ECONOMIC CONSEQUENCE OF PESTICIDES USE IN PADDY KOPPAL DISTRICT, KARNATAKA

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1. INTRODUCTION

Plant protection plays a vital role in modern agriculture. Fertilizers, plant protection measures, irrigation and improved seeds are the key elements of new agriculture of technology. The new technology is unfortunately associated with the high pests and disease incidences. In the absence of adequate plant protection measures, the positive contribution of improved seeds, fertilizers and irrigation to output could be completely nullified and farmers may incur heavy losses.

A pesticide includes such chemicals as insecticides, herbicides, fungicides, acaricides, molliscicides and nematioides, which are used on plants, soil and water to control pest and diseases. The use of pesticides to prevent pre-harvest and post-harvest losses has assumed a great significance during the last two decades, in an attempt to provide sufficient nutritive food for the ever growing world population. According to Rao (1980) unless production inputs are matched with protection measures, yield increases are not possible. Slightly more than 50 per cent of all yield increases in agriculturally advanced countries of the world today are the result of agro-chemicals (Srivastava, 1981).

The use of synthetic pesticides in agriculture has increased rapidly during the last four decades (2,353 mt in 1950s to 90,586 mt in 2000) and has over shadowed the traditional methods used to protect crop damages due to insects, pests, diseases and weeds. Though pesticide use is said to have contributed significantly to the food security by the way of reduction of crop production and post harvest losses, there is a growing concern over the ill-effects of pesticides on human and animal health, environment, natural resources and sustainability of agriculture production. In the classical writings "Silent Spring," Carson (1962), warned that pesticide are being used carelessly which cause hazards for non target organisms and result in technological failure of pest resistance, pest resurgence and emergence of secondary pests. Indiscriminate use of pesticides reduces bio-diversity and aggravates soil, water and air pollution. Modern agriculture which, by and large, is based on the use of chemicals is also a victim of its own toxic substances like pesticides. These chemicals are continued to be used indiscriminately and without due consideration of their impact on agro-ecology.

However, out of all inputs, pesticides play key role in increasing agricultural production by controlling agriculture pests and diseases. It has been observed that about one third of reliable global output is estimated to be lost due to insect pests, disease and weeds. In India, the value of crop lost due to pests was estimated at Rs.6, 000 crores in 1983 (Atwal, 1986), which reported to have further increased to Rs.29, 000 crores in early 1990s (Dhaliwal and Arora, 1996). The agro-chemical policy group- an apex body of 200 crop protection companies- has reported that agriculture produce lost in 2007 due to pest was about at Rs.1.40 lakh crores (Kumarswamy, 2008).

India ranks 10th in the world in pesticides consumption as its total consumption amounts to about 500 million tonnes. India is presently the largest manufacturer of basic pesticides among the South Asian and African countries, with an exception of Japan. The Indian pesticides market is the 12th largest in the world with a value of US$0.6 billion (Hundal *et al.,* 2006).

Pesticides together with fertilizers and high yielding varieties have helped Indian farmers to achieve significant increase in crop productivity since mid 1960s. For example, the yield of two most pesticides using crops, cotton and rice increased by a factor of 1.9 times and 1.8 times respectively. During the initial years of Green Revolution, the effectiveness of pesticides was so unambiguous that soon it over showed the traditional methods of pest control. According to one estimate, every rupee spent in chemical pest control helps saving crop output worth Rs. 3. The average per hectare consumption of pesticides in India had increased from 3.2 gm in 1954-55 to 570 gm in 1996 (Bami, 1996). The present use of pesticides in India was 580 gm per hectare which is very low as compared to Taiwan (17 kg/ha) followed by Japan (16.5 kg/ha) and in the US it is 4.5 kg/ha (Kumarswamy, 2008). However, India compares well with advanced countries in respect of certain cash crops and other intensively cultivated crops. For example, cotton consumed 55 per cent of total pesticides in India while the total area under cotton was only 5 per cent. Similarly, in the case of paddy 17 per cent of the pesticides were consumed, while the total area under paddy was 24 per cent. In the case of fruits and vegetables, the usage was 13 per cent of total production and the area was only 3 per cent of total cultivated area (Dikshit, 2008).

Paddy (*Oryza sativa* L.) is one of the important cereal crops of the world and forms the staple food for more than 50 per cent of population and is known as king of cereals. The United Nations General Assembly, in a resolution declared the year of 2004 as the "International Year of Rice", which has tremendous significance to food security. It very eloquently upheld the need to heighten awareness about the role of rice in alleviating poverty and malnutrition (Barath and Pandey, 2005). In Asia, India has the largest area under the rice accounting for 28.5 per cent of the global rice area. World production of rice has risen steadily from about 200 million tonnes in 1960 to 431 million tonnes in 2007. The top three producers of rice are China (29% of world production), India (21%) and Indonesia (8.3%). World trade figures are very different, as only about 5-6 per cent of rice produced is traded internationally. The largest three exporting countries are Thailand (30%), Vietnam (14%) and United States (9%), while the largest three importers are Philippines (6% of world imports), Indonesia (5%) and Bangladesh (4%) (Anon., 2008).

Indian paddy scenario

Rice is an important food crop of India and stands first in area and second in total food production. Among the rice growing countries, India has the largest area under rice in the world (45.50 million ha) with a total production of 96.43 million tonnes during 2007-08 and it stood next only to China in the world with respect to production. But, the yield levels in India are low at 2.20 tonnes per ha compared to other major rice producing countries *viz.,* Japan (6.52 t/ha), China (6.24 t/ha) and Indonesia (4.25 t/ha). About 67 per cent of the area under paddy in India is under HYVs.

In India, the highest area under paddy is in Uttar Pradesh (59.20 lakh ha) followed by West Bengal (56.90 lakh ha), Orrisa (44.50 lakh ha), Andhra Pradesh (39.80 lakh ha) and Karnataka (14.20 lakh ha). Production-wise West Bengal stands first (147.50 lakh tonnes) followed by Andhra Pradesh (118.70 lakh tonnes), Uttar Pradesh (111.20 lakh tonnes) and Karnataka (34.50 lakh tonnes). The highest yield is observed in the state of Punjab (3870 Kg/ha), followed by Assam (3360 Kg/ha) and Karnataka (2464 Kg/ha) (Anon., 2008).

India so far has witnessed two per cent growth in population while the growth in rice production was three per cent. The growth rate of rice output during the last two decades has remained well above the population growth rate, which has made the country not only self reliant in food grains but also generated surplus for exports. The production and productivity levels of rice in India are expected to reach respectively 130 million tonnes and 3 tonnes/ ha by 2010, and 160 million tonnes and 3.5 tones/ha by 2020.

Rice is consumed both in urban and rural areas and its consumption is growing due to high income elasticity of demand. To meet the growing demand a rapid increase in paddy production is needed. But, there is little scope to increase the area under paddy and hence increase in production has to come from increase in productivity with an improvement in efficiency of production.

Karnataka is one of the major rice growing states in India. It is grown on an area of 1.42 million ha with an annual production of 3.45 million tonnes during 2007-08. The area under rice production is increasing over the years. Rice is grown under varied conditions and bulk of the area is under assured rainfall and irrigated conditions of canals (60.52% of gross area irrigated under paddy) and tanks (19.28%). Karnataka ranks fourth in productivity and ninth in production among major rice growing states of the country. The average yield of rice is around 2464 kg/ha. The important rice growing districts of the state are, Haveri, Uttar Kannada, Dharwad, Koppal, Raichur, Mysore, Hassan, and Chitradurga (Anon., 2008). Paddy in the state is grown under different agro-climatic (upland, low land and rainfed) conditions and the crop is damaged by more than 100 species of insect pests of which about dozen are of significance. The state looses 30 per cent yield every year on this account. Some of important diseases of paddy crop include fungal, bacterial and viral diseases. Among them blast, brown spot, bacterial blight, foot rot, stem rot and false smut are important. The coordinated network trials conducted at different centers of India have indicated that controlling insect pests alone increases the yield by around one tonnes per hectare.

Paddy is one of the most important cereal crop grown in the Koppal district of Karnataka. In Koppal district the area under paddy is 75,196 ha. Paddy production in the district is 1, 80,145 tonnes. Monocroping of paddy is a common practice in this region. The farmers in the district are under the misconception that higher returns could be obtained through higher doses of plant protection chemicals. However this has resulted in pest resistance, pest resurgence and secondary pest out break in the region over the past few years. Though the subject of economic evaluation of pesticides use was dealt by many researchers, micro level empirical studies regarding this is lacking in this region. In this regard, the study provides insight into economics of pesticides use. The results of study would be useful to both policy maker and farmers of the region in understanding the nature and economic consequence of pesticides use.

Keeping these aspects in view, the present study is a modest attempt to analyse the economic consequence of pesticide use in paddy crop in Koppal district. The specific objectives of the study are

1. To estimate cost and returns in paddy production with special reference to pesticides use.
2. To study the frequency, extent and type of pesticides use in paddy production.
3. To estimate pesticides requirement, optimum use of pesticides and its impact on paddy productivity.

Hypothesis formulated

1. Farmers are using pesticides indiscriminately in paddy production in the study area.
2. Frequency, quantity and type of chemicals used are not proper in paddy production

Limitation of study

The study pertains to agriculture year 2008-09 and is based on information obtained by 120 randomly selected farmers. Hence, various conclusions drawn and the explanation of various problems have been based on behavior of the sampled farmers and availability of data during reference period. The respondents were not in the habit of maintaining records of their income and expenditure. The entire information was by recollecting past events by the farmers

Presentation of the study

The study has been presented in six chapters. In the initial introductory chapter, the objectives of the study have been defined. Chapter II that follows, deals with the review of relevant research efforts bearing on the objectives of the present study outlined in the chapter I. Chapter III describes the main features of the study area, the sampling design, the source of data, the method of collection of data and statistical tools and techniques adopted. Chapter IV is devoted to the presentation of results through a variety of tables and graphs into which relevant data have been compressed up on. Major findings of the study have been presented. Chapter V concentrates on the discussion of the results of the study. The study has been summarized and presented along with their policy implications in chapter VI.

2. REVIEW OF LITERATURE

This chapter presents the brief review of some of the studies under taken by various economists, research workers and organizations pertaining to present study. The reviews have been presented under following heads for the sake of simplicity.

2.1 Frequency, extent and type of pesticides use

2.2 Economics of pesticides use

2.3 Cost and returns related to pesticides use

2.1 Frequency, extent and type of pesticides use

Prokof'ev (1980) studied the economics of pesticides use in Kazakhstan. The study reported that pesticides were applied to over 15-16 million ha of cereals, sugar-beet, cotton, fruits and vegetables every year in Kazakhstan (USSR) so as to obtain the best yields, and over 1.5 million ha have to be treated against rodents, locusts and grasshoppers. The principal insecticides used were lindane (gamma - HCH), parathion-methyl (metaphos) and trichlorphon (chlorophos), and they were each applied against numerous arthropod pests.

Duffy (1983) studied the pesticide use and practices in USA. The study reported the nature and extent of pesticides use by crop, using data from the ERS-USDA's 1982 Crop and Livestock Pesticide Usage Survey. The survey covered 13 major field crops in 33 states with data from 6520 respondents. It was reported that 11per cent of farmers used professional scouting for pest problems, 59 per cent self scouted their fields, and 12 per cent were aware of beneficial insects and diseases. Almost 70 per cent of the farmers with livestock used insecticides for livestock insect control.

Frank *et al*. (1990) surveyed 300 farms for pesticides usage in Ontario, Canada. The survey reported that herbicide usage was markedly greater than that of the other pesticides, with atrazine being the main herbicide used on 103 farms, followed by 2-4-D (64 farms), glyphosate (56 farms) and metribuzin (52 farms). Well water analysis indicated that of the 10 wells, nine were contaminated with pesticides in 1986, atrazine and its metabolite diethyl atrazine ranging in concentration from 0.2 to 34 microgram/liter. In four cases the owner had used well water to mix and load atrazine and spray his maize crop. Thus, the water was contaminated as a result of carelessness around the well. The highest concentration was measured in a deep drilled well, suggesting spillage of the herbicide. In a further four cases, runoff water of leachate entering the well accounted for the contamination. In 1987, all of the four contaminated wells identified contained atrazine and three additionally contained metolachlor. Activities around the well appeared to have accounted for contamination in three of these cases, spillage in the fourth case.

Snoo and Sleeswijk (1993) studied the use of pesticides along field margins and ditch banks in the Netherlands. The study analysed the nature and extent of pesticide use along field margins. The results indicated that field margins were sprayed very intensively. About 90 per cent of farmers created a sterile strip along the field edge (especially ditch banks) by spraying with a variety of compounds, often several times a year. The principal compound involved was glyphosate. In contrast to the crop itself, where dosages were accurately recorded, the field margin dosage was only approximately known. The farmers did not make allowance for the exact area of strip being treated. Up to 60 per cent of farmers sprayed ditch banks using back-pack sprayers, spray-guns or tractor-mounted booms, usually with glyphosate. It was concluded that the spraying of field margins might constitute an important source of pesticides emissions to adjacent ditches.

Cahrles (1994) studied pesticide use and farm worker health in Ecuadorian potato production. The study reveled that the sample farmers used 43 different active ingredients among the formulations of fungicides. However, three compounds, each with world wide popularity, dominated the selection. The dithiocarbamate fungicide, mancozeb, made up more than 80 per cent of all fungicides active ingredients applied. The carbamate, carbofuron and methamidophos- restricted products in the U.S and Canada- made up 47 and 43 per cent of all insecticides active ingredients applied.

Crissman *et al.* (1998) studied economic, environmental and health tradeoffs in Agriculture- Pesticides and the sustainability of potato production in Lima, Peru. The study found that farmers utilized 38 different commercial fungicide formulations. Among the fungicides used, there were 24 active ingredients. The world wide popular class of dithiocarbamate contact type fungicide was the most popular among farmers, with the fungicide mancozeb contributing more than 80 per cent by weight of all fungicide active ingredients applied.

Sanatha Kumar and Dandapani (2000) studied frequency, intensity and determinants of pesticide use in rainfed cotton, by using farm level cross sectional data from Nanded district of Maharashtra. Average pesticide use was 3.2 kg active ingredient per hectare of cotton area. Farmers also used a number of cultural and physical methods directly or indirectly to limit the crop loss due to pest and diseases. The attitude of farmers towards insect pest risk varied and accordingly the use of pesticides. Risk avers farmers used pesticides excessively and indiscriminately. Findings suggested that improving existing stock of knowledge of pests and management practices could help reduce pesticide use.

Yogeshwari (2002) studied economics and environmental implications of pesticide use in paddy in Shimoga district. The study reveled that the average frequency of pesticide applications made by the sample farmers was 18 sprays with range of 12 to 28 sprays during the paddy crop for period of 140 to 145 days as against the 11sprays recommended. It was found that expenditure on pesticide (Rs. 8389) formed the major portion (31%) of total cost of cultivation of paddy crop. The total cost of cultivation of paddy was Rs. 27,258 per ha. Majority of the farmers used pesticides in the form of organophosphorus and organochlorine and 23 per cent farmers used organophosphorus chemical (monocrtophos) under the brand name Novocron. It was observed that 12 per cent of farmers used weedicides, 9 per cent farmers used weedicides in the form of 2-
4-D sodium salt followed by machete (10%), 30 per cent of the farmers used fungicides. Most of them used fungicides in the form of bavistin under the brand name Carbendizim (27%) followed by mancozeb (7%) and copper oxychoride (6%).

Crissman *et al.* (2002) studied potato production and pesticide use in Ecuador and eveluated research and rural development intervention for greater eco-system health. The study reported that the sample farmers employed three of the four main groups of insecticides while using 28 different commercial products. The sample farmers did not use organochlorine insecticides though found in Ecuador. The carbamate group was represented only by carbofuran, but this was the single most heavily used insecticide exclusively for control of the Andean weevil. Carbofuran was used in its liquid formulation, which was restricted in North America and Europe due to the ease of absorption of the liquid and the high acute toxicity of its active ingredient. Another 18 different active ingredients from the organophosphate and pyrethroid groups were employed to control foliage pests, though only four were used on more than ten per cent of parcels. Here the organophosphate, methamidophos (also restricted in North America due to its high acute toxicity), was the clear favorite. Carbofuran and methamidophos, both classified as highly toxic (1b) insecticides by the World Health Organization (WHO), made up 47 per cent and 43 per cent, respectively, of all insecticide active ingredients applied.

Nguyen and Tran Thi (2003) studied the economic and health consequences of pesticide use in paddy production in the Mekong Delta, Vietnam. The study reported that among the pesticides, insecticides were used the most (394 grams a.i. per ha) followed by herbicides (323 grams a.i per ha) and fungicides (300 grams a.i. per ha) in Mekong Delta. On an average, farmers applied 1,017 grams of pesticides (a.i. /ha) per crop. The amount of pesticides used by the sample farmers decreased by 43 per cent compared with the amount they used in the 1992 dry season. A general decrease in the quantity of pesticide use was observed, which was attributed to the adoption of the IPM (integrated pest management) program. Farmers tended to use less hazardous but highly effective pesticide types.

Bienkowski (2005) applied multi-criterial toxicity index for the assessment of pesticide impact on the environment in different types of farms. The extent of pesticide use and the impact of pesticides on the environment were surveyed in 30 farms representing three farm types (milk production, pig production and crop production) in Poland during 2002-03. Farms for crop production recorded the use of 1.77 kg a.i pesticide/ha. Were as farms specializing in pig production used 1.28 kg a.i. pesticides/ha, and dairy farms used 1.04 kg a.i. pesticides/ha. Multi-criteria index of pesticide impact on the environment was -27.9 in dairy farms, -21.8 in crop production farms and -20.9 in pig production farms.

Jeyanthi and Kombairaju (2005) studied the pest management practices in four important vegetable crops, *viz*. chillies, cauliflower, brinjal and bhendi using farm level cross-sectional data. The study reported that average pesticide usage has been estimated at 5.13, 2.77, 4.64 and 3.71 kg active ingredient per hectare on chillies, cauliflower and brinjal and bhendi crops, respectively. On an average, cauliflower and brinjal were each given 15 applications, chillies was given 13 and bhendi was given 12 applications. The study suggested for reducing pesticide-use. The studies conclude that farmers need education about different non-chemical control methods and should be encouraged to adopt integrated pest management practices.

