ECONOMICS OF PESTICIDE USE IN PIGEON PEA IN VIJAYAPURA DISTRICT, KARNATAKA

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By
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CERTIFICATE

This is to certify that the thesis entitled “ECONOMICS OF PESTICIDE USE IN PIGEON PEA IN VIJAYAPURA DISTRICT, KARNATAKA” submitted by Mr. AMBANA GOUDA DURGAD, for the degree of MASTER OF SCIENCE (AGRICULTURE) in AGRICULTURAL ECONOMICS, to the University of Agricultural Sciences, Dharwad, is a record of research work carried out by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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LIST OF ABBREVIATIONS

Sl. No.	Abbreviations	Long Form
1.	IPM	Integrated pest management
2.	mm	Millimeter/s
3.	^{o}c	Centigrade
4.	M.ha	Million Hectares
5.	%	Per cent
6.	Rs.	Rupees
7.	<	Less than
8.	>	More than
9.	Anon.	Anonymous
10.	PPC	Plant Protection Chemical
11.	FYM	Farm Yard Manure
12.	N	Nitrogen
13.	P	Phosphorus
14.	K	Potassium
15.	@	At a Rate
16.	B:C ratio	Benefit Cost ratio
17.	Hr	Hour/s
18.	Kg	Kilo Gram/s
19.	Q	Quintal/s
20.	L	Liter/s
21.	No.	Number/s
22.	Qty.	Quantity
23.	FIG	Farmers Interest Groups
24.	FFS	Farmers Field school
25.	Ha. NPV	*Helicovarpa armigera* Nuclear polyhydrosis virus

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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 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 nematicides, 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). 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, diseases 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 Rs. 1.40 lakh crores (Kumarswamy, 2008).

India ranks 10^{th} in the world pesticides consumption and its total consumption was 45,386 tonnes per annum (Anon. 2012). In India, 400 chemical factories are manufacturing 55 different basic pesticides. Totally 164 pesticides have been registered for use in the country. Pesticide use in India is increasing at a rate of 2 to 5 per cent annually and it is about 3 per cent of total pesticides used in the world. About 90,000 metric tonnes of technical grade pesticides are currently produced and more than 67 per cent is used in agriculture sector alone. 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 (Anon. 2012).

About 70 per cent of pesticides are being used in developing countries like India and remaining 30 per cent in developed countries. More than 1000 agro-chemicals are being manufactured and used for agriculture as well as for public health purposes. Out of these pesticides used, 80.5 per cent are insecticides, 11 per cent are fungicides and 7 per cent are herbicides. Karnataka stands 7th position in total quantity of consumption (1225 tonnes/annum), whereas consumption value of pesticides in Vijayapura district is Rs. 400 million (Anon, 2012).

Use of pesticide in pigeon pea

Pigeon pea is highly sensitive to wide range of insect pests both in the fields (at various stages of crop growth) and storage. Most of the pests attack the crop at reproductive stage causing direct losses. Diseases, insect pests and viral diseases transmitted by insects are the major bottlenecks in realizing higher yields in pigeon pea (Dubey and Sharma, 2002). Every rupee spent on chemical pest control helps in saving crop output worth of Rs. 3. The average per hectare consumption of pesticides for cultivation of crops in India had increased from 0.03 kg in 1954-55 to 0.57 kg in 1996 (Bami, 1996). During nineties in Northern Karnataka, application of almost all broad spectrum insecticides failed to reduce the extensive damage of pests (70 to 90%) and the losses incurred were to the tune of Rs. 400 crores (Lingappa and Yelshetty, 1994). Similar situation with incidence of pests ranging between 90 to 100 per cent was observed during 1997-98 (Yelshetty and Siddegowda, 1998).

Pigeon pea is susceptible to a large number of diseases and insect pests which cause heavy losses. Fletcher (1920) listed a total of 35 insects like *Helicoverpa armigera*, *Etiellazinckenella*, *Euchryspos cnejus, Odontotermes distans*, *Marucatestulalis* and *Gryllus bimaculatus*. Lal *et al.* (1985) reported nearly 200 species of insects on pigeon pea, among these, 34 as serious pests for other crops as well. Of late, insects which have become serious includes Podbug, *Calvigrallagibbosa, C.scutellarius,* various species of leaf webbers, especially *Cydiacritica, Maruca vitrata* and glaerucid beetle. Polyphagous pests like cutworms *(Agrotis ipsilon* and *Ochropleura flammatra)* and hairy caterpillars *(Amsacta moorei*, *A. albistriga* and *Spilosoma obliqua)* have also become serious (Arora and Dhaliwal, 1996). *H. armigera* being polyphagous has become a key pest in the pulse growing regions during the *Kharif* as well as *Rabi* season. With the introduction of transgenic cotton, incidence of *Helicoverpa* had gone down for a few years, but now it is again staging a comeback.

In pigeon pea, lepidopteran, hemipteran, dipteran and colleoptaran group of insects are major problems. These insect species belong to different categories, *i. e.*, oligophagous to polyphagous, surface feeding to concealed feeding and chewing to piercing and sucking types. In the view of a wide variety of pests, long reproductive phase and socio-economic constraints, the management of pests in pigeon pea has become relatively difficult (Shanower and Romeis, 1999). Relative population of different pod borers varies with varieties. In early maturing varieties, the incidence of *Maruca vitrata* and *Grapholita critica* are common, which usually maintains relatively high population than the rest of species. In medium and late duration varieties, *Lampides boeticus, M. vitrata, M. obtusa, H. armigera* and *Exelatis atomosa* are the dominant pests. During the grain filling stage, higher population of *M. vitrata, G. critica* and *L. boeticus* commonly prevail in early maturing varieties of the crop. The pod borer (*H. armigera)* has developed high level of resistance to several insecticides (Armes *et al.*, 1996) and has been confirmed from 43 locations from Indian States of Uttar Pradesh, Maharashtra, Andhra Pradesh, and Karnataka (http://www.pesticideresistance. org/Search/). The major diseases causing significant losses are Fusarium wilt (*Fusariumudum*), Sterlity mosaic (Pigeonpea Sterlity Mosaic Virus) and Phytopthora blight (*Phytopthora drechslei sp. cajani*). Minor diseases such as Cercospora leaf spot (*Cercospora indica*), Powdery mildew (*Leveillula taurica*), Alternaria blight (*Alternaria* spp), Stem canker (*Macrophominaphaseolina*), Collar rot (*Sclerotium rolfsii*), Bacterial canker (*Xanthomonas campestris* pv. *cajani*), Yellow mosaic, Mung bean yellow mosaic virus, Mild mosaic and tobacco mosaic virus cause losses in specific situations in localized pocket.

