, cost of cultivation and environmental sustainability.

6.1. Sampling

The study was conducted in Alappuzha district of Kerala. Alappuzha district was purposively selected for the study as it is a major rice growing area often referred as "Rice bowl of Kerala". Three stages purposive sampling method was adopted for sampling. Considering the criteria, area under paddy awareness and use of biopesticides for more than 4 years, Alappuzha district was selected purposively for taking up a research study on economic analysis of biopesticides use in paddy. From the selected district, two major paddy growing blocks, where both the biopesticides adopters and non-adopters are present were selected purposively at the second stage. From each block, two villages having both adopter and non-adopter were selected randomly. In the final stage, 30 farmers were selected randomly from each village, comprising of 15 farmers each of adopters and non-adopters. In total the sample size was 120.

The primary data were collected from the sample respondents from the month of September 2014 to February 2015 and the data collected in respect of area, production, and productivity of rice pertaining to the agricultural year 2012-13.

Major findings of the study are briefly stated below for a comprehensive review and to draw specific conclusion.

6.2. General characteristics of sample respondents

The average size of the family was 4.2 and 4.4 respectively for adopters and non-adopters farm categories. The average number of earners per family is 1.7 and 1.8 respectively. The earner-dependent ratio of the sample farm categories were 0.74:1 and 0.75:1 which implied that the number of dependents were more in both categories which necessitated for higher productivity and sustainability of paddy farms.

Sixty six per cent of the farmers, under the category of adopters were in the age group of above 50. Average age for farmers, under the category of adopters was 55.4 and that for non-adopters was 54. Thirty three per cent of adopter farmers and 36.6 per cent non-adopter farmers were under the age less than or equal to 50. It showed that in study area, aged people are involving in agriculture.

Education level was higher in adopted category of farms. On an average 63 and 22 per cent and 52 and 20 per cent of sample farmers had education up to secondary and higher secondary level respectively, both in adopted and non-adopted farm categories. The education level was higher in adopted category of farms.

Sixty two per cent of the farmers under adopter category were having farming experience more than 20 years. Only 57 per cent of the non-adopter farmers were having farming experience more than 20 years. Fifteen per cent of the non-adopter farmers were having farming experience less than 10 years. But only 10 per cent of the adopter farmers were having farming experience less than 10 years. ie., Almost 90 per cent of the farmers under adopter category were having better farming experience.

Nearly 53 per cent of the adopter farmers are depending on agriculture as the main source for their livelihood. But only 44 per cent of the non-adopter farmers were depending on agriculture as their major source of income. Farmers whose major source of income is from agriculture will have more opportunity to attend the various training programmes organised by KVKs and Krishi bhavan.

More than 55 per cent of the adopter farmers were coming under small and marginal category. Only 5 per cent adopter farmers were large farmers, whereas almost 17 per cent of farmers under non-adopter category were large farmers. The farmers under the category of adopters were having a low assets position when compared to non- adopter farmers.

Average annual on farm income was Rs. 147000 and Rs. 111571 for adopter and non-adopter farmer categories. Non- farm income for non -adopter farmers was higher than that of adopter farmers. That implies the dependence of non -adopter farmers on activities other than agriculture for their livelihood.

The sample farmers in both the categories allocated 35.95 and 36.23 per cent (0.87 and 1 ha) of their land area to staple food crop followed by 30.57 and 31.15 per cent (0.74 and 0.86 ha) and 28 and 30 per cent (0.67 and 0.83 ha) in vegetable and coconut crop which are commercial crops. The selected sample farmers in study area cultivated food crops to satisfy their food needs and commercial crops to increase their level of income towards meet out their family expenditure. Since most of the farmers in adopter category belong to small and marginal farmers category their livelihood depending only on agriculture.

Rice Research Station, Block Technology Managers, Krishi bhavan and Krishi Vigyan Kendra were providing timely technical information to the farmers in the study area. Apart from these farmers in the selected study block were utilising the sources like television, and newspaper for their information. It was interesting to note that 88.3, 86.6 and 100 per cent of selected sample farmers in adopter category were attended training programmes, exposure visits and field days, which makes them to follow the technologies as given. But it was seems to be lesser in non-adopter category.

Natural enemy population was higher in the fields of bio pesticide adopters than non-adopter paddy fields.

Chemical pesticides were used by all the non- adopter farmers and some of the adopter farmers. The adopter farmers were following chemical pesticide application in the recommended rate and the application is need based. But the non- adopter farmers were applying chemical pesticides indiscriminately. In adopter farm category, farmers came to know about the ill-effects of chemicals through training, exposure visits etc. Also they have started to use biopesticides and followed this practice on an average of 4.7 years.

The adopter farmers were having higher level of awareness regarding the beneficial effects of bio pesticides. It was because of the fact that adopter farmers were having more contacts with the technical persons. All the adopter farmers knew that bio pesticide use is safe to the farmer and natural enemies. About 98.3 per cent of the farmers believed that bio pesticides (Pseudomonas) effectively controls pest and diseases.

Sample farmers under adopter category were getting higher returns than non- adopter category. There was a net gain of Rs.10729 for the farmers under adopter category. The operational expenditure was less for adopter category farms. The additional expenditure in non-adopter category of paddy farms was higher due to usage of more quantities of plant protection chemicals. The positive net income showed the financial viability of the adoption of biopesticides.

6.3. Impact of biopesticides use on crop yield, cost of cultivation and pesticide use

The effect of biopesticide use on crop yield, cost of cultivation and pesticide use were analysed using ANOVA (Analysis of Variance) model. The farmers under the category of adopters in the study area were using Pseudomonas and Trichogramma for the management of pest and disease for the last 4 years.