Shakirullah *et al.* (2006) studied the nature and extent of adoption of pesticides among small, medium and large farmers in Union Council Palosi, District Peshawar. The results revealed that the Pesticides were used by 78.75 per cent of the farmers, while 2.25 per cent did not use them. Majority of the farmers (41.25%) started using pesticides 6-15 years ago for different pests. The per annum average cost of pesticide purchase was significantly higher at 1 per cent level for large farmers than medium and small farmers. This shows that the larger farms applied more pesticides.

Singh (2007) attempted the economic evaluation of environmental risk of pesticide use in paddy, vegetables and cotton under irrigated eco-system. The study found that 2.47 and 1.85 kg/ha active ingredient was used respectively on non-IPM and IPM adopted farmers. On an average, paddy crop was treated four times with pesticides. Fungicides were used in meager quantities (mainly for seed treatment) where as weedicides application was observed to be almost same on both the categories of farmers. The expenditure on pesticides was found to be higher on non-IPM farmers. It accounted for 15 and 12 per cent of the total cost of paddy cultivation on non-IPM and IPM farms respectively. In the case of vegetables, the average pesticide use in tomato was found to be much higher than that of cabbage on both the types of farms. In tomato, per hectare consumption of all kinds of pesticides was found to be 3.17 kg and 2.02 kg active ingredient on non-IPM and IPM farms respectively. Similarly in cabbage, pesticides consumption on non-IPM and IPM farms was reported to be 2.63 kg and 1.61 Kg active ingredient per hectare on sample farms. On an average, tomato and cabbage crops were treated five times with pesticides on IPM farms, where as the frequency was eight to nine times on non-IPM farms. The major pesticides used where insecticides and fungicides. Fungicides constituted less than five per cent of total pesticides used in both the crops. In cotton, per hectare consumption was found to be 2.71 kg and 2.01 kg active ingredient on non-IPM and IPM farms respectively. The use of fungicides was found to be extremely low and none of farmers used herbicides.

Prabuddha (2007) studied the pattern of pest infestation on vegetables and the extent of the use of pesticides by vegetable growers in 18 villages in Katwa-1 block, Bardhaman district, West Bengal, India. The study found that the intensity of insect pest infestation on aubergine, pointed gourd (Trichosanthes dioica), cabbage and cauliflower was greatest during the Rabi season, followed by the kharif and pre-kharif seasons over the last five years. Most of the farmers applied pesticides on aubergine and cabbage, but the application rates, number of chemical groups of pesticides and application frequency adopted by the farmers were more than the recommended. This practice was most pronounced for aubergine, followed by cauliflower, cabbage and pointed gourd.

Ngowi *et al.* (2007) studied pesticide use by smallholder farmers in Northern Tanzania who grew vegetables that include tomatoes, cabbages and onions. They observed that the types of pesticides used by the farmers in the study areas were insecticides (59%), fungicides (29%) and herbicides (10%) with the remaining two per cent being rodenticides. More than 50 per cent of the respondents applied pesticides up to five times or more per cropping season depending upon the crop. Insecticides and fungicides were routinely applied by 77 and 7 per cent, respectively. Majority of the farmers reported that the trend of pesticide use was increasing. Sixty-eight per cent of farmers reported having fell sick after routine application of pesticides.

2.2 Economics of pesticide use

Headly (1968) estimated the productivity of expenditure on agricultural pesticides from an aggregate production function for USA agriculture. He found that the chemical pesticides were highly productive inputs compared to commercial fertilizers. The marginal value product of pesticides exceeded the marginal factor cost by a considerable amount. The study also stressed on the need for better data on the response of crops and livestock to pest control as well as the need for data on external effects of chemical pesticides.

Ghodake *et al.* (1973) conducted a simple economic analysis of pesticide use in cotton in Haryana at regional research station IARI. It was found that pesticide was highly productive input and its recommendation based on the maximization of physical product was improper. It was also found that the quantities used were much lower. However, they did not consider the uncertainty and externalities in the use of pesticides.

Compbell (1976) used input-output data from a cross sectional sample of 300 fruit farmers in British Colombia to derive an estimate of marginal productivity of agricultural pesticides. The analysis indicated that the value of marginal dollar's worth pesticides was considerably higher than its private profit maximizing level. The study indicated that public policy aimed at reducing the level of pesticide input in the interest of environmental protection would have relatively high opportunity cost in terms of foregone agricultural output.

Mahalle and Jha (1977) estimated a quadratic production function to establish pesticide output relation using empirical data in cotton production in Maharashtra. Their results indicated that the use of pesticide was determined by the level of infestation. An increase in the level of infestation resulted in an increase in the optimum level of pesticide use.

Mahalle and Jha (1977) studied the economics of pesticide use in cotton production in Maharashtra state. The optimum pesticide use under certainty conditions was analyzed with the help of production functions based on experimental data for 1969-70 to 1971-72. Varying doses of four pesticide dust formulations were assessed for their effectiveness against cotton pests in fully replicated field trials. The level of pest infestation was measured in terms of the damage caused by the bollworms. Subsequently, Bayesian decision analysis was used to find out optimum strategies under uncertainty. Information on subjective probabilities of past infestation levels was elicited from a sample of farmers in the neighborhood of these experiment stations. The data on meteorological variables and bollworm pest infestation for 20 years (1954-73) were used to formulate a pest infestation model. Results showed that even in years of low infestation, the returns to optimum pesticide usage were quite high. Out of the four pesticide formulations evaluated for the control of pests, Carbaryl 10 per cent was found to be the most efficient. The dosage of pesticide recommended by the entomologists (75-100 kg per ha) came close to the optimum only for high infestation situations. For medium and low infestation conditions it implied wastage of the scarce resource. The Bayesian decision-theory approach used for working out the optimum strategies indicated maximization of expected (long-term) returns when the farmers applied the optimum dose consistent with medium level of infestation. Though the opportunity gains obtained under posterior analysis were higher than the expected pay-offs, the difference was modest. Considering minimization of risk as an alternative objective function, the optimum pesticide dose (72, 67 and 92 kg/ha in three areas respectively) for high level of infestation always resulted in minimum variability in returns.

Huh (1979) classified the effects of pesticide use as a beneficial and adverse effect. The benefits identified by him were increased yield, input saving and overall rise in productivity and quality of product. Consumer surplus model was employed to measure the adverse effects. The study indicated that from societal point of view, any action in relation to use of pesticide should be taken after thorough examination of all the effects of pesticides since the existence of external economy entailed an equilibrium output that was below optimal.

Blackshaw (1983) studied the factors influencing the economics of pesticide use in grassland. The study revealed that the point at which benefits from pest control exceed costs would vary with fluctuations in price. This was particularly true for grassland, where the value of grass was measured indirectly as animal protein. Successful pest control in grass would result in an increased margin/ha. Simple models were presented to illustrate difference in cost/benefit ratios resulting from different strategies for the utilization of the increased resources made available. It was concluded that the point where pest control costs equals benefits in grass was never constant, but was unique to a farm, season and management strategy.

Prabhu (1985) examined the relevance of production function frame work for the analysis of pesticide use behavior in cotton cultivators in Coimbatore district of Tamil Nadu. It was argued that production functions frame work based on the assumption of perfect certainty and suitability of inputs not suitable for yield saving, inputs like pesticides, the use of which was influenced by uncertainty regarding yield and technical complementarily with yield increasing inputs. The argument was sustained by the conclusion derived from empirical production function.

Subba Rao *et al.* (1987) highlighted the indiscriminate use of conventional insecticides as well as synthetic pyrethroids by cotton farmers in Guntur district of Andhra Pradesh. They found that expenditure on insecticides was Rs. 2000 per ha constituting around 20 to 25 per cent of total operational costs. The amount spent on conventional insecticides was Rs. 1046.39 per ha. Further multiple regression analysis was employed to study the influence of insecticides on yield with land in ha, conventional insecticides and synthetic pyrethroids in rupees as the independent variables. The coefficient of these two categories of insecticides revealed the irrational behaviour of cotton farmers.

Eswarprasad *et al.* (1988) estimated resource use efficiency of various resources in cotton farms in Guntur district of Andhra Pradesh. They used Cobb-Douglas production function for estimating resource use efficiency and found that marginal value product for pesticide and fertilizers were significantly lower than their opportunity costs. They concluded that excessive use of these two inputs in cotton frames resulted in lowering profit.

Pandurangadu (1988) made an attempt to determine the pesticides use efficiency in major commercial crops in Guntur district of Andhra Pradesh. He found that elasticity of pesticides use was negative on large and medium farms while it was positive on small farms of cotton. It was noticed that MVP\MFC ratio for pesticides was found to be less than unity and significant on pooled farms of cotton, clearly indicating excessive and indiscriminate use of pesticides in cotton farming.

Nagaraju *et al*. (1988) made an attempt to estimate the resource use efficiency in different crops in different cropping systems in Tungabhadra command area in Karnataka. It was found that the ratio of MVP to factor cost for plant protection chemical was found to be 6.21 in paddy followed by land (2.45) and human labour (2.78). It was suggested that there was scope to increase gross return from paddy in command area by using more of these resources keeping other variables at their respective geometric mean levels of use.

Pandurangadu and Raju (1990) studied the economics of pesticide use on cotton farms in Guntur district of Andhra Pradesh. The study found that the cultivation of high yielding varieties of cotton needed continual application of pesticide as a part of the technological package. The large-scale production of cotton in the state of Andhra Pradesh, in India, has led to the destruction of beneficial organisms and the transformation of previously minor pests into major ones, as a result of excessive pesticide use. Guntur district, ranking first in the utilization of pesticides, was chosen with the villages growing cotton there in arranged in descending order of their acreage. The top three villages were then selected for analysis. The results showed an alarming rise in the cost of cultivation of cotton, largely attributable to the increased use of expensive and broad spectrum chemicals such as synthetic pyrethroids. They suggested the farmers to adopt Integrated Pest Management practices which involved the use of low-cost, but effective, pest killing techniques like pheromone traps and biological control methods. Monocroping of cotton was one of the factors which appeared to encourage pest build-up in the study area. Hence, the cultivation of equally remunerative crops like maize, soybean, turmeric and coriander was recommended. They suggested to ensure the distribution of high quality inputs through agro-service centers. This action was particularly relevant as diluted pesticides not only failed to protect the produce but also allowed pests to build up a resistance to their contents.

Zilberman *et al.* (1991) studied the economics of pesticide use and regulation in USA. The study found that pesticides enhanced agricultural productivity, but the environmental and health side effects of their use justify government regulation, a subject of continuing societal debate. Bans on pesticide use were the principal regulatory device used in the USA. The economic impacts of such bans depended on the availability of substitutes, supply and trade conditions, and research and development. Without substitutes, pesticide ban would result in reduced production levels and higher prices, a substantial loss of discretionary income to consumers, and a redistribution of income among agricultural producers. Most food safety concerns could be addressed by establishing standards and markets for pesticide-differentiated products, but worker safety and clean water concerns would require direct controls. Pesticide use fees were shown to be more efficient than outright pesticide bans as a mechanism to achieve environmental goals.

Nagaraju *et al.* (1994) estimated the resource use efficiency in cotton in Tungabhadra command area on Karnataka. The regression coefficients for plant protection chemical in head (0.31) and tail reach (0.59) were significant. The ratio of MVP\MFC was found to be more than one (4.55 in head reach and 7.26 in tail reach). It was concluded that the farmers in the head reach of canal should reduce the use of human labour and machine labour and farmers in middle reach should increase use of inputs like seeds, manures and fertilizer, plant protection chemicals and bullock labour for realizing higher net returns.

Shanmugam (1994) estimated the technical efficiency in paddy cultivation in Ramanathpuram district of Tamil Nadu. Allocative inefficiency for plant protection was found to be 0.16. It was concluded that the farmers in the region were adopting the principle of economic threshold level in applying pesticides.

Tewari *et al.* (1994) in his study at Kulovally identified the characteristics and pattern of pesticide uses and estimated the pesticide consumption and demand for pesticides in the district. The average size of holding of users was three times more than that of non users. The users had 47.5 per cent of the area under food crops, while the non users share in food crops was 81.97 per cent of the total area. The group value of output per farm in the case of users was five times more than that of non users. On an average the per farm business income was higher in the case of users as compared to that of non users.

Teague and Brorsen (1995) studied the pesticide productivity trends and estimated pesticide productivity as an economic response to the growing public concern about the steady increase of pesticide use in the USA. The study employed a random coefficient model to determine the trend of the marginal value product of pesticides in agriculture in ten states of the USA for the period 1949-91. The study found a distinct downward trend in two states, Iowa and Texas. California, however, showed no evidence of a downward trend.

Rajasekhara and Krishnamoorthy (1998) estimated technical efficiency of pesticides in rice production in Kole lands of Kerala. They concluded that the absence of proper scientific knowledge on pesticides use emerged as one of the factor affecting technical efficiency.

Widawsky *et al.* (1998) studied the pesticide productivity, host-plant resistance and productivity in China. The study reported that pesticide productivity was low compared to the productivity of host-plant resistance. In fact, returns to pesticide use were negative at the margin. The Host-plant resistance was an effective substitute for pesticides and substantial reduction in pesticide use could be achieved, with no loss in rice production, through improvements in host-plant resistance. The results suggested that pesticides were over used in eastern China and host-plant resistance was under-utilized. They felt that government policy to promote increased pesticides in rice was wrong in the light of well known negative externalities associated with pesticide use.

Kim (2000) analysed the economic and environmental effects of pesticide application with special reference to vegetable production in Korea. Pesticide was applied to increase the yields of spinach and spring cabbage on a total of 180 farms in 45 different regions throughout the Korea Republic over the period 1979-97. The study reported that for every one per cent increased pesticide application in spring cabbage production the level of income would decrease by an average of 0.14 per cent as reflected in Cobb-Douglas production function analysis. The marginal value product of pesticide was only 0.06 and the additional application of pesticide did not increase marginal return.

Brithal *et al.* (2000) analysed on economics of integrated pest management (IPM). A sample of 40 farmers was randomly drawn from Ashta village to collect information on cotton cultivation practice with an emphasis on plant protection measures. Partial budgets were prepared to assess the economic feasibility of IPM. The IPM appeared to be an effective alternative to chemical pest control. The IPM package implemented on the farmers field was bio-intensive in nature with bio-control agents and cultural control as major components. This reduced the pesticide use to almost zero and without having any adverse effect on crop yield.

Wilson and Tisdell (2000) analysed the reasons for continued use of pesticides despite environmental, health and sustainability aspects. The study reported that Use of chemical inputs such as pesticides had increased agricultural production and productivity. However, negative externalities, too, have increased. The externalities included damage to the environment, agricultural land, fisheries, fauna and flora. Another major externality had been the unintentional destruction of beneficial predators of insects which had led to a virulence of many species of agricultural pests. Mortality and morbidity among agricultural workers, especially in developing countries from exposure to pesticides were also common. The costs from these externalities were large and affected farmers' returns. However, despite these high costs, farmers continued to use pesticides and in increasing quantities.

Khan *et al*. (2002) made an economic evaluation of pesticide use externalities in the cotton zones of Punjab, Pakistan. The study found that the additional cost of pesticide application, due to pesticide resistance developed in the pests, was about Rs. 11000 per hectare. This amounted to Rs.5667 million when extrapolated to 1.7 million hectares of cotton grown in the study area. Similarly, a loss of Rs. 374 million per annum was estimated due the loss of biodiversity resulting from pesticide use. About 272 kg per hectare increase in the yield of seed-cotton was estimated with pesticide use. The actual gross benefit of pest control was calculated as Rs. 8069 million by multiplying incremental yield with price of seed-cotton (Rs 17.5/kg) for a total cotton area of nine districts (1.7 million ha.)

Yardm and Edwards (2003) analysed pesticide application regimes for processing tomatoes in Ohio, USA. The recommended range of pesticide applications were compared with lower chemical input systems and the economics of pesticide use on processing tomatoes were estimated. The pesticide regimes included: (i) full-spectrum of recommended pesticide use, based on a comprehensive pesticide application schedule including insecticides (carbaryl, endosulfan and esfenvalerate), a fungicide (chlorothalonil) and herbicides (trifluralin and paraquat); (ii) insecticides only, based on applications of the same insecticides and doses used in (i); (iii) fungicides and herbicides only, based on applications of the same fungicides and herbicides used in (i) and (iv) control plots, which received no pesticide applications. The costs involved in applying pesticides (chemicals, machinery and labour) were recorded for all treatments for the economic analysis. The study reported that fungicide treatments resulted in higher yields than either the control or the insecticides-only regime, and the profits from the full-spectrum of pesticides and fungicide+herbicide regimes were greater than those from the insecticide-only regime and controls.

Bhavani and Thirtle (2005) studied the pesticide productivity and transgenic cotton technology on the South African smallholder farms. The cross-sectional data used in this study related to the 1999-2000 season, and were obtained from a sample of 58 Bt adopters and 33 non-Bt farmers. The study reported that farmers overused pesticides. The transgenic technology benefited farmers by enabling large reductions in pesticide use, the econometric evidence indicated that non-Bt smallholders in South Africa underused pesticide. Thus, the main potential contribution of the new technology was to enable them to realize higher productivity. By providing a natural substitute for pesticide, the Bt technology enabled the smallholders to over come the credit and labour constraints associated with pesticide application. The technology greatly reduced pesticide applications but only mildly affected yields, when used by large-scale farmers in China and elsewhere.

Huang *et al*. (2005) studied productivity and health effects of the insect-resistant GM rice in farmers fields in China. Surveys were conducted in 347 rice production plots (123 plots planted with insect-resistant genetically modified or GM rice cultivars and 224 plots planted with non-GM cultivars) in Fujian and Hubei, China, during 2002 and 2003 to investigate the effects of GM rice on crop productivity, pesticide use and farmers' health. The study found that small and poor farm households benefited from the adoption of GM rice by higher crop yields (by 6-9%) and reduced pesticide use (by 80%), which also contributed to improved health. Full adopters claimed that they were not adversely affected by pesticide use, whereas among those that used only the non-GM cultivars, the health of 8.3 per cent of the households in 2002 and three per cent in 2003 was adversely affected.

Pouchepparadjou *et al.* (2005) analysed the impact of IPM on pesticide use and yield in irrigated rice in Pondicherry. Data were collected from a sample of 450 farmers (225 had been trained on various aspects of IPM, while the other 225 did not undergo such training). The study revealed that the total pesticide cost and the dependence on pesticides were higher in non-adopter farms than those in adopter farms. Further, considerable scope existed for productivity gains for non-IPM adopter farms. Policies to improve education and extension services through further investment in human capital and related factors were therefore recommended.