The present use of pesticides in India is 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 (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 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).

Origin and history of pigeon pea

Pigeon pea (*Cajanus cajan* (L.) Millsp.) is one of the most important legume crops of the tropics and subtropics of Asia and Africa. Pigeon pea, also known by different names such as pigeon pea, arhar and pigeon pea in India, The crop is best suited for soils having pH between 5.0 to 7.0, with rainfall between 600 to 1000 mm/year and temperatures ranging from 18 to 38°C. Barring waterlogged field conditions, it grows on a wide range of soils varying from course to fine textured, offers nutritional security due to its richness in protein (21%) along with mineral supplements *viz.,* iron and iodine.

World scenario of pigeon pea

India is the world's largest producer and consumer of pulses including pigeon pea. About 90 per cent of the global pigeon pea area (4.9 m.ha.) is in India contributing to 93 per cent of the global production (Anon, 2013). The country annually imports 3-4 lakh tonnes of pigeon pea to meet the domestic demand. Myanmar contributes 95 per cent of the total imports due to geographical advantages.

Indian pigeon pea scenario

The major pigeon pea growing states of India are Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat, Andhra Pradesh, Tamil Nadu and Bihar. India with its area of 3.75 million hectares and production of 3.1 million tonnes ranks 9^{th} in the world productivity (Anon, 2013).

The area and production of pigeon pea in Karnataka is 6.81 lakh ha and 6.27 lakh tonnes, respectively (Anon, 2013). The major pigeon pea growing districts in Karnataka are Kalaburagi, Vijayapura, Bidar and Yadgir.

In Vijayapura district 1,83,550 ha, 1,40,257 tonnes, and 746 kg/ha was the area, production and productivity of pigeon pea, respectively during 2013-14 (Anon, 2014).

Integrated Pest Management

Pigeon pea being an important nitrogen fixing crop, it is widely grown for enriching the soil. Its deep penetrating roots helps in bringing nutrients from deeper layers of soil. With effective *Rhizobium* nodulation, it can fix up to 160–200 kg of nitrogen/ha/year. In this direction, there is a need to minimize the use of chemical inputs and save environmental damage. Thus, integrated pest management (IPM) approach has been globally accepted for achieving sustainability in agriculture. It has become more relevant due to a number of advantages like safety to environment, pesticides-free food commodities, low input based crop production program etc. Though the approach has been taken up since 1981, but the impact has not been felt until 1994.The initial attempts were made in 1992 to harmonize the IPM package of practices of various crops, subsequently concerted efforts were made in 1998, 2001 and 2002 to update and develop IPM package of practices for all agricultural crops. Presently IPM package of practices for 51 crops have been finalized to manage the pests and diseases and thereby to minimize the overuse of chemical pesticides. Thus, the IPM is a broad ecological approach which aims at keeping pest population below economic threshold level by blending more than one method of pest control such as, cultural, mechanical, biological, chemical and legislative measures in a compatible and environmentally sound manner and more over this method is considered to be economical, effective, practical, protective and eco-friendly (Anon, 2002). In the light of these aspects, the present study was undertaken purposively in Vijayapura district with the following specific objectives.

1. To study the socio-economic conditions of pigeon pea growers in the study area;
2. To analyse the profitability of IPM and non-IPM practices in pigeon pea;
3. To study the frequency, extent and type of pesticides use in pigeon pea production; and
4. To compare actual use and recommended dose of pesticide application and estimate its impact on pigeon pea yield.

Hypotheses

1. Farmers adopting IPM and non-IPM practices are similar with respect to socio-economic conditions.
2. Profitability of the IPM practicing farmers of pigeon pea is higher as compared to the non- IPM practicing farmers.
3. Frequency, quantity and type of pesticides used are not as per recommendation in pigeon pea production.

2. REVIEW OF LITERATURE

In this chapter, a review of past research studies conducted in the field has been compiled to enable better understanding of the research in various regions and method of analysis on the research subject. The chapter is presented under the following headings.

2.1 To study the socio-economic conditions of pigeon pea growers in the study area.

2.2 To analyse the profitability of IPM and non-IPM practices in pigeon pea.

2.3 To study the frequency, extent and type of pesticides use in pigeon pea production.

2.4 To compare actual use and recommended dose of pesticide application and estimate its impact on pigeon pea yield.

2.1 Socio-economic conditions of pigeon pea growers in the study area

Venkatesh *et al.* (2007) studied two taluks of Kolar district to assess the adoption level of vegetable growers with respect to integrated pest management practices of tomato crop. The results revealed that, relationship between socio-psychological characters of tomato growers, variables namely age, education, land holding, annual income, extension participation, innovative proneness and scientific orientation showed non- significant relationship with adoption level of IPM practices in tomato crop.

Sain (2008) conducted a study on socio-economic and technological constraints in adoption of SRI method in Chhattisgarh, Madhya Pradesh, Uttarakhand, Punjab, Tripura, and Andhra Pradesh and reported that majority (64%) of the SRI method adopting farmers were of medium age group (33-53 years) followed by 24 per cent of the farmers who belonged to old age group (more than 53 years) and 12 per cent of farmers were in young age group (less than 33 years).