The mean paddy yield for the farmers under adopter category was found to be higher than that of non -adopter farmers. The yield difference was statistically significant **at one per cent level of significance**. **Continuous application of biopesticide enhances the soil quality and natural enemy population in paddy farms of study area, which leads to increase in productivity of paddy crop.**

The cost of cultivation was found to be lower in paddy farms of adopter category. The observed difference in cost of cultivation was found to be statistically significant at one per cent level of significance. The cost difference was might be due to lesser usage of chemical inputs like fertilizers, plant protection chemicals and reduced use of human labour.

The expenditure on pesticides was found to be less for farmers using biopesticides in paddy farms than farmers following only chemical method of pest control. The difference in the expenditure on pesticide was found to be statistically significant at one per cent level of significance. From the results of Analysis of Variance, it was clear that the adopter farmers were getting higher yield with lesser cost of cultivation and lesser chemical use.

6.4. Factors influencing the adoption of bio pesticides for pest management

Age of the farmer, Years of schooling, Farm size, Extension agency contact and Awareness level of farmers were found to be the factors influencing the biopesticide adoption decision of the sample farmers.

One unit increase in age would increase the probability of adoption of biopesticides by 1.09 units. Similarly one unit increase in education level of farmers and their extension agency contact would increase the probability of biopesticide adoption by 1.16 and 1.58 units respectively. One unit increase in awareness level of farmers would increase biopesticide adoption by 2.76 units. But one unit increase in farm size of the farmer would decrease the adoption of biopesticides in paddy cultivation by 0.57 units.

6.5. Environmental benefits of bio pesticides use in pest management

Field use EIQ values were found to be higher for farmers under non adopter category. It was because of the fact that the sample farmers coming under the non- adopter category were applying the pesticide chemicals at higher rate than the adopter farmers. The average field use EIQ value was 12.01 and 5.15 for farmers under non-adopter and adopter category.

6.6. Constraints faced by the farmers in the adoption of bio pesticides

Availability of biopesticide in required quantity in time was the major constraint in the adoption of biopesticides in paddy cultivation (**Mean score value, 67)**. Quality of the biopesticide was another major constraint in the adoption of biopesticide **(Mean score value, 65).**

Conclusions

The following conclusions were drawn based on the analytical results

1. The economic benefits of the biopesticide adoption were clearly shown by the results of partial budgeting technique and ANOVA. The continuous biopesticide adoption in the paddy farms resulted in good soil condition and natural enemy population in the fields. The higher yield and less cost of cultivation were resulted in a net gain of Rs.10729 for adopter farmers.
2. Cost of cultivation was found to be less for biopesticide adopter farmers since non adopter farmers were using the costly inputs like fertilizers and plant protection chemicals in the rate higher than adopter farmers.
3. The farmers using biopesticides in their paddy fields were found to be more aware about the environmental benefits of biopesticide use, which revealed through presence of more number of natural enemies in their paddy farms.
4. The Age of the farmers, Education level, Farm size, Extension agency contact and Awareness level were found to be the factors influencing adoption decision of biopesticides.
5. The EIQ values found greater for non-adopter farmers than farmers using biopesticides.
6. The availability and quality of the biopesticides were the major constraints in the adoption of biopesticides. Short shelf life and prophylactic nature of protection were also found to be constraints in the adoption of biopesticides.

Policy implications

The present study reveals that the use of biopesticides can be implemented widely due to its economic and environmental benefits. But extension strategy still needs to be scaled up and speeded up for the wider implementation of such intervention. In order to achieve adoption of biopesticide measures for pest management, not only in paddy but also in the cultivation of other crops also, the following policy options may be considered:

1. The timely availability of biopesticide to the farmers should be ensured by the government authorities and NGO's in the area.
2. The quality of the biopesticides should be ensured before supplying to farmers

3. Since the awareness creates adoption decision, extension agencies can strengthen capacity building to the farmers.
4. Farm to farm technology transfer on biopesticides may be strengthened.
5. Since the adopter farmers are getting net gain from biopesticide adoption, higher capacity building towards biopesticides to be strengthened.

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Annexure 1

Major plant protection chemicals used in paddy cultivation in Kerala

Sl.No	Plant protection chemical	Category
1	Acetaf	Insecticides
2	Ambush	
3	Atom	
4	Dimecron	
5	Hostathion	
6	Karate	
7	Kargil 400	
8	Lanite	
9	Lindane	
10	Malathion 50 EC	
11	Metacid	
12	Monocrotophos	
13	Nuvacron 36 EC	
14	Rogor 30 EC	
15	Sevin 50 WP	
16	Tatamida	
17	Tatareeva	
18	Trebone	
19	Contaf	Fungicides
20	Bavistin	
21	Hinosan	
22	Kitazin	
23	Almix	Weedicides
24	2,4-D	
25	Diuron	

Source : Economic and political weekly, June 26, 2010

Annexure 2

Block wise area under Pseudomonas fluorescens use in paddy cultivation during 2014

(in Hectares)

Sl .No	Name of the blocks	Area under biopesticides use
1	Kuthiyathod	1066
2	Cherthala	1000
3	Alappuzha	4326
4	Ambalapuzha	4260
5	Haripad	2130
6	Charummood	1065
7	Champakulam	8520
8	Veliyanadu	8520
9	Chengannur	1066

Source: Records maintained in the office of Principal Agricultural Officer, Alappuzha