2.3 Cost and returns related to pesticide use

Fisher (1970) dealt with cost and returns aspects of pest control in Canadian apple production. Results indicated that per unit cost for pest control was the highest in small orchards while medium and large grower outlays were significantly lower. The results of pesticide productivity studies in USA indicated that chemical pesticides were making a positive contribution to agriculture output throughout USA (Headly and Edwards, 1972). But the prices of pesticides did not reflect the full costs of use because of spillover effects on environment.

Kishore (1994) attempted to calculate the external cost resulting from pest resistance to pesticide using a simulation model. He indicated that annual external costs (damage to non-cotton crops in Guntur and all crops in other potentially effected districts), could be as high as Rs. 66.8 crores which implied an increase in the existing cost of cotton cultivation by 52 per cent and would require an offsetting price increase of about 41 per cent. The annual expected value of catastrophic losses due to “complete” crop failure would be about Rs. 13 crores with an increase in the cost of cultivation of cotton almost ten per cent.

Grala *et al.* (1994) analysed the pesticide use in winter wheat crops in Poland. The study found that the minimum cost of applying insecticides, herbicides and fungicides was equivalent to 20-40, 40-100 and 50-100 kg wheat, respectively

Seal and Baranowski (2000) estimated the cost of use of pesticides in the Ukraine. The study found that the total value of agricultural production in the Ukraine amounted to US$30 billion, equivalent to 30 per cent of the Gross Domestic Product (GDP). The annual cost of pesticide inputs was estimated to be $200-225 million. Herbicides and insecticides accounted for approximately 50 per cent and 30 per cent of pesticide use, respectively.

Tzouvelekas *et al*. (2005) worked out returns of pesticide use in conventional and organic olive-growing farms in Crete, Greece. The study assessed the returns to pest control inputs against olive fruit fly (Bactrocera oleae) for a sample of conventional and organic olive-growing farms. The methodology used in the study captured both the biological and economic loss of pesticides and permitted indirect estimation of crop damage. The study found that the returns to pesticide use were significant and should be taken into account when analysing their productivity.

Demircan and Ylmaz (2005) analysed the pesticide use in apple production in Isparta, Turkey. The study was conducted in the main apple production villages of Egirdir, Gelendost and Senirkent districts during the 2002-03 production season. The data used in the study were obtained by questionnaires applied to 109 apple producers. The average usage of pesticide was 2226 g active ingredient per decare. The percentage of pesticides use was 74.32 per cent, 23.43 per cent and 2.25 per cent for fungicide, insecticide and acaricides, respectively. It was reported that pesticides, fungicides, insecticides and acaricides used were more than the recommended dosages. It was reported that 48.37 per cent of average pesticide cost per decare was due to the overuse of pesticides in apple production. The proportion of plant protection cost in total production cost and variable costs was 21.64 per cent and 29.83 per cent respectively.

Engindeniz and Engindeniz (2006) analysed the cost and returns of pesticide use on greenhouse cucumber growing in Menderes, Turkey during 2002. Data were collected from 28 growers using the random sampling method. The pesticide treatment index of growers varied between 0.2 and 2.5 and the number of growers who used overdose of pesticides was 17 (61%). Average of quantity of insecticides, fungicides, acaricides, and nematicides used in cucumber production was 29.34 g, 256.62 g, 3.34 g and 1528.14 g, active ingredient per 100 m^2 respectively. The average pesticide and pesticide application costs were found to be $ 150/1000 meter square. The average pesticide and pesticide application costs accounted for 11.72 per cent of the variable costs and 9.53 per cent of the total costs, respectively. The break-even yield was worked out to be 1875 kg/1000 $m^{2.}$

3. METHODOLOGY

This chapter deals with the description of study area, the nature and source of data and the sampling producer followed for selection of taluks, villages and farmers and the various analytical tools employed to quantify and evaluate the objectives. At the end of the chapter a few key concepts used in the study are explained to facilitate clear understanding of the issues with which the present study is concerned. The methodology is presented under the following heads.

3.1 Description of the study area

3.2 Nature and source of data

3.3 Methods of analysis

3.4 Concepts and terms used in the study

3.1 Description of the study area

The present study attempted to evaluate the economics of pesticide use in paddy. Paddy is predominantly grown in Koppal district. The area under paddy in Koppal district is 76,196 ha. The pesticide use studies in this area are lacking Hence, Koppal district in Karnataka state is purposively selected for the study. The map showing the study area is presented in Fig.1. Koppal district is located in the Northern part of Karnataka. It is situated between 15^0 09' to 16^0 03' 30" North Latitude and 75^0 47' 30" to 76^0 48' 10" East Longitude. It consists of four talukas *viz.,* Koppal, Gangavati, Kushtagi and Yelburga. Koppal district is surrounded by Raichur district in the East, Gadag district in the West, Bagalkot district in the North, Bellary district in the South. The soils of district are partly red sandy and black cotton soils suitable for growing wide variety of agriculture and horticulture crops. The climate of the district is very hot and dry. Hot season starts from middle of February and extends up to the end of May. South-West monsoon ranges from June end to September. Pos- monsoon ranges between October and November. Cold season starts from December and extends up to middle of February. The average rainfall of the district is 572 mm and average rainy days are 46. The total population of Koppal district is 11.96 lakh (2001 census) of which 9.97 lakh are residing in rural area and 1.98 lakh in urban area. The district is having sex ratio of 982 per 1000 males. The literacy level of district is 62.39 per cent. The population density is 166 per sq km. The total geographical area of Koppal district is 5, 52,495 hectares. The taluka wise population, literacy, inhabited villages, ration cardholders and hoblies in the district is presented in Table 3.1

The land use pattern in study area is presented in Table 3.2. The geographical area of Gangavati and Koppal taluks is 1,32,131 hectare and 1,36,755 hectare respectively of which area under forest in Koppal and Gangavati taluks is 10,779 hectares and 14,882 hectares respectively. The total uncultivable land in these taluks is 7,753 hectares in Gangavati and 2126 hectares in Koppal. The net sown area is 78012 hectares and 91,836 hectares in Gangavati and Koppal respectively. The net irrigated area in these taluks is 40,016 hectare in Gangavati and 16180 hectares in Koppal. The taluka wise area under irrigation according to sources of irrigation in the district is presented in Table 3.3. Canals are the major sources of irrigation. The area covered under Canal irrigation in Gangavati taluk is 36,205 hectare area of total 40,016 hectare irrigation in the taluk. The proportion of irrigated area covered by channels in Koppal is 77.18 per cent (12,488 ha out of 16,180 ha). The irrigated area covered by canals in the district is 65.80 per cent (48,693 ha out of 73,999 ha).

The important crops are grown in the district are paddy, jowar, maize, bajar, cotton, ground nut, sugarcane, wheat and sunflower. Among cereals paddy is major crop, followed by jowar, bajar, maize and wheat. The area under paddy in Koppal district is 76,196 hectare. The taluka wise area under paddy in the district is presented in Table 3.4. The paddy is one of the major crops grown in these taluks. The area under paddy in these taluks is 69,439 hectare in Gangavati and 6,392 hectare in Koppal. Jowar with an area of 7,258 hectare, sunflower with

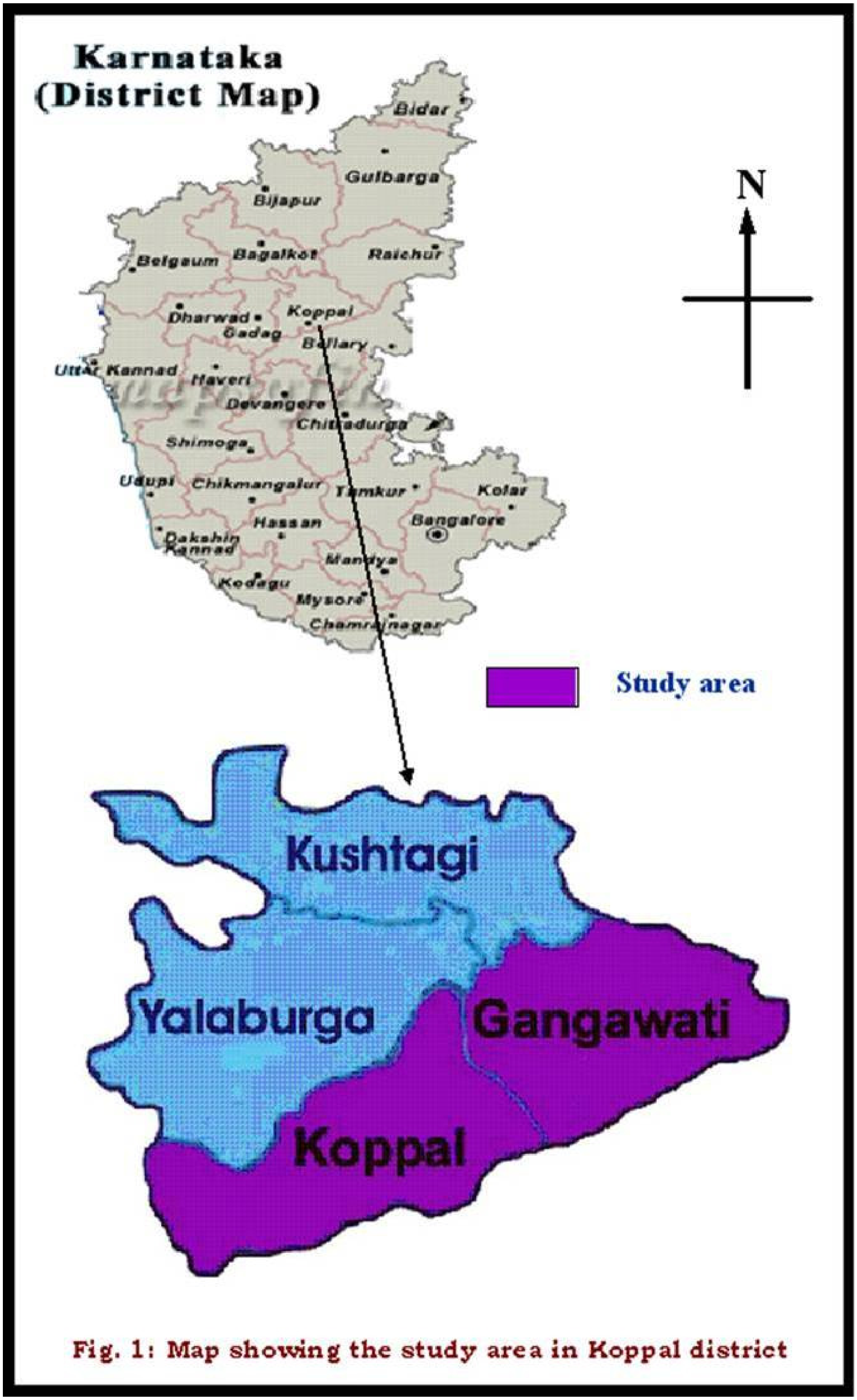

Fig 1. Map showing the study area in Koppa district

an area of 19,068 hectare are the next most important crops grown in Gangavati taluk. Jowar and sunflower are grown on an area of 12,219 hectare and 24,618 hectare in Koppal taluk. For analysing various issues of pesticide use in paddy production in Koppal district, two major paddy growing taluks were selected *viz*., Gangavati and Koppal.

3.2 Nature and source of data

The present study is mainly based on the primary data obtained from sample farmers through survey method. A multistage sampling procedure was adopted to get the necessary information from sample respondents. In first stage, two predominantly paddy growing taluks in the district were selected. In second stage, three villages based on predominance of paddy area were selected from each of the selected taluks. In final stage, 20 paddy growing farmers were randomly chosen from each village for getting the required information on paddy cultivation. Thus, the study was based on 120 randomly selected paddy growing farmers spread in Koppal district of Karnataka. The sample farmers were interviewed personally using a pre-tested and structured schedules specifically designed for the study. The schedule is used for the purpose appended.

The information pertaining to socio-economic aspects of sample farmers, such as family size and composition, education level, land holdings, cropping pattern etc. were elicited. The details pertaining to paddy cultivation namely, area under paddy, land preparation operations, inputs used and output obtained were collected. Data on prices of inputs and outputs, method of sale, use of plant protection chemicals, awareness of farmers with regard to toxicity levels of pesticide, safety measure followed during applications of plant protection chemicals (PPCs) and behavioural aspects before and after application of PPCs were collected. The survey was conducted during October 2008. The data pertained to the crop year 2007-08.

The secondary data with regards to cropping pattern, rainfall, area under crops in the district and the sample taluks and other necessary data were collected from the District Statistical Office (DSO), Koppal.

3.3 Method of analysis

The master tables were prepared from data collected and then subjected to statistical analysis. MS-Excel software package was used for analysis. A brief note on analysis is presented under the following headings.

3.3.1 Tabular presentation.

3.3.2 Production function analysis.

3.3.3 Plant protection chemicals expenditure function.

3.3.1 Tabular analysis

The data was summarized in the form of appropriate tables. The budgeting technique was used to asses the cost, returns and profits from paddy crop cultivation in the study area. The percentages and averages were computed and compared to draw meaningful inferences.

3.3.2 Production function analysis

The Cobb-Douglas (CD) production function was estimated to study the resource use efficiency and influence of inputs on paddy yield in Koppal district. The production function of the following type was specified in the present study.

Table 3.1: Salient features of Koppal district and sample taluks

Sl. No.	Particulars	Gangavati taluk	Koppal taluk	Koppal district
1	Geographical area (Hectares)	132131	136755	552495
2	Inhabited village (No.)	149	144	596
3	Population (No.)	406334	314051	1196089
4	Gram panchayahts (No.)	38	35	134
5	Rural population (No.)	30942	249776	997797
6	Urban population (No.)	101392	64275	198292
7	Population density (No. per sq km)	310	230	166
8	Literacy (%)			
	Male	71.50	47.65	74.70
	Female	76.0	52.85	50.08
9	Average rainfall (mm)	570	574	572
10	Ration card holders (No.)	84904	65152	241195
11	Net irrigated area (ha)	40016	16180	71734
12	Hoblies (No.)	8	4	20

Source *Koppal District at a Glance 2006-07, District Statistical Office, Koppal

$$Y = A\, X_1^{a_1}\, X_2^{a_2}\, X_3^{a_3}\, X_4^{a_4}\, e^{u}$$

Where,

Y= Gross income from paddy (Rs/ha)

X_1= Expenditure on Seeds (Rs/ha)

X_2 = Expenditure on Fertilizers and Manures (Rs/ha)

X_3 = Quantity of Pesticides used (l /ha)

X_4 = Expenditure on labour (Rs/ha)

A= Constant

a_i= Production elasticities

u = Radom error

One of the objectives of the study was to estimate optimum quantity of pesticide use. Hence, PPC input was measured in physical quantity while other inputs measured in monetary values. The above function was converted into the linear form through logarithmic transformation of all variables and is written as

$\log Y = \log A + a_1 \log X_1 + a_2 \log X_2 + a_3 \log X_3 + a_4 \log X_4 + \log u.$

The marginal value products for each input were calculated at the geometric mean levels of the respective resources and geometric mean level of output by using formula,

$$\text{Marginal value product of } X_i = a_i \frac{\overline{Y}}{\overline{X}}$$

Where,

$\overline{Y}$ = geometric mean of gross income

$\overline{X}_i$ = geometric mean of i^{th} resource

a_i = production elasticity of i^{th} resource

The marginal value product was equated the marginal factor cost to determine optimal use of the resources. To determine the optimum quantity of pesticide use, under the assumption of profit maximization behavior, the following relationship was estimated. The marginal physical product (MPP) of pesticides was equated to the price ratio of the pesticide and paddy.

$MPP= (dy\backslash dx) = P_p/P_y$

i.e. $a_3 (\overline{Y}\backslash\overline{X}) = P_p/P_y$

$X^* = (a_3.\ Y.\ \overline{P}_y)/P_p$

Where,

X^* = Optimum quantity of pesticides

a_3 = Production elasticity of pesticides

MPP = Marginal physical product of pesticides

P_p = Unit price of pesticides (Rs/l. a.i)

P_y = Farm gate price of the paddy (Rs/kg)

The rate of returns from pesticide use in the paddy was computed by using formula as suggested by Nguyen and Tran Thi, 2003. The rate of return was estimated as the ratio of (Returns – total cost other than pesticides)/ total pesticide cost

3.3.3 Plant protection chemical expenditure function

The following log linear regression function was used for estimating the plant protection chemical expenditure elasticity coefficient.

Table 3.2: Land utilization pattern in the study area and sample taluks

(area in ha)

Sl. No.	Particulars	Gangavati taluk	Koppal taluk	Koppal district
1	Geographical area	132131	136755	552495
2	Area under forest	14482	10779	29451
3	Non agriculture	7680	20401	38870
4	Cultivable waste	560	430	2568
5	Barren	4651	6790	16627
6	Permanent pasture	7193	1486	14675
7	Trees and groves	0.00	210	210
8	Total uncultivable land	7753	2126	17453
9	Net sown area	78012	91836	380700

Source *Koppal District at a Glance 2006-07, District Statistical Office, Koppal

$$\log Y = \log A + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + \log u$$

Where,

Y = Expenditure on plant protection chemicals (Rs/ha)

X_1 = Total family income (Rs/ha)

X_2 = Expenditure on fertilizers and manures (Rs/ha)

X_3 = Intensity of pesticide application (no of times /ha)

X_4 = Area under paddy (ha)

u = Random error

3.4 Concepts and the terms used in the study

Some of the concepts used in the study and measurement of inputs and outputs are briefly explained below.

Table 3.3: Irrigation status in Koppal district and sample taluks

(area in ha)

Sl. No.	Source of irrigation	Gangavati taluk	Koppal taluk	Koppal district
1	Canals	36205	12488	48693
2	Tanks	0.00	0.00	44
3	Bore wells	3011	2227	22997
4	Lift irrigation	800	1465	2265
	Total irrigation	40016	16180	73999

Source *"Koppal District at a Glance 2006-07, District Statistical Office, Koppal

Human labour

The human labour is measured in terms of man days for different farm operations of paddy cultivation. The women days were converted into adult man days of eight hours per day on the basis wage differential between man and women labour. For instance, in the present study the wage rate of man day is Rs. 100 and that for women day is Rs. 50, the adult man day is 50\100=0.50.

Bullock labour

Bullock labour is defined in bullock pair days, both owned and hired were charged at the prevailing rate paid per day (8 hours) in the study area.