Hanumanaikar *et al.* (2011) conducted study in Yellapur Taluk involving 120 Sidhi farmers. The study revealed that majority of the Sidhi farmers were middle aged (72.50%), illiterate (62.50%), and marginal holders (62.50%) and had large sized family (62.50%) with medium level of income. Regarding the existing cultivation pattern.

Mohammad (2011) conducted a study in three villages of Mardan district of Pakistan on socio-economic problems of small farmers in adopting new agricultural technology. He reported that 46.16 per cent of the sample respondents had primary education, while 38.46 per cent of the total respondents studied up to secondary level. Similarly, 15.38 per cent of the sample respondents were recorded in the category above secondary level.

Sangmesh (2011) revealed the cultivation of pigeon pea in transplanted method was found to be more profitable compared to conventional method. Total cost of cultivation in transplanted method and conventional method were Rs. 39,382.28 per hectare and Rs. 30,819.53 per hectare respectively. Age, education, income level, area under pigeon pea, irrigation availability, extension contact and family labour availability were the factors influencing the adoption of transplanted system of pigeon pea. Among these, education of the farmer and his extension contact were found to be the major factors influencing the adoption of transplanted method of pigeon pea cultivation.

Tidke and Rathod (2012) studied on knowledge and adoption for the management of pod borer complex in pigeon pea. Study revealed that the majority of farmers were found in middle (46.67%) to old age group (43.33%) only 10 per cent of respondents were young and in education 3.33 per cent respondents were illiterate and 70 per cent studied up to high school. From the total respondents 43.33 per cent had medium land holdings and 40 per cent had small land holdings, and 70 per cent of respondents were found in medium category of annul income while 73.33 per cent were having medium socio-economic status.

Ramchandra *et al.* (2013) revealed that the IPM techniques adoption index was 29.16 per cent in small farmers, subsequent adoption index of medium and large farmers were 48.02 and 72.11 per cent respectively which indicates the increasing trend of adoption.The overall cost of cultivation decreased with the increasing adoption techniques of IPM. The overall return was increased as B: C ratio indicated 1:1.78 in increasing trend.

2.2 Profitability of IPM and non-IPM practices in pigeon pea

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.

Razack (2000) studied the economics of integrated pest management (IPM) in paddy and cotton in Tamil Nadu. The overall benefits were calculated in terms of increased income in paddy cultivation to the farmer by using partial budget analysis. IPM farmers gained Rs. 1142.22 per hectare due to IPM adoption and the same in cotton was Rs. 6821.27 per hectare. In cotton crop this gain was mainly due to the reduction in pesticide use rather than increase in yield of cotton.

Gajanana *et al.* (2004) studied the economic analysis of Integrated Pest Management (IPM) in Cabbage using Indian mustard as a trap crop and spraying of neem and Pongemia soaps for control of major pests of cabbage at IIHR, Bangalore. Result revealed that IPM technology was found to be economically viable as it enhanced the yield by 7.2 per cent, reduced the cost by 13.33 per cent and increased the net returns by 44 per cent. The technology was also found to reduce the use of synthetic pesticides and was eco-friendly.

Moorthy *et al.* (2004) conducted study on adoption of Integrated Pest Management (IPM) module in tomato crop. The results showed that IPM significantly reduced the insecticide sprays, cost incurred towards insecticide and fungicide sprays, fruit borer (Helicoverpa armigera) incidence and cost of cultivation. The IPM also increased gross and net returns compared to non-IPM plots. The cost incurred by non-IPM farmers was significantly higher than IPM farmers. Cost of insecticides used by IPM farmers was on average Rs. 1253 per hectare, while that of non-IPM farmers was Rs. 1337 per hactare. The cost of cultivation incurred by IPM farmers was lower (Rs. 24,923/ha) than that incurred by non-IPM farmers (Rs. 34,283/ha). The highest yield obtained by IPM farmers was 87.4 tonnes per hectare, and that of non-IPM farmers was 31.3 tonnes per hectare.

Singh and Singh (2005) the adopters of IPM technology could get significantly higher yield as compared to that by non-adopters. These technologies have been found cost-effective due to higher production and reduce the per quintal production cost by Rs. 253. These technologies have been found to generate more income and employment as the adopters could earn Rs. 6840/ha more income as compared to that by the non-adopters in cotton production.

Singh *et al.* (2007) attempted the economic evaluation of environmental risk of pesticide use in paddy under irrigated eco-system. The study found that 2.47 and 1.85 kg per hectare 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) whereas 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 farmers respectively.

Chanderkant (2008) conducted study on economic analysis of IPM in pigeon pea in Bidar District of Karnataka and results revealed that per hectare cost of cultivation in IPM farmer’s category at cost A, B, C, and D as Rs. 14,671, Rs. 20,606, Rs. 21,635 and Rs. 22,205, respectively. In case of non-IPM farmer’s category, it was estimated to be Rs. 12, 373, Rs. 17, 493, Rs. 18, 936 and Rs. 19, 328, respectively. The net returns per hectare of pigeon pea in IPM farmers were Rs. 12, 553 as against non-IPM farmers category (Rs. 7, 257) and net additional benefits from IPM was Rs. 5, 295 per hectare. The B: C ratio in IPM farmers was higher (1:1.57) as compared to non- IPM farmers (1:1.38).

Kantharaju *et al.* (2011) conducted the front line demonstrations in Gulbarga district at 75 farmers fields, to demonstrate production potential and economic benefits of improved technologies comprising of seed treatment,Integrated Disease Management (IDM) and Integrated Pest Management (IPM). The improved technologies recorded a mean yield of 12.2 q/ha which was 20.8 per cent higher than the farmer's local practice (10.1 q/ha). The improved technologies resulted in higher income with a benefit cost ratio of 3.3 as compared to local practice with a benefit cost ratio of 2.73. The demonstrated technology also recorded less incidence of sterility mosaic and Fusarium wilt (<5%), Heliothis pod borer (5-10%) and pod fly (<8%) when compared to farmers practice.