Machine labour

The cost of machine labour both hired and owned was calculated for differential rates for deferent type of operations prevailed in study area.

Seed cost

The cost of own seeds was calculated at local market price for the paddy seeds and the actual expenditure incurred in the case of purchased seeds was considered.

Farm yard manure (FYM)

The quantity of FYM used in the cultivation of paddy was measured in terms of tonnes and the cost was imputed at the market price prevailing in the village.

Fertilizers

Cost of fertilizer was computed considering the actual price paid by the farmers including the transportation cost and other identical charges, if any.

Table 3.4: Area under major crops in Koppal district and sample taluk

(in ha)

Sl. No.	Crops	Koppal district	Gangavati taluk		Koppal taluk	
			Area	%	Area	%
1	Paddy	76196	69439	91.13	6392	8.39
2	Jowar	48607	7258	14.93	12219	25.14
3	Bajra	69097	13512	19.56	12175	17.62
4	Maize	17528	515	2.94	10831	61.79
5	Wheat	4923	177	3.60	512	10.40
6	Total cereals	216351	90901	42.02	42129	19.47
7	Total food grains (6)	216351	90901	42.02	42129	19.47
8	Ground nut	32310	2381	7.37	11759	36.39
9	Sunflower	102142	19068	18.67	24618	24.10
10	Other oil seeds	16045	2671	16.65	2380	14.83
11	Fruits	6004	924	15.39	202	3.36
12	Vegetables	3105	764	24.61	1182	38.07
13	Spices and condiments	840	81	9.64	310	36.90
14	Sugarcane	1396	547	39.18	773	55.37
15	Cotton	3779	579	15.32	802	21.22
16	Non- food crops	165621	27015	16.31	42026	25.37

Source *Koppal District at a Glance 2006-07, District Statistical Office, Koppal
* Percentages area share of the taluk in the district.

Plant protection chemicals

The cost of different insecticides, weedicides and fungicides used in controlling paddy pests and diseases were charged on the basis of actual price paid by the farmers towards the purchase of these chemicals.

Irrigation charges

Per crop irrigation charges as fixed by the government for canal irrigated farmers (Rs. 80/ha/annum for paddy) and electricity charges incurred by bore well and well irrigated farmers were considered.

Land revenue

Land revenue was charged at the rate imposed by the government.

Rental value of land

It was imputed at the prevailing rents in the study on area per hectare and per annum basis.

Interest on working capital

Interest on working capital was calculated at the rate which banks are advancing shot-term loans. The prime lending rate during the agriculture year was 6 per cent for crop loan of paddy. It was charged for a period of six months for paddy crop.

Depreciation

The depreciation was calculated by straight line method. The charges on account of minor repairs of implements and machinery during the year were added to the depreciation charges. It was apportioned on the basis of area of land under each crop grown during the year.

Total cost of cultivation

The total cost included the cost of human labour, bullock labour, tractor power, manures, fertilizers, plant protection chemicals, and seeds etc, and other fixed costs.

Gross returns

The gross returns were computed by multiplying the quantity of output (main and by product) obtained with respective prices received.

Net returns

It indicates profit or loss. This is computed as the difference between gross returns and total cost incurred by the farmers. The costs and returns were computed on per hectare basis for comparison.

4. RESULTS

The results obtained from the analysis of the data are summarized and presented in this Chapter under the following heads.

1. General characteristics of sample farmers
2. Cost and returns from paddy cultivation
3. Cost and returns with reference to pesticide use
4. Safety practices followed by the sample farmers

4.1 General characteristics of the sample farmers

The farmers having land holdings of two ha and less than two ha were grouped as small farmers, while, the farmers having land holdings of four and less than four ha were grouped as medium farmers and the farmers having land holdings of more than four ha were grouped as large farmers. The average age of the sample respondents was 41.84 years (Table 4.1) and it was 42.35 years, 41.93 years and 41.25 years for small, medium and large farmers respectively. The average family size was around seven members which composed of two males, two females and three children. The average size of holding of the respondents was 3.24 ha. The size of holding of small, medium and large farmers was 1.38 ha, 2.70 ha and 5.64 ha respectively. The average size of irrigated farm was 2.99 ha. Small, medium and large farmers respectively had 1.09 hectares, 2.46 ha, and 5.42 ha under irrigation. The average area under the paddy for the sample farmers was 2.21 ha and it ranged from 0.93 ha in the case of small farmers to 3.78 ha for large farmers. The average paddy yield was 65.86 q/ha. It was 65.14 q/ha, 66.28 q/ha and 66.15 q/ha for small, medium and large farmers respectively.

The educational status of the sample farmers was presented in Table 4.2. It was noticed that on an average 87.50 per cent of farmers were literate. Among literates, 49.18 per cent of farmers had education up to primary level, 25 per cent of them studied up to secondary school. The farmers who had college education worked out to 13.33 per cent. The remaining 12.5 per cent of the farmers were illiterate. It was noticed that 95 per cent of the large farmers were literate which was highest when compared to the other groups.

4.1.1 Cropping pattern and major crops grown

As could be seen from Table 4.3, all the three categories of farmers are growing a number of crops on their farm. Paddy and maize were the major crops grown, where as sorghum, bajra, sunflower, wheat and ground nut were the other crops grown by the sample farmers. Paddy is the major food crop of the area grown in *kharif* and *rabi* season by all the categories of farmers. Monocropping of paddy (paddy after paddy) is a highly prevailing in the area.

The major crops grown during kharif by sample farmers were paddy, maize, sunflower, sorghum and bajra. Among these crops the area under paddy was found to be highest (2.21 ha), maize, sunflower, sorghum, and bajra occupied an average area of 0.23 ha, 0.31 ha, 0.05 ha, and 0.10 ha respectively.

During *rabi* season paddy, maize, sunflower, sorghum and wheat were the major crops grown. The average area under these crops was 2.2 ha, 0.50 ha, 0.11 ha, 0.03 ha, and 0.23 ha respectively. Since the mono-cropping is common practice in the area, the area under paddy in the both the seasons were almost same. The proportion of area under paddy to size of holding worked out to 68 per cent kharif and Rabi seasons. This shows the dominance of paddy in study area. Across the size group, though the area under paddy varied apparently interms of absolute area, it did not show sizable difference interms of proportion in the size of holding.

Table: 4.1 General characteristics of sample farmers

Sl. No.	Particulars	Farmers			
		Small (n=40)	Medium (n=40)	Large (n=40)	All (n=120)
I	Average age (years)	42.35	41.93	41.25	41.84
II	**Family composition (no)**				
	Male	1.93 (36.35)	2.60 (38.07)	2.85 (37.35)	2.46 (37.33)
	Female	1.05 (19.77)	1.70 (24.89)	2.00 (26.21)	1.58 (23.98)
	Children	2.33 (43.88)	2.53 (37.04)	2.78 (36.44)	2.55 (38.69)
	Average family size	5.31 (100.00)	6.83 (100.00)	7.63 (100.00)	6.59 (100.00)
III	**Size of land holding (ha)**				
	Average size of dry farm	0.29 (20.01)	0.24 (8.74)	0.22 (3.90)	0.25 (7.72)
	Average size of irrigated farm	1.09 (78.99)	2.46 (91.11)	5.42 (96.10)	2.99 (92.28)
	Average size of land holding	1.38 (100.00)	2.70 (100.00)	5.64 (100.00)	3.24 (100.00)
	Average area under paddy	0.93 (67.39)	1.92 (71.11)	3.78 (67.02)	2.21 (68.21)
IV	Yield (q\ha)	65.14	66.28	66.15	65.86

Note: Figures in parenthesis are percentages

During summer where irrigation facility was available maize, sunflower and ground nut were grown. The average area for these crops was 0.18 ha, 0.10 ha and 0.16 ha respectively. It was noticed that the large farmers had slightly higher cropping intensity (210.99%) as compared to small (187.68%) and medium farmers (199.26%). The average cropping intensity in the study area was 204.31 per cent.

4.2 Cost and returns from paddy cultivation

The cost incurred and returns realized from paddy cultivation were calculated and presented in Table 4.4 and Fig. 2. Among the three categories of farmers, the total cost incurred by the large farmers was high (Rs. 66722.07/ha) as compared to small and medium

Table: 4.2 Educational status of the sample farmers

Sl. No.	Education	Farmers			
		Small (n=40)	Medium (n=40)	Large (n=40)	All (n=120)
1	Illiterate (no)	6 (15.00)	7 (17.50)	2 (5.00)	15 (12.50)
2	Primary (no)	23 (57.50)	19 (47.50)	17 (42.50)	59 (49.18)
3	Secondary (no)	8 (20.00)	5 (12.50)	17 (42.50)	30 (25.00)
4	College and above (no)	3 (7.50)	9 (22.50)	4 (10.00)	16 (13.33)
	Total	40 (100.00)	40 (100.00)	40 (100.00)	120 (100.00)

Note: Figures in parenthesis are percentages

farmer (Rs.6497.50/ha and Rs. 65564.68/ha). The average cost of cultivation in paddy worked out to Rs.65591.53/ha.

The gross returns obtained per hectare by large farmers were high (Rs.83062/ha) as compared to small and medium farmers (Rs.82517/ha and Rs.82631/ha respectively).

The net returns per hectare obtained by small farmers were high (Rs. 18014.50/ha) as compared to medium and large farmers (Rs.17066.32 and Rs.16339.93/ha respectively). The share of variable cost was 62.07 per cent and that of foxed cost was 37.93 per cent. Labour expense was the major component of variable cost while rental value of land was major the fixed cost. Across the farm groups there was no noticeable difference in different component of costs.

The distribution of pattern of operational cost under various inputs revealed that labour shared the highest proportion (33.40%) of the total cost. The share of human labour, bullock labour and machine labour was 15.81 per cent, 0.63 per cent and 16.88 per cent respectively. The share of fertilizers and manures was 14.19 per cent and 3.40 per cent respectively. The pesticide shared the 5.50 per cent of the total cost of cultivation in of paddy. It was noticed that the expenditure on pesticide was highest (Rs.4095.64 l/ha) for large farmers as compared to small and medium farmers. The per hectare average pesticide expenditure worked out to Rs. 3607.5. The pesticide expenditure increased with the increase in farm size.

The average yield of paddy was 65.86 q/ha. The yield of paddy was highest in the case of medium farmers being 66.28 q/ha as compared to (65.14 q/ha) small and large farmers (66.15 q/ha). There was no glaring difference in the cost and returns across different categories of framers.

Table 4.3: Cropping pattern followed by the respondents

Crop\ season	Small (n=40)	Medium (n=40)	Large (n=40)	All (n=120)
Kharif	Area (ha)	Area (ha)	Area (ha)	Area (ha)
Paddy	0.93	1.92	3.78	2.21
Maize	0.12	0.0	0.57	0.23
Sunflower	0.14	0.13	0.66	0.31
Sorghum	0.02	0.00	0.12	0.05
Bajra	0.17	0.14	0.00	0.10
Rabi				
Paddy	0.93	1.92	3.78	2.21
Maize	0.025	0.71	0.75	0.50
Sunflower	0.0	0.00	0.34	0.11
Sorghum	0.0	0.00	0.10	0.03
Wheat	0.16	0.20	0.32	0.23
Summer				
Maize	0.02	0.06	0.45	0.18
Sunflower	0.0	0.00	0.31	0.10
Ground nut	0.07	0.00	0.40	0.16
Horticulture crop				
Pomegranate	0.00	0.30	0.32	0.21
Gross cropped area	2.59	5.38	11.9	6.62
Size of land holding	1.38	2.70	5.64	3.24
Cropping intensity (%)	187.68	199.26	210.99	204.31

4.2.1 Resource use efficiency in paddy

The Cobb- Douglass production function was estimated to analyse the relationship between resources and productivity of paddy using survey data from sample farmers. The gross realized income expressed in rupees from paddy output was taken as dependent variable while expenditure made on seeds (Rs), fertilizers and manures (Rs), labours (Rs) and quantity of pesticide used (l) were taken as independent variables. The dependent and independent variables in production function were defined on per ha basis. The estimated production functions are presented in Table 4.5. The inputs included in model explained 90 per cent (small farmers), 86 per cent (medium farmers), 85 per cent (large farmers) and 81 per cent (all farmers) of variation in paddy output as revealed by the coefficient of multiple determination (R^2). The summation of production elasticities indicated decreasing returns to

Table 4.4 Per hectare Costs and returns in paddy cultivation

Sl. No.	Particulars	Unit	Small		Medium		Large		All	
			Phy. Units	Value (Rs)	Phy. units	Value (Rs)	Phy. units	Value (Rs)	Phy. units	Value (Rs)
1	Human labour	Man days	105.15	10515 (16.30)	105.42	10542.29 (16.08)	100.47	10046.61 (15.06)	103.68	10367.97 (15.81)
2	Bullock labour	Pair days	1.06	263.75 (0.41)	1.72	429.6875 (0.68)	2.21	552.81 (0.83)	1.66	415.42 (0.63)
3	Machine labour	Hr	18.93	11125 (17.25)	18.93	11125 (16.97)	18.93	11125 (16.67)	18.93	11125.00 (16.96)
3	Seed	Kgs	63.79	1275.75 (1.98)	64.30	1286.042 (1.96)	63.79	1275.78 (1.91)	63.96	1279.19 (1.95)
4	FYM	Tones	5.12	2303.44 (3.57)	5.09	2292.188 (3.48)	4.66	2098.13 (3.14)	4.96	2231.25 (3.40)
5	Fertilizer									
	N	Kg	310	2500 (3.88)	310	2500 (3.81)	310	2500 (3.75)	310	2500.00 (3.81)
	P	Kg	230	4500 (6.98)	230	4500 (6.86)	230	4500 (6.74)	230	4500.00 (6.86)
	K	Kg	82.2	695 (1.08)	75	648 (0.99)	75	625 (0.94)	77.40	656.00 (1.00)
	Zn	Kg	12.5	1500 (2.33)	12.5	1500 (2.29)	16.25	1950 (2.92)	13.75	1650.00 (2.52)
6	PPCS’									
	Dust	Kgs	0.35	324.46 (0.50)	0.37	366.78 (0.56)	0.45	562.82 (0.84)		416.37 (0.63)
	Liquid	L	1.27	2765.08 (4.29)	1.47	3275.71 (5.00)	1.92	3532.82 (5.29)	1.56	3191.20 (4.87)

Contd..

Sl. No.	Particulars	Unit	Small		Medium		Large		All	
			Phy. Units	Value (Rs)	Phy. units	Value (Rs)	Phy. units	Value (Rs)	Phy. units	Value (Rs)
7	Irrigation			80 (0.12)		80 (0.12)		80 (0.12)		80.00 (0.12)
8	Int on working capital			2270.85 (3.52)		2312.74 (3.53)		2330.94 (3.49)		2303.27 (3.51)
I	Total variable cost			40118.33 (62.20)		40858.44 (62.32)		41179.91 (61.72)		40715.67 (62.07)
1	Land revenue and taxes			62.00 (0.10)		62.00 (0.09)		62.00 (0.09)		62.00 (0.09)
2	Depreciation charges			317.17 (0.49)		644.24 (0.98)		1480.16 (2.22)		813.86 (1.24)
3	Rental value			24000 (37.80)		24000 (36.61)		24000 (35.97)		24000.00 (36.43)
II	Total fixed cost			24379.17 (37.61)		2470.24 (37.68)		25542.16 (38.28)		24875.86 (37.93)
III	Total cost			64497.50 (100.00)		65564.68 (100.00)		66722.07 (100.00)		65591.53 (100.00)
1	Output	Qt	65.14	82517.00	66.28	82631.00	66.30	83062.00	65.86	82736.67
2	Gross income			82512.00		82631.00		83062.00		82736.67
3	Net income			18014.5		17066.32		16339.93		17415.14

Note: Figures in parenthesis are percentages to the total cost

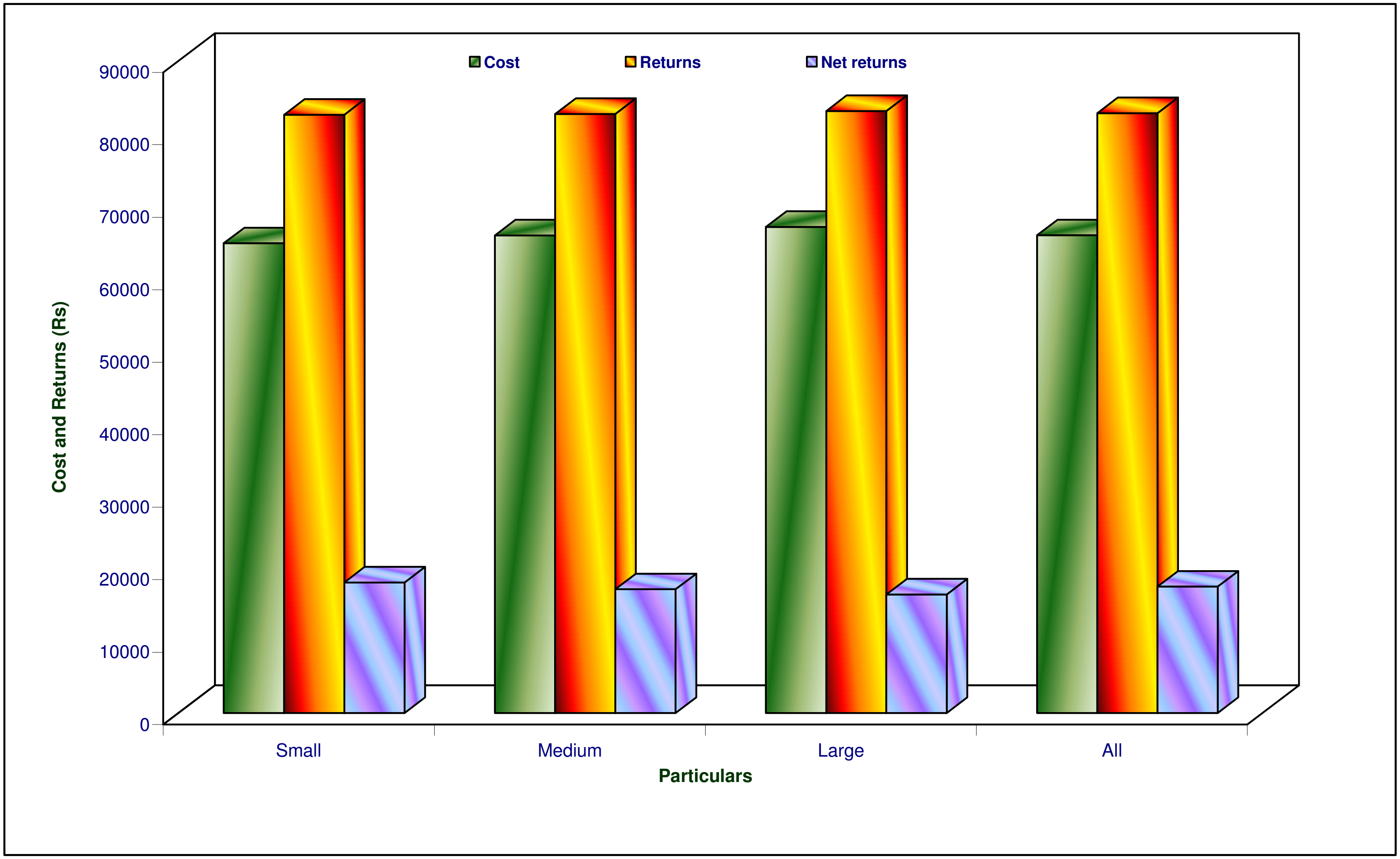

Fig. 2 : Cost and returns in paddy cultivation (Rs/ha)

scale *i.e.* for each per cent incremental use of all inputs simultaneously farmers would get less than one per cent of output.

The estimated parameters of seeds and pesticides were positively significant at one per cent of probability level for all farmers indicating that every one per cent increase in seed would result in increase of gross return by 0.049 per cent and for every one per cent increase in pesticides would result in an increase of gross income by 0.0215 per cent. The coefficients of fertilizers and manures and labour were negative for all categories of farmers and significant at five per cent for medium farmers and non significant for small, large and all farmers. One per cent increase in fertilizer and manures would result in decrease of gross income by 0.0251 per cent. The estimated production elasticity of labour was negative and significant at one per cent probability level for all farmers and it was non significant for small, medium and large farmers. Every one per cent increase in the labour would result in decrease in the gross income by 0.0370 per cent.

4.2.2 Marginal value product to marginal factor cost

The Cobb-Douglas function estimates and geometric levels of inputs and outputs were used to estimate the marginal value products of the inputs. The knowledge of the marginal value products of resources facilitates comparison of marginal value product with marginal factor cost of the resources to arrive at optimal use of resources.

It was evident from Table 4.6 that the ratio of marginal value product and marginal factor cost was positive and more than unity for seeds for all categories of farmers indicating that the resource was under utilized and there was scope for maximizing returns by increasing the use of seeds. The ratio of marginal value product and marginal factor cost were negative and below unity for fertilizers and manures where as positive but below unity for pesticides in the case of all categories of farmers indicating that these resources were over used *i.e.* decrease in the use of these inputs would enhance the returns. Thus, the scope for optimization exists with respect to these inputs.

4.3 Cost and returns with reference to pesticide use

The cost incurred and returns realized from pesticide use were calculated and presented in Table 4.7. Among the three categories of farmers the total cost incurred on pesticides by large farmers was the highest (Rs.4095.644/ha) as compared to small (Rs.3089.99/ha) and medium farmers (Rs.3642.51/ha). On an average the expenditure on pesticides worked out to Rs. 3607.57 per hectare (Fig.3).

The rate of return from pesticide use was computed by using formula as suggested by the Nguyen and Tran Thi (2003). The result also indicated (Table 4.7 and Fig.4) that the rate of return obtained from pesticides use was high for small farmers (Rs.6.73) as compared to medium (Rs.5.89) and large farmers (Rs.5.46). The per ha pesticide expenditure increased with an increase in the size of holding.

4.3.1 Distribution of sample farmers according to the number of pesticides application

The farmers in the study area were found to use pesticides frequently in paddy cultivation. Large majority of farmers (50%) treated the crop five times during its production cycle (Table 4.8). Most of the small farmers (72%) and medium farmers (60%) were found to treat five times during the production cycle of paddy. More than 60 per cent of large farmers applied pesticides more than six times. Out of all farmers none of them were reported spraying less than three times. In the entire sample, Maximum number of application was observed to be seven times.

Most of the small farmers (85 %) and majority of the medium farmers (70 %) were found to apply three sprays of insecticides where as 47.50 per cent of the large farmers applied four sprays of insecticides. About 10 per cent of farmers applied five sprays of insecticides. On an average most of the farmers (61 %) found to apply three sprays of insecticides.

Table 4.5 Estimated Cobb- Douglass production function in paddy production

Sl. No.	Explanatory variable	Small (n=40)	Medium (n=40)	Large (n=40)	All (n=120)
1	Intercept	9.2394** (0.8268)	10.0862** (1.0237)	9.0226** (1.3558)	8.2376** (0.5008)
2	Expenditure on Seeds (Rs)	0.3994** (0.0641)	0.5973** (0.1016)	0.3650** (0.1441)	0.4926** (0.0484)
3	Expenditure on Fertilizers and manures (Rs)	-0.0434 (0.0471)	-0.2243* (0.0892)	-0.0259 (0.0410)	-0.0251 (0.0264)
4	Quantity of Pesticide (l)	0.0291* (0.0051)	0.0222* (0.0108)	0.0267** (0.0072)	0.0215** (0.0030)
5	Expenditure on Labour (Rs)	-0.0589 (0.0539)	-0.1126 (0.0606)	-0.0275 (0.0424)	-0.0370** (0.0285)
6	R^2	0.90	0.86	0.85	0.81*
7	Adjusted R^2	0.88	0.84	0.84	0.80
8	'F' value	75.69	53.48	20.77	104.34
9	Reruns to scale	0.3262	0.2827	0.3384	0.4520

Note: Figures in parentheses are standard errors
*denotes significance at 5%
** denotes significance at 1%

It was observed that the use of weedicides was not common and about 30 per cent of the farmers, did not use weedicides. About 70 per cent of farmers opted for one weedicide application. The fungicides were mainly used to control fungal diseases. About 97 per cent of the farmers used fungicides, of which 76 per cent of them opted for one fungicide spray while 20 per cent of them opted for two fungicides sprays.

4.3.2 Quantity of pesticide use on paddy

Table 4.9 presents the quantity of pesticides used in paddy production. Among the three categories of farmers, the quantity of pesticides use was observed to be the highest by large farmers (2.37 l/ha) as compared to small and medium farmers (1.62 l/ha and 1.84 l/ha respectively).

On an average one hectare of paddy area received 1.95 l of technical grade pesticides in the study area. Insecticides were the most frequently used pesticides which accounted for bulk of the share (60%) in total pesticides used and followed by fungicides (24%) and weedicides (16%).

Table 4.6 Ratio of marginal value product to the marginal factor cost in paddy production

Sl. No.	Resources	Farmers											
		Small (n=40)			Medium (n=40)			Large (n=40)			All (n=120)		
		MFC	MVP	MVP\MFC	MFC	MVP	MVP\MFC	MFC	MVP	MVP\MFC	MFC	MVP	MVP\MFC
1	Seeds (Rs)	1	25.83	25.83	1	38.38	38.38	1	23.67	23.67	1	31.86	31.86
2	Fertilizer and manures (Rs)	1	-0.31	-0.31	1	-1.62	-1.62	1	-0.18	-0.18	1	-0.18	-0.18
3	Pesticides (ml)	1.91	0.80	0.42	1.98	0.53	0.27	1.69	0.52	0.31	1.84	0.50	0.27
4	Labour (Rs)	1	-0.25	-0.25	1	-0.48	-0.48	1	-0.12	-0.12	1	-0.16	-0.16

Table 4.7 Cost and returns with reference to pesticide use

Farmers	Cost (Rs)	Rate of Return (Rs)
Small (n=40)	3089.54	6.73
Medium (n=40)	3642.49	5.89
Large (n=40)	4095.64	5.46
All (n=120)	3607.57	5.97

Note: Rate of return to pesticides = (Return - all costs other than pesticides)/total pesticide cost (Nguyen and Tran Thi, 2003)

4.3.3 Frequency distribution of pesticide use intensity

Frequency distribution of farmers by pesticide use intensity was presented in Table 4.10. On an average about nine per cent of the farmers used pesticide in the range of 2.5 to 3.0 liter per hectare. There was a substantial inter farm variation in pesticide use intensity. It ranged from 0.85 liters per hectare to 3.37 liter per hectare. On the lower side about 34 per cent of the farmers used pesticides less than 1.5 liter per hectare. Most of the small farmers (56%) were found to use less than1.5 liters per hectare. On the other hand, 10 per cent of the farmers used pesticides more than three liters per hectare and all of them were large farmers.

4.3.4 Type of pesticides used by paddy growers

Pesticide use in paddy cultivation has become a regular and inevitable feature in the study area even though most of the farmers discount the complexity involved in and consequence of indiscriminate use of pesticides. Organochlorines, Organophosphates, Pyrethroids, Neoonicotinoids and Aclyurea compounds were the major group of insecticides used by the farmers in the study area (Table 4.11). In the cultivation of one hectare of paddy about 30 per cent of the pesticides applied belonged to Organochlorines category. Organophosphates comprised 26 per cent of total technical grade pesticides followed by Aclyurea compounds, Pyrethroids and Neoonicotinoids (12, 7 and 1.5%, respectively).

Among the three categories of farmers, Organochlorines were used mostly by medium farmers (0.64 l/ha), organophosphates were used mostly by large farmers (0.98 l/ha), Pyrethroids were used mostly by medium famers (0.20 l/ha), Neoonicotinoids were used mostly by medium farmers (0.06 l/ha) and Aclyurea compounds were used most by small farmers (0.23 l/ha).

It was also observed that the cost incurred was highest on Aclyurea compounds Rs. 1389.25 per hectare. This accounted for about 38 per cent of the total cost incurred on all type of pesticides used, followed by organophosphates (Rs. 563.33/ha) which accounted for 16 per cent of the total cost incurred on all type of pesticides used and Pyrethroids (Rs. 516.65/ha) accounted for about 14 per cent of the total cost.

4.3.5 Optimum quantity of pesticide requirement

The optimum quantity of pesticide requirement for paddy production was presented in Table 4.12. The optimum quantity of pesticide required for paddy was estimated to be 0.97

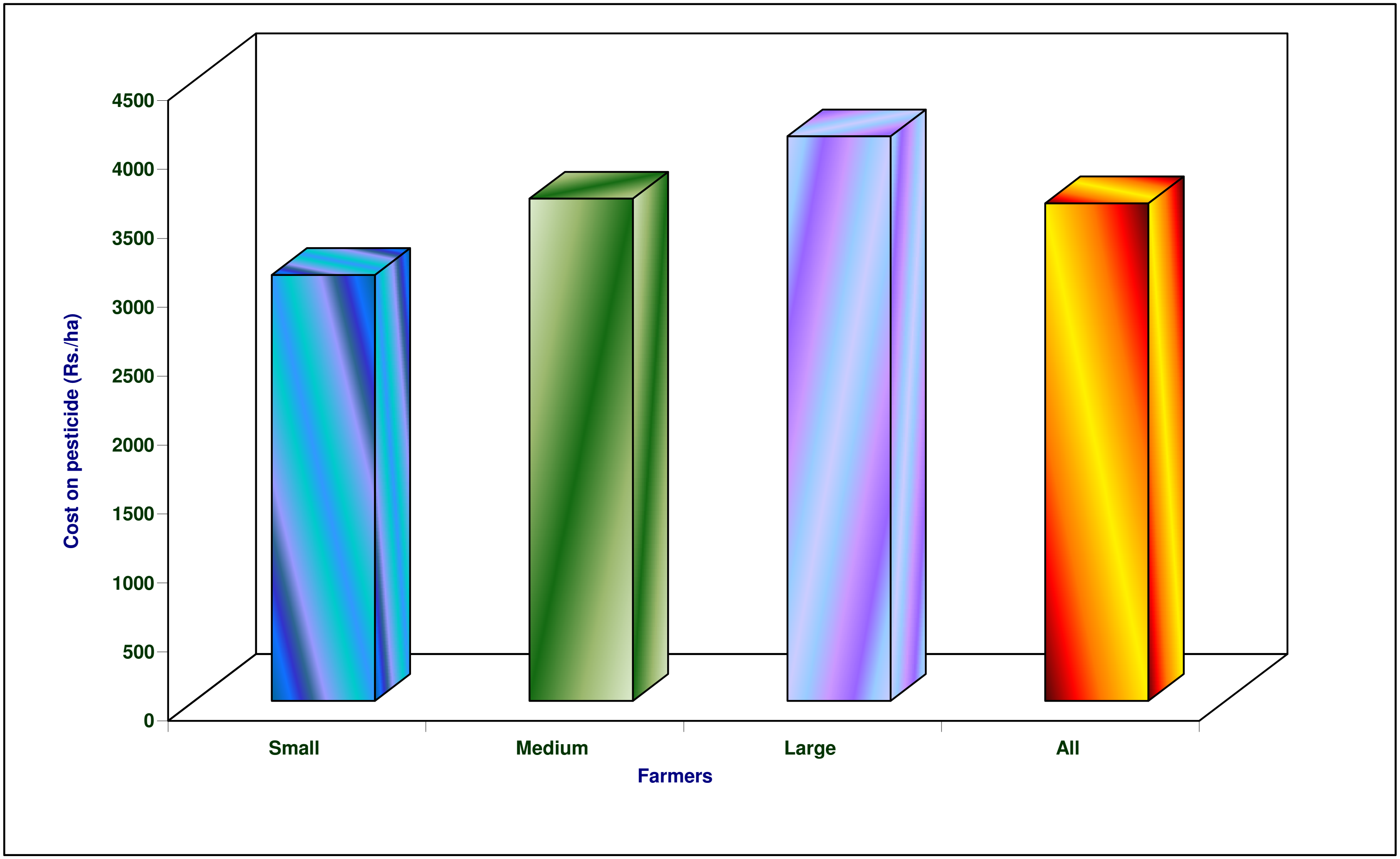

Fig. 3 : Per ha Cost pesticide use

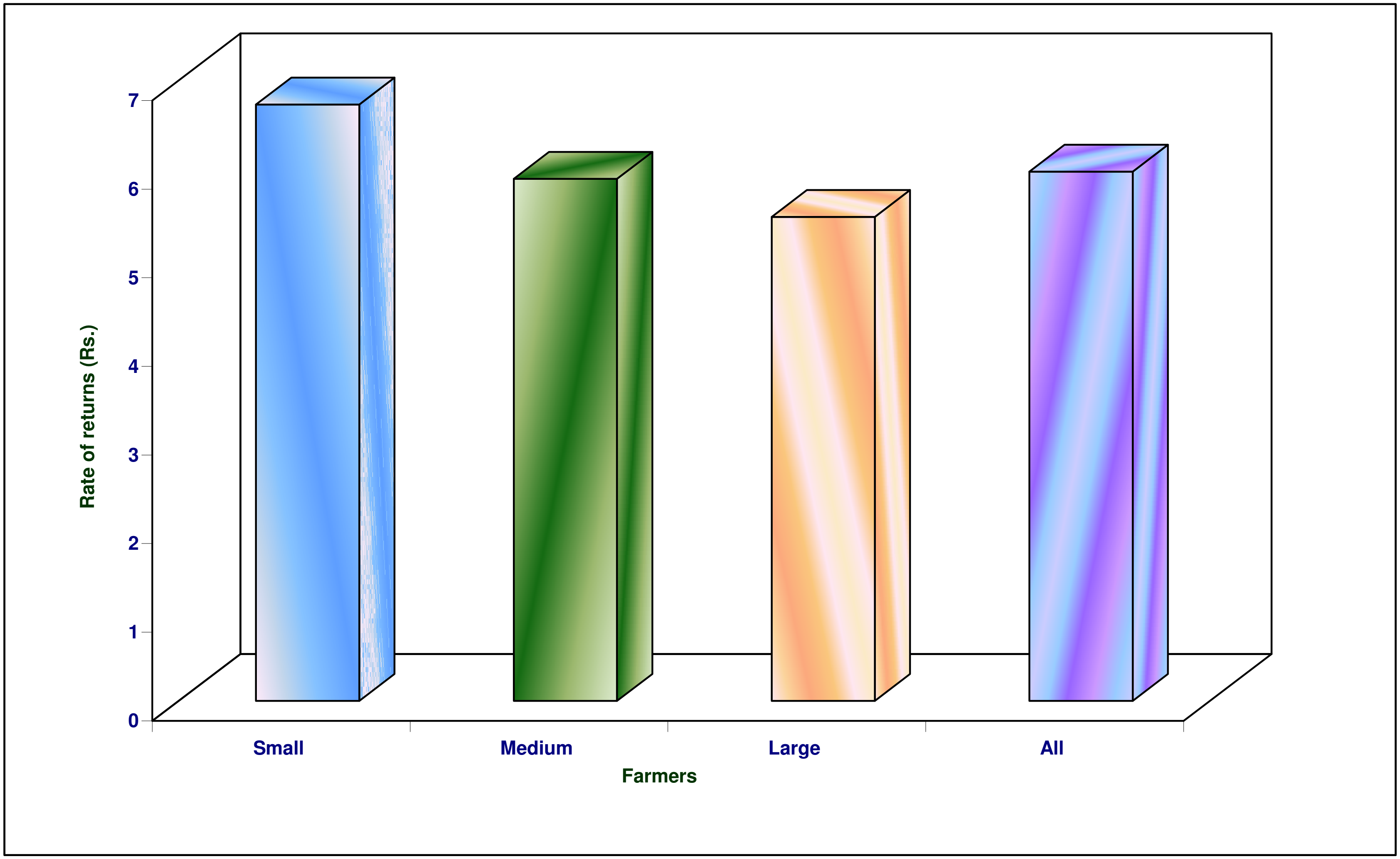

Fig. 4 : Rate of returns to pesticide use

Table 4.8: Distribution of sample farmers according to the number of pesticide applications