Sangmesh (2011) revealed that the cultivation of pigeon pea in transplanted method was found to be more profitable compared to conventional method. Total cost of cultivation in transplanted method and conventional method were Rs. 39,382.28 per hectare and Rs. 30,819.53 per hectare respectively. Net returns were found to be higher in the case of Transplanted system (Rs. 54,103.25/ha) than in conventional method (Rs. 25,562.78/ha). Resources were optimally used in transplanted system, whereas in the case of conventional system, resources were not used optimally. The coefficient of multiple determination (R^2) was 0.72 and 0.69 for conventional and transplanted system of pigeonpea growers, respectively.

Sudha (2014) conducted a study on Ecological and economic impact of plant protection methods in cotton. The awareness and adoption level of IPM in cotton, economic and environmental impacts of plant protection measures in IPM and Non-IPM cotton growing areas in the western zone of Tamil Nadu. Cobb-Douglas production functions to analyze the resource-use efficiency in IPM cotton Non-IPM cotton. The coefficients of pesticides were negative and significant which indicated the overuse of pesticides and coupled with increased cost of production and there by reducing yield. Environmental Impact Quotient index (EIQ) was used to quantify the impact of pesticides on human health and environment in sample farms. The high EIQ values denote in Non-IPM cotton (46.93) compared to IPM cotton. The important safety precautions like using masks or gloves were followed by only very few farmers among all sample farms.

2.3 Frequency, extent and type of pesticides used in pigeon pea production

Santkumar 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 averse 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 revealed 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%).

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 study concluded that farmers need education about different non-chemical control methods and should be encouraged to adopt integrated pest management practices.

Singh *et al.* (2007) reported that 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 farmers respectively. Similarly in cabbage, pesticides consumption on non-IPM and IPM farmers was reported to be 2.63 kg and 1.61 kg active ingredient per hectare on sample farmers. On an average, tomato and cabbage crops were treated five times with pesticides on IPM farmers, whereas the frequency was eight to nine times on non-IPM farmers. The major pesticides used were insecticides and fungicides. Fungicides constituted less than five per cent of total pesticides used in both the crops. The use of fungicides was found to be extremely low and none of farmers used herbicides.

Udaykumar (2009) conducted a study on economic consequence of pesticide use in paddy in Koppal district. Results revealed that about 50 per cent of the farmers applied pesticides five times for paddy during its production cycle. More than70 per cent of farmers used fungicides and weedicides at least once.

Savita *et al.* (2012) conducted a study on efficiency of paddy farmers in TBP area of Karnataka state. The results of the study revealed that, majority of the farmers were operating in medium efficiency level (74%) were higher than those of high (13%) and low efficiency levels (13%). The percentage excess of plant protection chemicals from 42.53 per cent to 70.54 per cent plant protection chemicals were used indiscriminately in the study area in view of practice of their own method of cultivation. It was suggested that farmers should be trained about adoption of Integrated Pest Management (IPM) practices in paddy cultivation in TBP area.

2.4 Actual use and recommended dose of pesticide application and its impact on pigeon pea yield

Clevo and Clem (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 to 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.)

Udaykumar (2009) conducted a study on economic consequence of pesticide use in paddy in Koppal district. Results revealed that 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. The optimum quantity of pesticide was estimated to be 0.97 liter per hectare, where as the farmers were found to 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 be gained through higher dose of plant protection chemicals.

Manjunath (2010) conducted study in Raichur district of Karnataka during 2009-2010. About 47.00 (46.85) per cent of the farmers adopted furadan pesticide for control of stem borer. Only 17.14 and 21.71 per cent of them adopted proper concentration of Carbofuran and Dimethoate, whereas 58.28 per cent of the farmers had adopted proper concentration of Endosulfan 35 EC. About 38.85 per cent of the respondents had an income more than Rs. 1, 21,217. Lack of knowledge about chemicals and lack of knowledge about number of spray were the major constraints as expressed by 43.42 and 62.85 per cent of respondents, respectively. High cost of chemicals were also the major constraints expressed by 76.00 per cent of respondents respectively.

Shend and Bagde (2013) conducted a study on economic consequences of pesticides use in paddy cultivation. Study revealed 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. Though the pesticide use was high, the farmers in the study area were already using more quantity of pesticide. This is not only uneconomical but also would lead to other ill effects of pesticide use.

Sudha (2014) conducted a study on ecological and economic impact of plant protection methods in cotton. The awareness and adoption level of IPM in cotton, economic and environmental impacts of plant protection measures in IPM and Non-IPM cotton growing areas in the western zone of Tamil Nadu. The coefficients of pesticides were negative and significant indicated the over usage of pesticides and increased cost of production there by reducing returns. Environmental Impact Quotient index (EIQ) was used to quantify the impact of pesticides on human health and environment in sample farmers. The high EIQ values denote in Non-IPM cotton (46.93) compare to IPM cotton. The important safety precautions like using masks or gloves were followed by only very few farmers among all sample farmers.

3. METHODOLOGY

This chapter deals with the brief description of the study area,selection of respondents and the techiques used in sample selection and data analysis. The details are presented under the following sub headings.

3.1 Description of the study area

3.2 Land utilization pattern

3.3 Nature and sources of data

3.4 Analytical tools employed

3.5 Terms and concepts used in the study.

3.1 Description of the study area

Karnataka is the eighth largest state in India with a geographical area of 190 lakh ha. It is situated between 11°5' and 18°45' North Latitude and between 74°12' and 78°40' East Longitude in the Southern Plateau. The state receives the average rainfall of about 1139 mm both from Southwest and Northeast monsoons. The temperature ranges from 14°C to 40°C. The important crops grown in the state are sorghum, paddy, ragi, maize and wheat among cereals and pegion pea, chick pea and green gram among pulses, while, groundnut, sunflower and safflower are the major ones among oilseeds crops. The crops, namely, cotton, chilli, sugarcane and tobacco are important ones among commercial crops. mango, sapota and banana among fruit crops and coconut, arecanut and coffee among plantations are prominent ones.

3.1.1 Location of the study area

The present study attempted to evaluate the economics of pesticide use in pigeon pea. Pigeon pea is predominantly grown in Vijayapura district. The area under pigeon pea in Vijayapura district is 1,83,550 hectare (2014). The Pesticide use studies in this area is lacking hence, Vijayapura in Karnataka state is purposively selected for the study. The map showing the study area is presented in Fig.3.1. Vijayapura district is located in Northern part of Karnataka and is

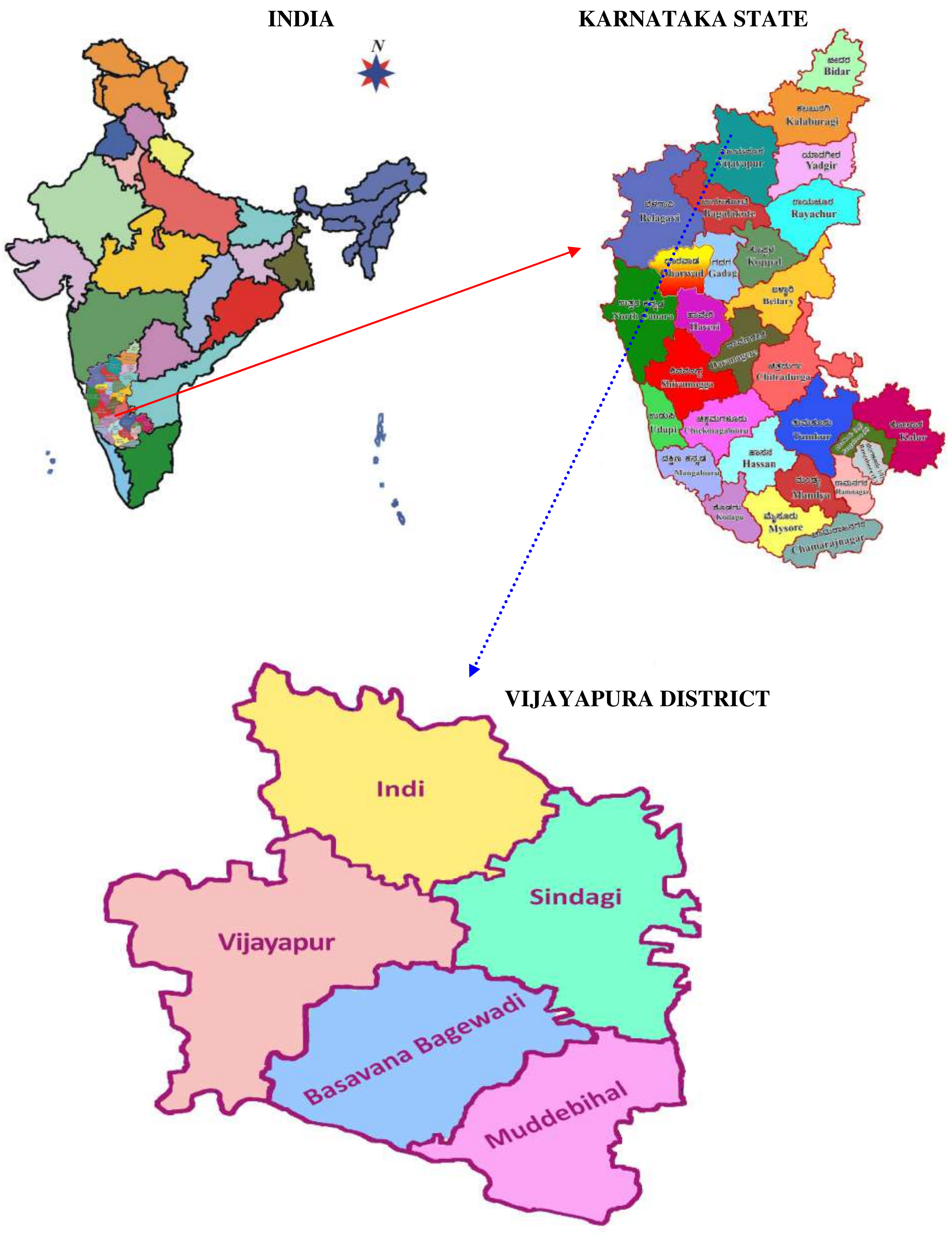

Fig. 3.1. Map of study area in Karnataka

situated between 15^0 $20^'$ to 17^0 $28^'$ North latitude and 74^0 $4^'$ to 76^0 $28^'$ East longitude.

It consists of five taluks viz., Vijayapura, Sindagi, Indi, Muddebihal and Basavana Bagewadi. Vijayapura district is bound on the North by Sholapur district and on North West by Sangli district Maharashtra. The other sides are bounded by Kalaburagi, Bagalkot and Belagavi district. The soils of the district are mostly black, deep black and red sandy loam suitable for growing wide variety of agriculture and horticulture crops. The climate of the district is very hot and dry. The hot season starts from middle of February and extends up to the end of May. South -West monsoon ranges from June end to September. Post – monsoon ranges between October and November. Cold season starts from December and extends up to middle of February. The average rain fall of the district is 433.7 mm and average rainy days are 40. The total population of the Vijayapura district was 21,77,331 (2011 census) of which 16, 75,353 are residing in rural area and 5, 01,978 in urban area (Table 3.1). The district is having a sex ratio of 960 per 1000 males. The literacy level of the district is 56.72 per cent. The population density is 207 per Sq. km. The total geographical area of Vijayapura district is 10, 53,471 hectares.