No of application	Farmers			
	Insecticides			
	Small N=40	Medium N=40	Large N=40	All N=120
2	3 (7.50)	1 (2.50)	0 (0.00)	4 (3.33)
3	34 (85.00)	28 (70.00)	11 (27.50)	73 (60.83)
4	3 (7.50)	11 (27.50)	19 (47.50)	33 (27.50)
5	0.0 (0.00)	0 (0.00)	10 (25.00)	10 (8.33)
Total	40 (100.00)	40 (100.00)	40 (100.00)	120 (100.00)
	Weedicides			
0	11 (27.50)	7 (17.50)	16 (40.00)	34 (28.33)
1	29 (72.50)	33 (82.50)	24 (60.00)	86 (71.66)
Total	40 (100.00)	40 (100.00)	40 (100.00)	120 (100.00)
	Fungicides			
0	3 (7.50)	0.0 (0.00)	0.0 (0.00)	3 (2.50)
1	37 (92.50)	29 (72.50)	26 (65.00)	92 (76.67)
2	0.0 (0.00)	11 (27.50)	14 (35.00)	25 (20.83)
Total	40 (100.00)	40 (100.00)	40 (100.00)	120 (100.00)
	Total number of pesticide application			
3	3 (7.50)	0 (0.00)	0 (0.00)	3 (2.50)
4	8 (20.00)	1 (2.50)	5 (12.50)	14 (11.67)
5	29 (72.50)	24 (60.00)	7 (17.50)	60 (50.00)
6	0.00 (0.00)	15 (37.50)	12 (30.00)	27 (22.50)
7	0.00 (0.00)	0.00 (0.00)	14 (35.00)	14 (11.67)
Total	40 (100.00)	40 (100.00)	40 (100.00)	120 (100.00)

Note: Figures in parenthesis are percentages

Table 4.9 Quantity of pesticide used in paddy cultivation (a.i/ha)

Sl. No.	Pesticides	Farmers			
		Small (n=40)	Medium (n=40)	Large (n=40)	All (n=120)
1	Insecticides(l)	0.94 (58.02)	0.92 (50.00)	1.60 (67.51)	1.16 (59.49)
2	Weedicides (l)	0.29 (17.90)	0.37 (20.10)	0.28 (11.81)	0.31 (15.90)
3	Fungicides (l)	0.39 (24.07)	0.55 (29.89)	0.49 (20.68)	0.48 (24.62)
	Total (l)	1.62 (100.00)	1.84 (100.00)	2.37 (100.00)	1.95 (100.00)

Note: Figures in parenthesis are percentages

Table 4.10: Frequency distribution of sample farmers according to pesticide use intensity

Pesticide use intensity (l\ha)	Farmers				
	Small (n=40)	Medium (n=40)	Large (n=40)	All (n=120)	Yield (q/ha)
<1.5	23 (57.50)	13 (32.50)	5 (12.50)	41 (34.17)	65.27
1.5-2.0	17 (42.50)	17 (42.50)	3 (7.50)	37 (30.83)	65.30
2.0-2.5	0 (0.00)	7 (17.50)	12 (30.00)	19 (15.83)	66.52
2.5-3.0	0 (0.00)	3 (7.50)	8 (20.00)	11 (9.17)	67.20
>3.0	0 (0.00)	0 (0.00)	12 (30.00)	12 (10.00)	67.30

Note: Figures in parenthesis are percentages

Table: 4.11 Types of pesticides used by paddy growers

Pesticides	Farmers							
	Small (n=40)		Medium (n=40)		Large (n=40)		All (n=120)	
	Quantity of ai/ha (l)	Cost/ha (Rs)	Quantity of ai/ha (l)	Cost/ha (Rs)	Quantity of ai/ha (l)	Cost/ha (Rs)	Quantity of ai/ha (l)	Cost/ha (Rs)
Organochlorines	0.49 (30.25)	449.88 (14.56)	0.64 (34.78)	547.77 (15.04)	0.57 (24.00)	520.83 (12.72)	0.57 (29.38)	506.16 (14.02)
Organophosphates	0.42 (25.93)	490.27 (15.87)	0.14 (7.61)	214.99 (5.90)	0.98 (41.54)	990.74 (24.19)	0.51 (26.50)	565.33 (15.66)
Pyrethroids	0.07 (4.32)	275.96 (8.93)	0.20 (10.87)	576.24 (15.82)	0.13 (5.42)	697.75 (17.04)	0.13 (6.86)	516.65 (14.31)
Neoonicotinoids	0.02 (1.23)	49.18 (1.59)	0.06 (3.26)	163.61 (4.49)	0.00 (0.00)	0.00 (0.00)	0.03 (1.42)	70.93 (1.97)
Aclyurea compounds	0.23 (14.20)	1377.05 (44.57)	0.25 (13.59)	1511.78 (41.50)	0.20 (8.44)	1278.85 (31.22)	0.23 (11.77)	1389.23 (38.49)
Others	0.39 (24.07)	447.20 (14.47)	0.55 (29.89)	628.10 (17.24)	0.49 (20.60)	607.47 (14.83)	0.48 (28.46)	560.92 (15.54)
Total	1.62 (100.00)	3089.54 (100.00)	1.84 (100.00)	3642.49 (100.00)	2.37 (100.00)	4095.64 (100.00)	1.95 (100.00)	3607.57 (100.00)

Note: Figures in parenthesis are percentages

l/ha. The requirement of pesticide as estimated through production function varied from 0.93 l/ ha in the case of medium farmer to 1.31 l/ ha for large farmers.

The actual quantity of pesticide use was high in case of large farmers (2.37 l/ha) as compared to small and medium farmers (1.62 l/ha and 1.84 l/ha). The optimum quantity of pesticide required was 0.97 l/ha as compared to actual quantity of 1.95 l/ ha pesticide used. Thus the farmers were found to use almost double the optimal requirement.

4.3.6 Expenditure elasticity co-efficient of pesticides use in paddy

A log linear regression model was estimated considering the cost of pesticides as dependent variable. Total family income (Rs), expenditure on fertilizers and manures (Rs), number of pesticide applications and area under paddy (ha) were taken as independent variables. The independent variables included in model explained 80 per cent (small farmers), 70 per cent (medium farmers), 87 per cent (large farmers) and 77 per cent (all farmers) of total variation in expenditure on PPCs (Table 4.13). The estimated parameter of total family income was positively significant at one per cent probability level for all type of farmers, indicating that one per cent increase in total family income would result in increase expenditure on plant protection chemicals by 9.87 per cent. The regression coefficient for fertilizers and manures was positively significant at one per cent probability level for small farmers and five per cent for all famers, while it was non significant for medium and large farmers. It implied that one per cent increase in expenditure on fertilizer and manures would result in increase in expenditure on plant protection chemicals by 1.01 per cent. The number of pesticide application was positively significant at one per cent level for all farmers, where the co efficient was significant at five per cent for large farmers, while it was non significant for small and medium farmers. This indicated that one per cent increase in number of pesticide application would result in increase in the expenditure on plant protection chemicals by 0.51 per cent. The co efficient for area under paddy was positive and significant at one per cent for all farmers, significant at 10 per cent for large farmers, non significant for medium and small farmers. The coefficient was negative for medium farmers. On an average one per cent increase in area under paddy, would result in increase in the expenditure on plant protection chemicals by 0.09 per cent with an exception of medium farmers.

4.4 Safety practices followed by sample farmers

4.4.1 Farmer’s response towards pesticide use

It could be seen that from Table 4.14 among the three categories of farmers, majority of the large farmers (37.5%) reported that pesticide use was adequate. But a small per cent of (17.5%) small and medium farmers (25%) felt that the use of PPC was adequate. More than 73 per cent of the farmers felt that the pesticide use in paddy was inadequate.

Among the different categories of farmers, about 10 per cent of the large farmers were aware of the recommended dose of pesticides while the awareness was low among small and medium farmers (7.5 and 7.5%).

At the aggregate level only 8.33 per cent of farmers were aware about the recommended dose. Nearly 45 per cent of the sample farmers were observed to look at the labels on the pesticide container. The per cent of the farmers observing labels was high in large farmers (77.50%) as compared to small (7.50%) and medium farmers (50.00%). The sample farmers who were aware of colour symbol on PPC container and toxicity level were only 14.17 and 9.17 per cent, respectively.

Only 32.5 per cent of the sample farmers were aware of the prices of all pesticides. The awareness level increased with increase in the size of holding. About 45 per cent of large farmers were aware of prices.

Table 4.12 Optimum quantity of pesticide requirement in paddy cultivation

Farmers	Optimal use		Actual used		Savings	
	a.i (l/ha)	Cost (Rs/ha)	a.i (l/ha)	Cost (Rs/ha)	a.i (l/ha)	Cost (Rs/ha)
Small (n=40)	1.26	2401.24	1.62	3089.54	0.36	688.00
Medium(n=40)	0.93	1834.41	1.84	3642.49	0.91	1808.08
Large (n=40)	1.31	2263.79	2.37	4095.64	1.06	1831.85
All (n=120)	0.97	1778.84	1.95	3607.57	0.98	1828.73

Table 4.13 Expenditure elasticity of pesticide use in paddy

Sl. No	Variables	Small	Medium	Large	All
1	Intercept	-188.1434** (19.7133)	-110.8981** (22.8825)	-78.7873** (21.2600)	-114.0123** (11.5851)
2	Total family income (Rs)	14.8318** (1.3993)	9.3670** (1.3218)	6.8691** (1.7530)	9.8715** (0.8722)
3	Fertilizer and manure (Rs)	2.9843** (1.0437)	1.3765 (1.6663)	0.7965 (0.5244)	1.0104* (0.4321)
4	Number of pesticide application (no)	0.1897 (0.1797)	0.0980 (0.3731)	0.9318* (0.1493)	0.5181** (0.1147)
5	Area under paddy (ha)	0.1106 (0.1218)	-0.0701 (0.1161)	0.1418 (0.0784)	0.0916** (0.0303)
6	R^2	0.80	0.70	0.87	0.77
7	Adjusted R^2	0.78	0.66	0.86	0.76
8	‘F’ value	34.72	20.07	60.93	94.77

Note: Figures in parentheses are standard errors
*denotes significance at 5%
** denotes significance at 1%

Table 4.14 Farmer's awareness towards pesticide use

Sl. No.	Particulars	Farmers			
		Small (n=40)	Medium (n=40)	Large (n=40)	All (n=120)
1	Adequacy of pesticide use	7 (17.50)	10 (25.00)	15 (37.50)	32 (26.66)
2	Aware of recommended dose	3 (7.50)	3 (7.50)	4 (10.00)	10 (8.33)
3	Look at the labels	3 (7.50)	20 (50.00)	31 (77.50)	54 (45.00)
4	Aware of importance of colour symbols on PPC containers	4 (10.00)	9 (22.50)	4 (10.00)	17 (14.17)
5	Aware of toxicity level	2 (5.00)	5 (12.50)	4 (10.00)	11 (9.17)
6	Aware of prices of all pesticides	8 (20.00)	13 (32.50)	18 (45.00)	39 (32.50)

Note: Figures in parenthesis are percentages

4.4.2 Pesticide handling practices

The pesticide handling practices followed by sample farmers were presented in Table 4.15. Most of the farmers (95%) applied PPC's along the wind direction. Table also revealed that 1.66 per cent of the farmers applied pesticides across the wind. About four farmers out of 120 did not consider the direction of wind as important. It was important to notice that 93 per cent of the farmers were not using any protective coverings. Few farmers (1.67 %) reported that plastic covers or polythen bags were used instead of shoes during PPCs application. Where as 3.33 per cent of the farmers used shoes and five per cent of the farmers used hand gloves. Around 1.67 per cent of farmers were using face masks. The farmers were found to wash hands after spraying. In the sample around 93.33 per cent were washing with soap, while five per cent were washing with mud and soap. About 98 per cent of the farmers have taken bath after spraying.

As regards mixing of the pesticides with water was concerned majority of the farmers (64%) used wooden stick for mixing of which majority were small farmers (92%). About 12.50 per cent of farmers used sprayer lancer method, of which majority of them were large farmers (27.50%). As may as 8.33 per cent farmers used pouring water method and 15 per cent farmers mixed the chemical by pouring water and sprayer lancer in which most of them were large farmers (42.50%). For measuring the chemicals, most of the respondents (81.67%) used measuring jar while 18.33 per cent of them used bottle cap.

Table 1.15 Pesticide handling practices followed by sample farmers

Sl. No.	Particulars	Farmers			
		Small (n=40)	Medium (n=40)	Large (n=40)	All (n=120)
1	**Direction of PPC application**				
	a) A long with wind	38 (95.00)	39 (97.50)	37 (92.50)	114 (95.00)
	b) Across the wind	2 (5.00)	0 (0.00)	0 (0.00)	2 (1.66)
	c) Do not consider wind direction	0 (0.00)	1 (2.50)	3 (7.50)	4 (3.33)
2	**Protective coverings**				
	a) No protective covers	38 (95.00)	38 (95.00)	36 (90.00)	112 (93.33)
	b) Use of hand gloves	0 (0.00)	2 (5.00)	4 (10.00)	6 (5.00)
	c) Use of shoes	0 (0.00)	2 (5.00)	2 (5.0)	4 (3.33)
	d) Use of face masks	0 (0.00)	0 (0.00)	2 (5.00)	2 (1.67)
	e) Use of plastic \polythene bags as shoes	2 (5.00)	0 (0.00)	0 (0.00)	2 (1.67)
3	**Hand washing practice**				
	a) Wash hands	40 (100.00)	40 (100.00)	40 (100.00)	120 (100)
	i) With soap	35 (87.50)	37 (92.50)	40 (100.00)	112 (93.33)
	ii) With mud	2 (5.00)	0 (0.00)	0 (0.00)	2 (1.67)
	iii) With soap and mud	3 (7.50)	3 (7.50)	0 (0.00)	6 (5.00)
4	**Take bath after spraying**	38 (95.00)	40 (100.00)	40 (100.00)	118 (98.33)
5	**Pesticide and water mixing practices**				
	a) Use wooden stick	37 (92.50)	28 (70.00)	12 (30.00)	77 (64.17)
	b) Use sprayer lancer	1 (2.50)	3 (7.50)	11 (27.50)	15 (12.50)
	c) By pouring water	2 (5.00)	8 (20.00)	0 (0.00)	10 (8.33)
	d) By sprayer lancer and pouring water	0 (0.00)	1 (2.50)	17 (42.50)	18 (15.00)
6	**Measurement of pesticides**				
	a) Measuring jar	29 (72.50)	33 (82.50)	36 (90.00)	98 (81.67)
	b) Pesticide bottle cap	11 (27.50)	7 (17.50)	4 (10.00)	22 (18.33)

Note: Figures in parenthesis are percentages

Table 4.16 Sprayer use and maintenance by sample farmers

Sl. No.	Particulars	Farmers			
		Small (n=40)	Medium (n=40)	Large (n=40)	All (n=120)
1	**Type of sprayer used**				
	a) Knapsack sprayer	39 (97.5)	7 (17.50)	0 (0.00)	46 (38.33)
	b) Power sprayers	0 (0.00)	30 (75.00)	40 (100)	71 (59.17)
	c) Knapsack and power sprayers	1 (2.50)	3 (7.50)	0 (0.00)	3 (2.50)
2	**Wash sprayer after use**				
	a) Yes	3 (7.50)	5 (12.50)	8 (20.00)	16 (13.33)
	b) No	37 (92.5)	35 (87.50)	32 (80.00)	104 (86.67)
3	**Disposal of washed water**				
	a) To field	24 (60.00)	21 (52.50)	27 (67.50)	72 (6.00)
	b) To irrigation channel	16 (40.00)	19 (47.50)	13 (32.50)	48 (40.00)
4	**Disposal of pesticide bottle**				
	a) In field	15 (37.50)	11 (27.50)	16 (40.00)	42 (35.00)
	b) Sell	11 (27.50)	15 (37.50)	12 (30.00)	38 (31.67)
	c) Burrying in field	0 (0.00)	4 (10.00)	2 (5.00)	6 (5.00)
	d) Use for other purposes	14 (35.00)	10 (25.00)	10 (25.00)	34 (28.33)

Note: Figures in parenthesis are percentages

4.4.3 Use and maintenance of sprayer

Table 4.16 indicated that two different types of sprayer were used by farmers in the study area. About 38.33 per cent of the farmers used knapsack sprayer in which most were small farmers (97.5%). About 59.17 per cent of the farmers used power sprayers in which majority were large famers (100%). The famers using both knapsack and power sprayer were 2.5 per cent.

About 86.67 per cent of the farmers did not wash the sprayer after use, while those washed spray after use formed 13.33 per cent in which most of them were small farmers (92.5%). About 40 per cent of the farmers let the washed water on to fields while 60 per cent of the famers let the washed water into irrigation channel. About 35 per cent of the farmers were found to throw pesticide bottle in fields and 38 per cent of them were found to sell the bottles. Only 5 per cent of the farmers were burrying pesticide bottles in fields. About 28.33 per cent of the farmers were found to use bottles for other purposes.

Table 4.17 revealed that majority of (95%) PPC applicators had taken food before going for PPC application and most of the applicators did not work in the field after spraying. Only 6 per cent of the farmers worked in the field after spraying and a good majority of (94%) of them took rest after spraying.

Table 4.17 Attitudinal response of PPC applicators

Sl. No.	Activities	Farmers			
		Small (n=40)	Medium (n=40)	Large (n=40)	All (n=120)
1	Eat/drunk before	36 (90.00)	38 (95.00)	40 (100.00)	114 (95.00)
2	Work in the field after spraying	4 (10.00)	4 (10.00)	0 (0.00)	8 (6.17)
3	Rest after spraying	35 (87.50)	38 (95.00)	40 (100.00)	113 (94.17)

Note: Figures in parenthesis are percentages

5. DISCUSSION

The results presented in the previous chapter are discussed in this chapter. The discussion throw light on the possible causes for the results obtained and are presented under the following heads.

1. General characteristics of the sample farmers
2. Cost and returns from paddy cultivation
3. Cost and returns with reference to pesticide use
4. Safety measures followed by the sample farmers

5.1 General characteristics of the sample farmers

Table 4.1 revealed the general information about the sample paddy growers in the study area. The average age of the respondents was 41.84 years indicating that most of the farmers were of middle age group. The average size of the family was around seven. This was slightly more for large farmers. Most of the families in large farmers group were living joint families. The average size of the land holding by large farmers was 5.64 ha. The size of holding in this group was more since most of them were joint families and consisted adult working members. The average irrigated land of the sample farmers in the study area was 2.99 ha and they had assured irrigation facility mostly from canal. More than 90 per cent of the landholdings were under irrigation. There was no much difference in the socioeconomic features of the farmers across different categories except for the size of holding. These features revealed the picture of a normal rural population predominately belonging to agriculture. Agriculture is the major occupation in the study area. The irrigation facility provided by canal irrigation promoted the farmers to cultivate paddy.