3.2 Land utilization pattern

The land use pattern in study area is presented in Table 3.2. The total geographical area of Indi, Sindagi, Vijayapura, Muddebihal and Basavana Bagewadi taluk is 2,22,492, 2, 17,601, 2,65,749, 1,49,744 and 1,97,865 hectares respectively. The total uncultivable land in these taluks was 2,501, 2,290, 808, 2091 and 1423 hectares in Vijayapura district. The net sown area was 1,71,070, 1,91,267, 1,98,097, 1,22,529 and 1,53,468 hectares in Indi, Sindagi, and Vijayapura, Muddebihal and Basavana Bagewadi taluk respectively. The net irrigated area in these taluks was 90,267 in Indi, 92,962 in Sindagi, 52,460 in Vijayapura, 32,761 in Muddebihal and 2,93,390 in Basavana Bagewadi. The taluk 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 was 31,376 hectare, 48,815 hectare, 9,452 hectare, 11,668 hectare and 1,13,206 hectare irrigation in the taluks. The proportion of

Table 3.1. Salient features of Vijayapura district and sample taluk

Sl. No.	Parameters	Indi	Sindagi	Vijayapura	Muddebihal	Basavana Bagewadi	Vijayapura district
1.	Geographical area (ha)	222492	217601	265749	149744	197865	1053471
2.	Inhabited villages (No)	129	149	130	149	123	680
3.	Gram panchayat's (No.)	44	40	46	31	38	199
4.	Rural population (No.)	382952	358449	393648	224781	315523	1675353
5.	Urban population (No.)	38217	37226	327427	65910	33198	501978
6.	Population density (No. per Sq. km)	189.40	181.70	271.00	193.50	176.10	207.00
7.	**Literacy (%)**						
	Male	74.14	74.69	79.57	80.59	76.10	77.21
	Female	53.27	51.40	63.28	56.31	53.42	56.72
8.	Average rain fall (mm)	446.50	494.20	410.40	404.10	413.50	433.70
9.	Ration card holders (No.)	82631	70851	149348	63059	70323	436212
10.	Net irrigated area (ha)	171070	191267	198097	122529	153468	836431
11.	Hoblis (No)	03	03	05	04	03	18

Source: Vijayapura district at a glance 2012-13. District statistical office, Vijayapura.

Table 3.2. Land utilization pattern in the study area and sample taluk (area in ha)

Sl. No.	Particulars	Indi	Sindagi	Vijayapura	Muddebihal	Basavana Bagewadi	Vijayapura district
1.	Geographical area	222492	217601	265749	149744	197865	1053471
2.	Area under forest	0.00	0.00	834.00	0.00	1143	1977
3.	Non-agriculture	10429	4312	9986	2487	8919	36133
4.	Cultivable waste	834	263	3627	623	155	5502
5.	Barren	3773	5726	9975	6064	3521	29059
6.	Permanent pasture	1637	1509	4145	1016	1268	9575
7.	Trees and groves	30	518	316	452	0.00	1316
8.	Total uncultivable land	2501	2290	8088	2091	1423	16393
9.	Net sown area	171070	191267	198097	122529	153468	836431

Source: Vijayapura district at a glance 2012-13. District statistical office, Vijayapura

Table 3.3. Irrigation status in Vijayapura district and sample taluks (area in ha)

Sl. No.	Source of irrigation	Indi	Sindagi	Vijayapura	Muddebihal	Basavana Bagewadi	Vijayapura district
1.	Canals	31376	48815	9452	11668	11895	113206
2.	Open wells	28214	18315	18590	5995	6385	77499
3.	Bore wells	19463	24532	23420	7015	13716	88143
4.	Other sources	11214	1258	998	562	765	14797
Total irrigation		**90267**	**92962**	**52460**	**25240**	**32761**	**293690**

Source: Vijayapura district at a glance 2012-13. District statistical office, Vijayapura

irrigated area covered by channels in Vijayapura district was (1,13,206 ha out of 2,93,690 ha). The irrigated area covered by canals in the district was 38.55 per cent.

The important crops grown in the district are jowar, bajra, maize, wheat, cotton, groundnut, sugarcane, pigeon pea, bengalgram and sunflower. Among pulses pigeon pea is second most major crop next to the Bengal gram. The area under pigeon pea in the district is 1,83,550 hectare. The taluka wise area under pigeon pea in the district is presented in Table 3.4. The pigeon pea was one of the major crop grown in below talukas. The area under pigeon pea is 20,358 hectare, 27,570 hectare, 3,455, 18,834 hectare and 15,982 hectare in Indi, Sindagi, Vijayapura, Muddebihal and Basavana Bagewadi taluk respectively.The other major crops in the study area is jowar (2, 32,476 ha) and bengal gram (1, 81,651 ha). For analysing various issues of pesticide use in pigeon pea production in Vijayapura district, all taluks were selected.

3.3 Nature and source of data

The present study was mainly based on the primary data obtained from sample farmers through personal interview method. Multistage sampling procedure was adopted to get a necessary information from sample respondents. In the first stage, all five taluks were predominantly selected in the second stage, four villages based on highest area under pigeon pea were selected from each of the selected taluks. In third stage, six pigeon pea growing farmers out of which three are IPM and other three are non-IPM were randomly chosen from each village for getting the required information on pigeon pea cultivation. Thus, the total sample size is 120. The sample farmers were interviewed personally using a pre-tested and structured schedules specifically designed for the study.

The detail information pertaining to socio-economic aspects of the sample farmers, cropping pattern, the details pertaining to pigeon pea cultivation namely, area under pigeon pea, land preparation operations, input used and output obtained. 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

Table 3.4. Area under major crops in Vijayapura district and sample taluk (ha)

Sl. No.	Crops	Indi	Sindagi	Vijayapura	Muddebihal	Basavana Bagewadi	Vijayapura district
		Area	Area	Area	Area	Area	Area
1.	Jowar	46536	45060	66096	34148	40636	232476
2.	Bajra	12026	13666	7666	11297	10783	55438
3.	Maize	17676	17109	18906	4744	13811	72246
4.	Wheat	14217	12669	13502	3347	8339	52074
5.	Total cereals	90455	88569	106170	53545	73592	412331
6.	Tur	20358	27570	3455	18834	15982	86199
7.	Bengal gram	27533	38922	40697	33274	41225	181651
8.	Total pulses	50572	67243	45467	53868	57842	274992
9.	Total food grains	141027	155812	151637	107413	131434	687323
10.	Groundnut	10686	11708	2626	11223	3494	39919
11.	Sunflower	5845	10934	24941	15307	17154	74181
12.	Total oil seeds	16907	23584	28524	27801	23090	119906
13.	Fruits	5716	1768	10469	285	925	19163
14.	Vegetables	2592	1529	9090	1593	5401	20205
15.	Sugarcane	25009	28151	11421	1617	4667	70865
16.	Cotton	1276	8018	183	1875	1595	12947

Source: Vijayapura district at a glance 2012-13. District statistical office, Vijayapura

Table 3.5. Samples selected from the villages of different taluks

Villages	Indi	Sindagi	Vijayapura	Muddebihal	Basavana Bagevadi
1.	Atharga	Markabbinahalli	Utnal	Madikeshwar	Mangoli
2.	Nagathan	Devoor	Ukkali	Davalgi	Nandyal
3.	Hirebennur	Gundagi	Jumnal	Kannur	Yarnal
4.	Tadvalga	Manur	Sarwad	Minajagi	Hattarkihal

were collected. The survey was conducted during October 2014 to march 2015. The data pertained to the crop year 2013-14. 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), Vijayapura.

3.4 Analytical tools employed

The following were the analytical techniques used in the analysis to fulfill the objectives.

3.4.1 Tabular analysis.

3.4.2 Production function analysis

3.4.3 Partial Budgeting Technique

3.4.1 Tabular analysis

The tabular analysis were employed for determining general characteristics, Socio–economic conditions, cropping pattern, pesticide usage, costs, returns and profits etc, from pigeon pea cultivation in the study area. The percentages and averages were worked out to draw meaningful inferences.

3.4.2 Production function analysis

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

$$Y = A\, X_1^{a_1} X_2^{a_2} X_3^{a_3} X_4^{a_4} X_5^{a_5} X_6^{a_6}\, e_u$$

Where,

Y= Gross income from pigeon pea (Rs. ha^{-1})

X_1= Expenditure on Seeds (Rs. ha^{-1})

X_2= Expenditure on Farm yard Manure (FYM) (Rs. ha^{-1})

X_3= expenditure on Fertilizers

X_4 = Expenditure on human labour (Rs. ha^{-1})

X_5 = Expenditure on bullock labour (Rs. ha^{-1})

X_6= Quantity of Pesticides used (L ha^{-1})

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,

Marginal value product of $X_i = a_i \; = \overline{Y}/\overline{X}$

Where:

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

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

a_i = production elasticity of i^{th} resource

3.4.3 Partial Budgeting Technique

In order to compare the costs and returns of IPM and non-IPM partial budgeting technique was employed. This will reflect difference in quantitative aspects of IPM and non-IPM model.

The following pattern was used in partial budget analysis.

Sl. No.	Debit	Credit
a.	Increasing in cost due to IPM	Decreasing in cost due to IPM
b.	Decrease in returns	Increasing in returns
c.	Total Debit	Total credit
d.	Net gain	

3.5 Concepts and terms used in the study

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

Human labour

The human labour is measured in terms of man days for different operations of pigeon pea cultivation. The women days were converted into adult man days of eight hours per day on the basis of wage differential between man and women labour. For instance, in the present study the wage rate of human day was Rs. 210.80 per day.

Bullock labour

Bullock labour is defined in bullock pair days, both owned and hired were charged at the rate of Rs. 322 paid per day (8 hr) in the study area.

Machine labour

The cost of machine labour both hired and owned was calculated for differential rates for different type of operations prevailed on an average it was Rs. 393/hr in study area

Seed cost

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

Farm yard manure (FYM)

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

Fertilizers

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

Plant protection chemicals

The cost of different insecticides, weedicides and fungicides used in controlling pigeon pea 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. 100/ha/annum for pigeon pea) 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 based on 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 short-term loans. The prime lending rate during the agriculture year was 12 per cent for crop loan for pigeon pea. It was charged for a period of six months for pigeon pea 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.

Interest on fixed capital

Interest on fixed capital was calculated at the rate which banks are advancing medium-term and long term loans. The prime lending rate during the agriculture year was 10 per cent for machine loan, land loan and animal loan etc.

Total cost of cultivation

The total cost included the cost of human labour, bullock labour, tractor power, manures, fertilizers, plant protection chemicals, seeds 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.

Added cost

These are the costs additionally incurred towards the adjustment made in the operations. Only paid out cost are considered.

Added returns

These are the returns that are added as result of substitution.

Reduced costs

These are the costs, which are incurred due to the particular operation, for which another operation is substituted.

Reduced returns

These are the returns which are foregone due to the operation of particular activity, for which another is substituted.

4. RESULTS

In consonance with the objectives of the study, the data collected from primary source subjected to various statistical tools and techniques to draw meaningful conclusions. The major findings of the study are presented in this chapter under the following subheads.

4.1 Socio-economic characteristics of the sample farmers

4.2 Cost and returns structure of pigeon pea cultivation.

4.3 Frequency, quantity and type of pesticide used in pigeon pea cultivation.

4.4 Actual use *vis-a-vis* recommended dose of pesticide used by sample farmers

4.1 Socio-economic characteristics of the sample farmers

The socio-economic characteristics of sample farmers like family type, age, education level, family size, average land holding and distribution of sample farmers are presented in Table 4.1.