The larger holding combined with assured canal irrigation motivated the sample farmers to cultivate irrigation intensive and high profit oriented paddy crop which requires modern inputs like fertilizers and PPCs in large quantities. For the sample respondents out of the total irrigated area of 2.99 ha, the area under paddy worked out to 2.21 hectares forming 73 per cent of the total irrigated area.

The education status of the sample farmers revealed that 12.5 per cent of the farmers were illiterate where as 49 per cent had primary education. Thus nearly 62 per cent of the farmers had very little education or illiterates (Table 4.2). Only few sample farmers (13.33 %) had college and above education and 25 per cent of had secondary education. Thus about 38 per cent of sample respondents had better education.

Paddy crop was an important crop and was grown since few decades. The black soil and assured irrigation facility of the region was an important reason for its dominant cultivation in the study area.

5.2 Cost and returns from paddy cultivation

Table 4.4 revealed that the total cost incurred by the large farmers was slightly high (Rs. 66722.07/ha) and the production of paddy was also slightly high (66.30 q/ha). The application of manures, fertilizers and seeds across the different groups of farmers did vary much. The gross income received by farmers was also high on the large farms (Rs.83062/ha). The share of pesticide was 5.50 per cent of the total cost. S. Tripathi (1999) noticed that the gross income received by larger farmers was more compared to others in cabbage cultivation in Tehri district of Uttar Pradesh. He noticed that the pesticide expenditure was 6.43 per cent of the total cost. Subba Rao *et al.* (1987) indicated that in the cotton growing region of Guntur districts of Andhra Pradesh, the pesticide expenditure was 20 per cent to 25 per cent of the total cost. Birthal *et al.* (200) reported that farmers spent 29 per cent of total cost on pesticides in cotton crop. Engindeniz (2006) reported that the cost of pesticide and pesticide application were 11.72 per cent of total variable cost in cucumber. Thus, these studies indicated the share of pesticides in the total cost of cultivation was in the range of 6 per cent to 29 per cent.

It may be noted that the share of PPC was high for cotton and vegetables. Paddy also required a substantial expenditure on PPC in the view of the attack of varied pest and diseases. Table 4.4 indicated that the net return realized was higher for small farmers as they spent slightly less on bullock labour compared to medium and large farmers. The study conducted by Raghuvanshi *et al* (1999) on wheat also revealed similar results. The gross return from paddy worked out to be Rs. 82,736 per ha in the study area where as total cost amounted to Rs. 65888. A net returns of Rs. 16,822 per ha has been realized by the farmers. The cost and returns structure did not very substantially across different categories of farmers. Different categories of farmers were practicing almost similar cultivation methods and thus could be the reason for this.

The Cobb- Douglass production function was employed to analyze the relationship between resource use and productivity of paddy using survey data of sample farmers. The gross income realized from paddy output was taken as dependent variable while expenditure on seed (Rs), fertilizers and manures (Rs), labour (Rs) and quantity of pesticide use were taken as independent variables. The results of the production function analysis are summarized in Table 4.5.

The elasticity co-efficient for seeds and pesticides were 0.4926 and 0.0215 at the over all level. This indicated that one per cent increase in expenditure on seeds and pesticides would result in increasing the gross income by 0.4926 and 0.0215 per cent respectively. The increased use of seeds enhances population and there by production and gross income. The pesticides is considered as yield increasing input, by controlling insect pests the possibility of reducing the yield loss would increase and the gross income of the farmers would also increase.

The elasticity coefficients of fertilizers and manures (-0.0251) and labour (-0.0370) were negative suggesting that one per cent increase in expenditure on manures and fertilizers and labour would result in decrease of gross income by 0.0370 and 0.0251 per cent respectively. In study area farmers are in the habit of applying excess manures and fertilizers. This would result in growth of plant as fleshy and greenly. This in turn attracts more insect and pests and leads to crop loss and finally reduces gross income. It was observed that the net income of sample farmers would decrease with increased use of labour. The above results were in concurrence with the results obtained in the cotton farmers in the Guntur district of Andhra Pradesh in a study by Eswaraprasad *et al.* (1988) and Pandurangudu (1988) for the pesticides, fertilizer and manures and labour. The study conducted by Nagaraj *et al.* (1994) in Tungabhadra command area also revealed similar result with respect to PPCs in cotton. However, Prabhu (1985) criticized the production function approach for estimating the marginal productivity and optimum quantity of pesticides use since the plant protection chemicals could not be compared with the yield increasing inputs such as fertilizers and manures which appeared to be lacuna of production function approach. The analysis of production elasticities indicate the extent of change in output for every per unit increase or decrease in the use of resources. The scope for re-organization of the resources was also indicated by the production elasticities. However to compute the optimal use of resources, the marginal value products must be compared with their respective marginal factor costs. This is analysed in the subsequence section.

The production elasticity coefficients were used for the estimation of marginal value products of the resources. The Cobb-Douglas function coefficients and geometric mean level of inputs and outputs were used to estimate the marginal value products. The knowledge of the marginal returns of resources is useful because it indicates economic optimal level of resources to be used. The producers by comparing marginal value products with the marginal factor costs can decide optimal use of resources. Maximum efficiency of resources occurs when the ratio of marginal value product to marginal factor cost is one.

As indicated in Table 4.6 the ratio of marginal value product to the marginal factor cost was more than one for seeds. This implied that further increased use of this resource would bring higher returns. The scope for enhancing profit by increased use of seeds was evident from the analysis. The ratio was found to be less than one for plant protection chemicals, labour, fertilizers and manures revealing that these resources were used more than optimally. The farmers in the study area were found to use PPC more than optimality level. This supported the hypothesis that the farmers in the study area using the pesticides indiscriminately which needs immediate attention by technocrats to avoid possible wastage of resources and reduce the environmental damage by excessive pesticide use. The ratio for fertilizer was negative implying that farmers could maximize their profit by using lesser quantities of fertilizers. In fact they are using more than recommended dose (630 kg/ha), where the recommended dose of fertilizers was 320 kg per hectare. The above results were in conformity with results obtained by Eswarprasad *et al* (1988) and Pandurangadu (1988) for the fertilizers. Similar results were noticed for labour also. The marginal value productivity of labour was negative and the elasticity of production was less than zero. Thus the labour use was uneconomical in the study area.

5.3 Cost and returns with reference to pesticide use

Table 4.7 revealed that the rate of return from pesticide use for large farmers was low compared to other farmers. This was because of the excessive and uneconomical pesticide use by these farmers as compared to small and medium farmers. The large farmers because of easy access to funds and in the aunxity to get better yields appeared to spend slightly more on PPC. The rate of return from pesticide use was the highest for small farmers (6.73). The PPC cost appeared to increase with increase in size of holdings. Though the rate of return on pesticides was more than five in all the cases, it should not be based on inferred that the farmers should spent more on PPCs. The decision to spend on PPC must be economic threshold of pests infestation. The farmers need be educated with respect to various issues of pesticides.

The large majority of farmers (50%) applied pesticides to the crop more than five times during its production cycle. Some of the large farmers (37%) treated the crops six times (Table 4.8). The weedicides application was not common in the study area. Some farmers used fungicides mainly to control fungal disease like blast and bacterial blight. Sanatha and Dhandapani (2000) indicated that the cotton crop in Nanded district of Maharashtra was treated with PPCs eight times during its production cycle. The study conducted by Singh *et al.* (2007) under irrigated paddy reported that the crop received four sprays of pesticides during its production cycle.

Table 4.9 revealed that among three categories of farmers, the quantity of pesticide use was observed to be highest for large farmers. The large farmers because of their better investment capacity and risk aversive nature to crop loss due to pests used higher quantity of PPCs. The insecticides were the most frequently used pesticides which accounted for bulk of share (60%) in total pesticides used. This was because of the severity of loss due to infestation of insect pests like stem borer, brown plant hopper and leaf roller in the study area. The farmers in the study area used 1.95 l (active ingredient) of pesticides per ha to protect the crop from pest infestation. Most of the previous research reported the use of about one kg (a.i) of pesticides per ha of paddy crop. Thus the current use was slightly on a higher side. The optimality analysis also supported (Table 4.12) that farmers need around one liter (a.i) of pesticides per ha for profit maximization. This again supported the hypothesis of indiscriminate use of pesticides in the study area.

The study conducted by Singh *et.al* (2007) in paddy, vegetables and cotton found that the pesticide consumption was 2.47 kgs and 1.85 kgs active ingredient per hectare on NIPM and IPM farmers respectively. The fungicides used were in meager quantity and weedicides application observed to be almost same on both categories of farmers. In the case of tomato, cabbage and cotton, the consumption of pesticide was 3.17 kgs, 2.63 kgs and 2.71 kgs for non IPM farmers respectively. Sanatha and Dandapani (2000) reported that on an average one hectare of cotton area received 3.2 kg technical grade pesticides. Nyugen and Tran Thi (2003) found that on an average one hectare of paddy area received 1.02 kgs active ingredient and also observed that among pesticides, insecticides used were most.

Table 4.10 revealed that most of the small farmers (57.50%) used less than 1.5 liter active ingredient per hectare while most of the medium farmers (42.50%) used in the range between 1.5 and 2.0 liter active ingredient per hectare and the most of the large farmers (30%) used around 2.25 liter active ingredient per hectare which was the highest quantity. This was due to better investment capacity of large farmers and risk aversion nature of these farmers. On an average, most of the farmers used in the range between 1.5 and 2.0 l active ingredient per ha. The study conducted by Santa and Dhandapani (2000) in cotton growing region of Nanded district reported that most of the farmers used pesticides in the range between 3 kgs and 3.5 kgs active ingredient per ha.

Respondents in the study used pesticides in the form of Organochlorines, organophosphates, Pyrethroids, neocotinoids and Aclyurea compounds (Table 4.11). Organophosphates are highly toxic to human and live stock compared to other groups of insecticides (Langham and Edward, 1969). However they are less persistent in the environment, thus the effect of organophosphates is short duration in nature. They may often cause short run health problems to applicators of these chemicals.

Organochlorines are another group of insecticides which are also toxic in nature but highly persistent in the environment. The effects of these insecticides are observed to manifest in the long-run, through storage in human/animal bodies as bio-concentrations (Arun Kumar, 1995). It was observed in the study area that farmers were using larger quantities of Organochlorines and organophosphate compounds as insecticides to control the insect pest. Stem borer is one of the most important insects causing yield loss in paddy in the study area. Hence, to control this pest farmers in the study area are using Organochlorines in the form of endosulfon. Brown plant hopper is another serious pest in the study area which occurs in later stage of growth, causing heavy yield loss in paddy by making paddy seeds chaffy. Hence, farmers used the organophosphates and aclyurea group chemicals in the form of dichlorovas, quinolphos and monocrotophos and bufrofezin respectively. Endosulfon and dichlorovas were used in larger quantity because they are cheap and easily available insecticides, where as bufrofezin was used in larger quantity even though price was higher because it was more effective against pests. The rice blast was serious disease in the study area and to control this, farmers used corbandizium. The Above results were in conformity with results obtained by Yogeshwari (2002) in paddy farmers in Shimoga district of Karnataka.

Table 4.12 provided the information on the optimum quantity of pesticide required for paddy. The optimum quantity of pesticide required was estimated at 0.97 l per hectare for sample farmers. However, the mean level of pesticide used in study area was 1.95 l active ingredient per hectare. As such farmers where found to over use pesticides by 0.98 l active ingredient per hectare which was almost double the optimum quantity required. In other words the farmers spent Rs.1290.38/hectare extra because of an uneconomical use of pesticides in the paddy farming. This was because of the risk aversive nature farmers to avoid crop loss due to pest infestation. Therefore, any increase in pesticides higher than the optimal level is really not a rational expenditure. Moreover, in the process of overusing pesticides, environmental problems are inevitably generated. The above results were in concurrence with results obtained by Nguyen and Tran Thi (2003) in the paddy farmers in Mekong and Delta, Vietnam.

A log linear regression model was estimated by considering the cost on pesticides as the dependent variable. Total family income (Rs.), fertilizers and manures (Rs.), intensity of pesticide application (Rs.) and area under paddy (ha.) were taken as independent variables. Table 4.13 indicated that the pesticide expenditure elasticity of total family income was positive and significant at one per cent probability level indicating that an increase in one per cent of family income would increase in expenditure by 9.87 per cent on plant protection chemicals. The regression coefficient of area under paddy was 0.09. This indicated that one per cent increase in area under paddy crop would bring about 0.0916 per cent increase in expenditure on plant protection chemicals. Thus as the area under paddy increases the chance of applying more pesticides would also increase in order to secure higher returns by controlling the insect pests. The farmers in the study area were spending more than Rs.3600 on pesticides. Similarly the intensity of pesticide application was found to contribute positively to the expenditure on PPC which clearly indicated that the farmers in the study area were spending more on pesticides. The mono-cropping without crop rotation has been followed since many years in study area. Because of this, brown plant hopper and stem borer have emerged as serious pests. It was noticed that as the family income increased, the farmers tend to spend more on pesticides to control the pests which is not only uneconomical but also would lead to emergence of pest as resistance. Similarly, manures and fertilizers were positively contributed to the expenditure on plant protection chemicals, while in the present study the co-efficient of manures and fertilizers was positive and significant.

These results were in accordance with the results obtained by Arun Kumar (1995) for cabbage cultivation in Mallur Taluka of Karnataka were it was observed that total family income and pest intensity contributed positively to expenditure on plant protection chemicals.

Cook and beaker (1983) stated that organic amendments could favour biological protection of the plant. The biological control achieved with organic amendments results in parts, from enhanced competition from the micro organism for nitrogen and carbon or both and might be expressed as fewer propogules germinated or less pre-penetration growth of pathogens in the infestation count.

5.4 Safety measures followed by the sample farmers

Table 4.14 revealed that most of the farmers surprisingly opined that pesticide use was inadequate (73%) in the view of inefficient control of pests with the existing dose usage .Of the total respondents, only 8.33 per cent of the farmers were aware about recommended dose of pesticides and remaining 91.67 per cent were unaware of recommended dose. This is the reason for farmers using pesticides indiscriminately. Nearly 45 per cent of the sample farmers were observed to look at the labels on the pesticide container as about 12.50 per cent of the respondents were literate. The farmers who had education up to secondary, college and above were aware of colour symbols (14.17%) on PPCs container and toxicity level (9.17%). Further only 32.5 per cent of the farmers were aware of the prices of all pesticides. The ones who had education of secondary, college and above were able to know the prices. In the study carried out by Howitt and Moore (1975) reported that 20 per cent of farm workers could not understand pesticides warning labels

It was observed that most of the farmers applied PPCs along the with wind direction (95%) which reduces farmers' exposure to chemicals (Table 4.15). This is the correct method of applying PPCs and reduces the probability of poisonous effects, through inhalation of chemicals. But most of the applicators (93%) did not use any protective coverings like hand gloves, shoes and facemasks. This increased the probability of exposure to poisoning by contact and health hazards. Particles of PPCs, which adhered to body and hands of the applicator were washed with soap and mud through bathing, after spraying, thus, reducing the risk of health hazards.

Majority of the applicators (64%) mixed the chemical by using wooden stick. This was the practice of farmers while some sample farmers also used pouring water and by spray lancer there by protecting themselves from the probability of pesticide exposure. Nearly 82 per cent of the respondents used measuring jar for measuring pesticides which is correct method. While 18 per cent of the farmers used pesticide bottle cap for measuring pesticides and also in the process of diluting the PPCs with water. The volume of water used by the farmers was rough approximation which often did not yield the required dilution as per recommendation. This might have resulted in either sub lethal or over dose of chemical. Sub lethal dose would result in uncontrolled population of pest and development of pesticide resistance where as over dose would result in greater health hazard. The study conducted by Arun Kumar (1995) reported that eight per cent of the farmers did not follow the wind direction and twelve per cent of them applied chemicals across the wind direction thus, increasing the risk of inhaling hazardous chemical particles

Tables 4.16 revealed that majority of the respondents used power sprayer and knapsack sprayers. Most of the sample respondents (87%) did not wash their sprayer after use. This result was contradictory to the results obtained by Arun Kumar (1995). Moreover those who washed sprayers, disposed the washed water in to the crop field it self. The contamination of soil with PPCs would lead to a negative effect on soil health since it might affect some of the beneficial micro flora of the soil. The respondents were unaware of negative consequences of PPCs on soil health. Table 4.17 revealed that about 95 per cent of the respondents ate\drunk prior to spraying activity, to avoid the possible consumption of pesticide residue due to human negligence in washing the hand after spraying activity. Only 6 pre cent of the farmers reported working in field after spraying activity which revealed the tiresome work of spraying activity.

6. SUMMARY AND POLICY IMPLICATIONS

The use of plant protection chemicals emerged as an important agricultural input to ensure sustainable agriculture production. India is considered as one of the largest consumer of pesticides in South Asia. India is presently the largest manufacture of basic pesticides among the South Asian African countries with an exception of Japan. The Indian pesticide market is the 12th largest in world with value of US$ 0.6 billion. So for as crop wise consumption is considered, paddy accounts for 23 per cent of cropped area and consumes about 15.9 per cent of total pesticides in India. Now a day there is growing concern about pesticides and their impact on environment. Pesticides being highly toxic in nature have potential for causing direct and substantial harm to human beings, animals and ecosystem. On the other hand control of pests continues to be crucial for farmers and excessive and indiscriminate use of pesticides has resulted in pest resurgence.

India ranks second among all rice growing countries in respect of area while yield levels were low at 2.20 tonnes per hectare. Among the states in India, Karnataka occupies 5th position with respect to area while it stands 3rd in production of rice. In Koppal district the area under paddy is 75,831 ha. Paddy production in the districts 1,80,145 tonnes. Monocropping of paddy is a common practice in this region which has resulted in pest build up. The farmers in the district are under the misconception that higher returns could be gained through the use of higher doses of plant protection chemicals. However this has resulted in pest resistance, pest resurgence and secondary pest outbreaks in the region over the past few years. Though the subject of evaluation of economics of pesticide use has been dealt by many researchers, micro level empirical studies in the region are limited. Such studies provide insights into economics of pesticide use. Results of the study would be useful to both policy makers and farmers of the region in understanding the nature and economic consequence of pesticide use.

In view of these issues, the present study is a modest attempt to analyse the economic consequences of pesticide use in paddy crop in Koppal district. The specific objectives of the study are:

1. To estimate cost and returns in paddy production with special reference to pesticide use.
2. To study the frequency, extent and type of pesticide use in paddy production
3. To estimate pesticide requirement, optimum use of pesticide and its impact on paddy productivity.

Methodology

Koppal district was selected purposively as the area under paddy is 78,831 ha. The paddy production in district is 1, 80,145 tonnes. The pesticides use in the district as result of mono0-cropping of paddy has increased over the fast few years. Two taluks namely Gangavati and Koppal were purposively selected since they are considered paddy belt in Koppal district. Three villages from each taluk were selected based on predominance of paddy area. A sample of 20 farmers were randomly selected from each of the villages for getting required information on paddy cultivation using pre-tested and well structured schedules. The total sample for the study was 120 farmers. The data pertained to the 2007-08 crop year. Secondary data with regarded to cropping pattern, rainfall, area under paddy and other necessary data were collected from District Statistical Office (DSO), Koppal.

Tools of analysis

Budgeting technique was followed to compute the cost, returns, and profits. Tabular presentation was used to work out samples means and percentages with respect to the general characteristics of sample farmers. Cobb-Douglas production function was estimated to study the resources use efficiency and to analyse the influence of inputs on paddy yield in Koppal district. To determine the optimum quantity of pesticide requirement in paddy the marginal value product of pesticides was equated with the price ratio of pesticides and paddy. A log linear regression modal was used for estimating elasticity coefficient of plant protection chemicals expenditure.

Major findings

The average age of sample respondents was 41.84 years. The average family size was around seven members where as it was around eight for large farmers indicating that most of the large families were joint families. The average size of land holding was 3.24 hectares. The average size of irrigated land holding was 2.99 hectares indicating that more than 92 per cent of the total area was irrigated. The average area under paddy was 2.21 hectares implying that paddy occupied 73 per cent of the total irrigated area. Nearly 62 per cent of the farmers were either illiterate or had very little education. Only 13.33 per cent of the sample farmers had college and above level education. Paddy is the major crop grown by the sample respondents. The cropping intensity was worked out to be 204.31 per cent.

Cost and returns from paddy cultivation

The average total cost of cultivation of paddy was found to be Rs 65591.53 per hectare of which cost of pesticide accounted for 5.50 per cent. The total cost of cultivation of paddy for large farmers was found to be the highest (Rs. 66722.07/ha). The farmers realized a net returns of Rs. 17145.14 per ha of paddy cultivation. Across the size groups, there was no much difference in cost as well as net returns.

Resource use efficiency

The Cobb-Douglas production function was used to analyse the relationship between gross income and various inputs used in paddy cultivation. The elasticity coefficient of labour and manures and fertilizers were negative and significant indicating that increase in the use of labour and fertilizers and manures would lead to decrease in gross income. The resources such as seeds and pesticides have contributed positively to the gross income and thus, indicated that there is scope for re-organization of the inputs for profit maximization. The MVP to MFC was positive for seeds indicating greater scope for using additional units of this inputs, where as the MVP/MFC ratio was negative for labour, fertilizer and manures while below unity but positive for pesticides indicating the excess use of these resources. This confirms that there is a very good scope for enhancing profits by re-organizing the use of the inputs in the study area.

Cost and returns with reference to pesticide use

On an average the expenditure on pesticides in paddy cultivation was Rs. 3607.57 per hectare. The rate of return obtained from pesticide use for small farmers was high (Rs.6.73) as compared to medium (Rs.5.89) and large farmers (Rs.5.41). About 50 per cent of the farmers applied pesticides five times for paddy during its production cycle. The number of pesticide application went up to even seven times. About 61 per cent of the farmers applied three sprays of insecticide where as more than70 per cent of farmers used fungicides and weedicides at least once. The quantity of pesticide use was found to be 2.32 liter per hectare by large farmer which was highest as compared to small and medium farmers. On average the farmers used 1.95 liter technical grade pesticides for one hectare of paddy area. About 30 per cent of the pesticides applied belonged to Organochlorines category, organophosphates comprised 26 per cent of total technical grade pesticides used followed by aclyurea compounds, pyrehtroids and neo-onicotinoids (12, 7 and 15% respectively). The optimum quantity of pesticide was estimated to be 0.97 liter per hectare, where as the farmers were found to be use (1.95 liter/ha) almost double the optimal quantity. The reason for over usage of pesticides was that the farmers in the study area are under the misconception that higher returns could gained through higher dose of plant protection chemicals.

A log linear regression model was used to analyse relationship between expenditure on plant protection chemicals and the factors influencing it. The regression coefficients for total family income, fertilizers and manures, number of pesticide application and area under paddy were positive and implied that these variables contributed positively and significantly to the expenditure on plant protection chemicals.

Most of the respondents applied plant protection chemicals along the wind direction, which is the correct way of application. However, it was observed that usage of protective coverings like hand gloves, shoes and face masks were neglected by the sample farmers. This increased the probability of exposure to poisoning.

Majority of farmers mixed the chemical pesticides by wooden stick, by pouring water and spray lancer. Most of the farmers (81.5%) have used measuring jar for mixing pesticides which is the correct method. Few of the sample farmers used bottle cap for measuring pesticides. Majority of the farmers have not washed sprayer after use.

Most of the farmers ate food before going for spraying as they needed energy during plant protection chemical application. Only few (6%) sample farmers were engaged in work in the field after spraying since most of them felt tiredness after plant protection chemicals application.

Policy implications

The following policy implication are drawn based on the major findings of the study

1. The resource use efficiency analysis clearly indicated that the resources are not optimally used as guided by the economic principles. The MVP/MFC ratios were negative for labour and plant nutrients and less than one for plant protection chemicals. Thus the withdrawal of these resources would maximize the returns from paddy production. The farmers need to be educated and advised about the proper use of these resources particularly plant protection chemicals and fertilizers.

2. Though the pesticide use was high, the farmers in the study area are already using almost double the amount of pesticide. This is not only uneconomical but also would lead to other ill effects of pesticide use. Therefore there is an urgent need for proper education to the farmers about the balanced use of pesticides. The farmers should be educated to identify the threshold level of pest infestation and take measures only after that instead of blindly following the neighboring farmers while applying plant protection chemicals. They also need to be advised about the method of applying and indentifying the spurious chemicals.

3. The knowledge about the integrated pest management (IPM) practice is not wide spread in the study area. Therefore large scale demonstrations to show the benefits of IPM may be organized.

4. The farmers may be encouraged to use not only less toxic chemicals to human and livestock but also less persistent in the environment in place of more toxic and more persistent chemicals.

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Appendix I: Type of pesticide of pesticide use by paddy grower s in study area

Pesticides	Farmers							
	Small		Medium		Large		All	
	Quantity of ai\ha (lit)	Cost\ha (Rs)	Quantity of ai\ha (lit)	Cost\ha (Rs)	Quantity of ai\ha (lit)	Cost\ ha (Rs)	Quantity of ai\ha (lit)	Cost\ ha (Rs)
Organochlorines								
endosulfan 35EC	0.20	196.47	0.27	268.00	0.29	289.35	0.25	251.27
butachlor 50EC	0.12	79.23	0.18	89.99	0.10	49.60	0.13	72.94
pretilachlor 50EC	0.17	174.18	0.19	189.79	0.18	181.88	0.18	181.95
Organophosphates								
monocrtophos 36SL	0.18	224.59	0.08	103.08	0.06	81.02	0.11	136.23
chloropyriphos 25EC	0.07	118.34	0.01	17.67	0.00	0.00	0.03	45.34
quinolphos 25EC	0.06	84.63	0.05	94.24	0.29	488.10	0.13	222.32
dichlorovos 76EC	0.11	62.70	0.00	0.00	0.63	421.63	0.25	161.44
Pyrethroids								
cypermethrin+ Chloropyriphos 55EC	0.045	36.89	0.13	108.97	0.04	29.76	0.07	58.54
lambda-cyhalothrin 25EC	0.00	0.00	0.02	35.34	0.02	49.60	0.01	28.31
deltamethrin+Buprofezin 5.625EC	0.027	239.07	0.05	431.94	0.07	618.39	0.05	429.80
Neonicotinoids								
imidacloprid 75SC	0.02	49.18	0.06	163.61	0.00	0.00	0.03	70.93
Acylurea compounds								
buprofezin 25EC	0.23	1377.05	0.25	1511.78	0.20	1278.85	0.23	1389.23
Others								
isoprothiolan 40EC	0.02	30.75	0.18	261.32	0.04	49.60	0.08	113.89
tricyclazole 75WP	0.15	161.89	0.05	45.85	0.04	44.64	0.08	84.13
propiconazole 25EC	0.01	38.52	0.00	0.00	0.00	0.00	0.003	12.84
hexacodazole 5EC	0.01	53.48	0.00	0.00	0.00	0.00	0.003	17.83
carbendazim 50WP	0.13	125.68	0.13	132.15	0.31	453.70	0.19	237.18
mancozeb 75WP	0.07	36.89	0.19	188.78	0.10	59.52	0.12	95.06
Total	**1.62**	**3089.54**	**1.84**	**3642.49**	**2.37**	**4095.64**	**1.95**	**3609.2**

Appendix-II: Interview Schedule

SCHEDULE FOR DATA COLLECTION

Research problem: Economic Consequence of Pesticide use in Paddy in Koppal district, Karnataka

I. GENERAL INFORMATION:

Name of the respondent: ____

1. Age: __________________

2. Village:__________

3. Taluka:__________

4. Education: i. primary ii. High school iii. College iv. Illiterate

5. Main occupation:__________

6. Subsidiary occupation:__________

7. Family composition

Sl.No	No	Education I, P, M, H, C	Engaged in Agriculture	Others	Total
1. Male					
2.Female					
3.children					
Total					

I- Illiterate, P- Primary, M- Middle, H- High school, C- College.

II. LAND HOLDINGS:

Sl. No.	Type of land	Owned (acres)	Leased in		Leased out		Total area (acres)
			Area (acres)	Value (Rs.)	Area (acres)	Value (Rs.)	
1	Dry land						
2	Tank irrigated						
3	Well irrigated						
4	Canal irrigated						
5	Permanent fallow						
6	Total						

8. Source of Income

Sl. No.	Source	Annul Income
1	Agriculture and Allied Activity	
2	Business	
3	Salary	
4	Wages	
	Others	

9. Source of Funds

i. Owned (Rs.) ____________ ii. Borrowed (Rs.) ____________

If borrowed, what are the sources of credit?

Sl. No.	Sources of Credit	Amount of Loan (Rs.)	Interest rate (%)	Year of Loan Obtained	Repayment made (Rs.)	Outstanding amount (Rs.)	Remarks
1							
2							
3							

10. Cropping pattern

Crop	Variety	Area (acres)	Season	irrigated	Dry	Yields (qt/acre)	Value (Rs/qt)

III. FARM INVENTORY:

Major Farm Implements:

	Item	No.	Year of purchase	Purchase value (Rs.)	Average life (years)	Annual repairs(Rs)
1	Iron plough					
2	Wooden plough					
3	Seed drill					
4	Hoes					
5	Harrows					
6	Bullock cart					
7	Power tillers					
8	Cultivators					
9	Levelers					
10	Tractor					
11	Sprayer					
12	Duster					
13	Pumpset					
14	Others					

Livestock:

Sl. No.	Item	No.	present value	Income (Rs)	Expenditure (Rs)	Net income(Rs)
1	Cows					
2	Buffaloes					
3	Bullocks					
4	Sheep/goat					
5	Poultry					
6	Others					

IV. COST AND RETURNS OF PADDY:

1. Variety: ______________
2. Area: Main field__________
   Nursery bed:________
3. Soil type:___________
4. Previous crop:__________________
5. Source of irrigation:____________
6. Season: K/R/S:

Labour wage rate (eight hrs. per day)

Male: ___________

Bullock pair:__________

Female:________

Tractor (per acre):___________

Harvesting machine (per acre):____________

power tiller____________

A.COSTS:

(i) Labour costs:

Sl. No.	Operation	No of times	Family labour (man days)			Haired labour (man days)		
			Male	Female	BP/T/PT	Male	Female	BP/T/PT/HM
Nursery preparation								
1	Ploughing							
2	Clod crushing							
3	Harrowing							
4	Fym transport							
5	Fym application							
6	Puddling							
7	Fertilizer application							
8	Seed treatment chemical							
9	Spraying							
10	Seedling pulling							
Main field								
1	Ploughing							
2	Clod crushing							
3	Harrowing							
4	Fym transport							
5	Fym application							
6	Puddling							
7	Sowing /transplanting							
8	Fertilizer application							
9	Gap filling							
10	Hand weeding							
11	Intercultivation							
12	Herbicide application							
13	Spraying							
14	Harvesting							
15	Cleaning							
16	Others(specify)							

Note: BP=Bullock pair T=Tractor PT= Power tiller HM= Harvesting machine

(ii).Input costs:

Sl. No.	Particulars	Quantity (kg/acre)	Price/unit(Rs)	Total cost(Rs)
I	FYM			
II	Seeds			
III	Seed treatment chemicals			
	a)			
	b)			
	c)			
IV	Fertilizer application			
	a)			
	b)			
	c)			
	d)			

	e)			

(iii). Plant protection chemicals:

Name of pests	Crop stage (days after transplanting)	Type of pesticide used	No. of times	Quantity/each time	Method of application	Total quantity	Price	Labour wage
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
Name of weeds								
1.								
2.								
3.								
4.								
5.								
Name of diseases								
1.								
2.								
3.								
4.								
Others (specify)								
1.								
2.								
3.								

Returns:

Sl. NO.	Particulars	Quantity (Qtl.)	Price/unit	Total returns
1. 2.	Main product Byproduct			

(iv). Marketing cost:

Place of sale	Quantity sold (qt)	Packing charges(Rs)	Transportation cost(Rs)	Commission (Rs)	Tax (Rs)	Hamali (Rs)	Per quintal	Others

VI. General awareness:

i. Since when you are growing paddy crop?

ii. Since when you have been using pesticides?

iii. What are the major pests, weeds and diseases

Major pests	Major weeds	Major diseases
1.		
2.		
3.		

4.		
5.		

2. Do you think that quantity of pesticide used is adequate?

Yes/No

If yes substantiate?

i. This much of pesticides are able to control pests.

ii. I will be getting higher reruns for this quantity of PPC

iii. Any other.

3. Due you know the recommended level of pesticide use in paddy production.

What is the dose you are using? RD / >RD /<RD (Recommended dose)

If >RD Reasons

i. Anticipate higher incident of pests.

ii. Pesticides are not effective.

iii. Anticipate higher returns.

iv. Other farmers apply pesticides, it is necessary for me to use pesticides, so that pest would not develop.

v. Any other.

If < RD, Reasons

i. due to lack of funds

ii. lack of technical know how

iii. lack of availability of PPC

iv. unaware of effectiveness of pesticides

v. aware of effectiveness of pesticides

vi. aware of the bad effects of pesticides

vii. less pest attack

viii. any other

4. Due you also use pesticides for other crops? Yes /No

a. if yes which are the crops and name of the pesticide you use

Sl. No.	Crop	Name and pesticide	Quantity (Ltr/Kg)	Value (Rs.)
1 2 3 4 5				

b. if no what others crops you grow which requires pesticides? And why you do not use pesticides

5. Indicate the crops that are grown in surrounding area of isolation distance (50mt)

Sl. No	Crop	Area (acre)	Distance (mt)
1			
2			
3			
4			
5			

6. Do you purchase/bring the pesticides from a known company?

Yes /No

7. Do you bring the packed pesticide or loose pesticide?

Packed/ loose

8. If it is packed, do you see labels on packs?

Yes /No

9. Are you aware of the importance of toxicity, expiry date colour symbols that are present on the label?

Yes /No

If yes what do they indicate?

10. Pesticide application procedure (interview the person employed for application)

Equipment used	Safety measures	Direction of application	Washing pesticide spraying equipment, after use.
1. knapsack sprayer	1. use gloves	1. along with wind	Yes /No
2. Gator sprayer	2. use of shoes	2. across the wind	
3. power sprayer	3. use of face masks	3. against wind	
4. duster	4. take bath		
5. soil application	5. wash hands		
6. Any other	a. with mud b. soap c. other material		

11.

Disposal of washed water	Disposal of pesticide bottle	Activities during application	Time of application
1. infield	1. in field	1. drinking water or beverages	Morning ______ hrs To ______ hrs
2. to irrigation canal	2. sell	2. smoking	
3. any other	3. use it for other purpose	3. eating without washing hands / body	

12. a. how do you measure the chemical to be used?

b. how do you mix the chemical?

i. Use wooden stick

ii. Use bar hands

iii. Any other

c. if you are not following safety measures, would like to follow them? Why?

13. Information sources of farmers regarding pesticide application

a) Other farmers b) agriculture extension c) television d) radio e) news paper

f) Input seller g) experience h) others

14. Do you work in field after spraying? Yes /No

If yes, after how many hours / day ____________

What type of work you do?

15. Are you aware that you should not go to field after spraying?
Yes / No

16. are you aware about the bad effect of pesticide application

ECONOMIC CONSEQUENCES OF PESTICIDES USE IN PADDY IN KOPPAL DISTRICT, KARNATAKA

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ABSTRACT

The excesses use of the pesticides in the agriculture has not only increased production costs but also led to ill effects of pesticide use. The present study attempted to analyse economic consequences of pesticides use in paddy in Koppal district of Karnataka. The study was based on the primary data obtained from 120 randomly selected farmers growing paddy spread across two taluks of Koppal district. Multiple log linear regression was used to compute the plant protection chemicals expenditure elasticity.

The total cost of cultivation of paddy was found to be Rs 65591.53/ha of which the cost of pesticide accounted for 5.50 per cent. On an average the expenditure on pesticides in paddy cultivation was Rs. 3607.57/ha. The yield obtained by the sample farmers was 66.90 quintals. The farmers realized net returns of Rs. 17145.14/ha of paddy cultivation. The elasticity coefficient of labour and manures and fertilizers were negative and significant indicating that increase in the use of labour, fertilizers and manures would lead to decrease in gross income. The resources such as seeds and pesticides have contributed positively to the gross income thus, indicated that there is scope for re-organization of the inputs for profit maximization.

About 50% of the farmers applied pesticides five times for paddy during its production cycle. The number of pesticide application went up to even seven times. The optimum quantity of pesticide was estimated to be 0.97 l/ha, where as the farmers were found to be use (1.95 liter/ha) almost double the optimum quantity. Number of pesticide applications and area under paddy were contributing positively and significantly to the expenditure on plant protection chemicals. The farmers should be educated to identify the threshold level of pest infestation and take measures only after that instead of blindly following the neighboring farmers while applying plant protection chemicals.