The total sample size of the IPM and non-IPM farmers were grouped into joint family and nuclear family. About 51.67 per cent of IPM farmers belonged to nuclear family and 48.33 per cent of farmers belonged to joint family, whereas in case of non-IPM farmers, 65 per cent and 35 per cent of the respondents belonged to joint family and nuclear family, respectively. Farmers adopting IPM and non-IPM practices are similar with respect to socio economic conditions, hence the null hypothesis is accepted. It could be seen from the table that majority of the sample farmers belonged to middle aged group in both IPM (55%) and non-IPM farmers (56.67%), followed by old aged group and young aged group. With respect to family size, more number of sample farmers belonged to medium size family (43.33%) followed by large size (30%) and small size family (26.67%). Whereas in case of non-IPM famers, majority of the respondents belonged to large size family group (40%), followed by medium size (36.67%) and small size groups (23.33%)

Table 4.1. Socio-economic characteristics of sample farmers

(N=120)

Sl. No.	Particulars	IPM Farmers (n=60)	Per cent	Non-IPM Farmers (n=60)	Per cent
1. Type of family (No.)					
a.	Nuclear family	31	51.67	21	35.00
b.	Joint family	29	48.33	39	65.00
2. Age of farmer (No.)					
a.	Young (< 35 years)	10	16.67	11	18.33
b.	Middle (35 to 50 years)	33	55.00	34	56.67
c.	Old (> 50 years)	17	28.33	15	25.00
3. Family size (No.)					
a.	Small (4 members)	16	26.67	14	23.33
b.	Medium (5- 7 members)	26	43.33	22	36.67
c.	Large (> 7 members)	18	30	24	40.00
4. Education level(No.)					
a.	Illiterates (0-4)	25	41.67	21	35.00
b.	Primary (up to 7 std.)	13	21.67	8	13.33
c.	Secondary (8-10 std.)	12	20.00	15	25.00
d.	PUC (XI and XII std.)	8	13.33	14	23.33
e.	Degree	2	3.33	2	3.33
5. Average land holding (in hectare)					
a.	Irrigated	1.15	20.99	1.35	22.41
b.	Rainfed	4.33	79.01	4.66	77.59
c.	Total	5.48	100	6.02	100
d.	**Area under pigeon pea**	**2.91**	**53.06**	**3.18**	**52.93**
6. Distribution of land holding (in Nos.)					
a.	Small and marginal farmer	15	25	8	13.33
b.	Medium farmer	17	28.33	18	30.00
c.	Large farmer	28	46.67	34	56.67
	Total	**60**	**100**	**60**	**100.00**

The educational level of the IPM farmers depicts that majority of them were illiterates (41.67%) followed by literate groups which composed of primary (21.67%) and secondary education (20%), PUC (13.33%) and degree (3.33%). In case of non-IPM farmers also 35 per cent of the respondents were illiterates followed by literate groups which composed of secondary (25%), PUC (23.33%), primary (13.33%) and degree (3.33%).

The average size of land holdings in IPM farmers was 5.48 hectares of which, 4.33 hectares was under rainfed condition and remaining 1.15 hectares was under irrigated condition. Similarly, in case of non-IPM farmers, out of 6.02 hectares area, majority of the area was under rainfed condition (4.66 ha) and only 1.35 hectares area was under irrigated condition. The average area under pigeon pea was more in case of non-IPM farmers (3.18 ha) than that of IPM farmers (2.91 ha). With respect to distribution of sample farmers based on their holding size indicating that, majority of the sample farmers belonged to large size group in both IPM (46.67%) and non-IPM farmers (56.67%), followed by medium size group (28.33% and 30%) and small and marginal size groups (25% and 13.33%) in case of IPM and non-IPM farmers, respectively.

4.1.2 Cropping pattern of sample farmers

Farmers were growing number of crops on their farm, of which pigeon pea and cotton were the major crops grown in both seasons. Whereas, green gram, sorghum, sugarcane, wheat bengal gram, sugarcane and grapes grown by the sample farmers in the study area. Pigeon pea was the major food crop grown in *kharif season* by both IPM and non-IPM farmers showed in Table 4.2.

The major crops grown during *kharif* by sample farmers were pigeon pea (56%), green gram (12%) and cotton (32%). Among these crops the overall area under pigeon pea was found highest in the study area (3.04 ha), followed by cotton and green gram occupied an average area of 1.71 ha and 0.64 ha, respectively.

During *rabi* season, overall area under pigeon pea was found to be

Table 4.2. Cropping pattern of sample respondents in the study area

(Area in ha)

Sl. No.	Crops	IPM (n=60)	Per cent	Non-IPM (n=60)	Per cent	Overall (N=120)	Per cent
I	***Kharif***						
1	Pigeon pea	2.91	57	3.18	56	3.04	56
2	Green gram	0.68	12	0.67	12	0.64	12
3	Cotton	1.58	31	1.84	32	1.71	32
A	**Subtotal**	**5.17**	**100**	**5.70**	**100**	**5.39**	**100**
II	***Rabi***						
1	Pigeon pea	2.91	53.30	3.18	53.09	3.04	53.24
2	Cotton	1.58	28.94	1.84	30.72	1.71	29.95
3	Sorghum	0.58	10.62	0.56	9.35	0.57	9.98
4	Bengal gram	0.12	2.20	0.21	3.51	0.16	2.80
5	Wheat	0.27	4.95	0.2	3.34	0.23	4.03
B	**Subtotal**	**5.46**	**100**	**5.99**	**100**	**5.71**	**100**
III	**Annual/Horticultural crop**						
1	Sugarcane	0.34		0.28		0.28	
2	Grapes	0.04		0.08		0.06	
IV	**Gross cropped area**	11.01		12.11		11.10	
V	**Net cropped area**	5.48		6.01		5.75	
VI	**Cropping intensity (%)**	200.91		201.49		193.04	

highest (53.24%) followed by cotton (29.95%), sorghum (9.98%), wheat (4.03%) and bengal gram (2.80%). Since the mono-cropping is common practice in the study area, the sugarcane area (0.28 hectare) in both seasons was almost same and the average area under horticulture crop like grapes was 0.06 hectare. On overall basis the study area showed a cropping intensity of 193.04 per cent which results from a net cropped area of 5.75 hectares. The average gross cropped area was higher in case of non-IPM farmers (12.11 ha) compared to IPM farmers (11.01 ha).

4.2 Cost and returns structure of pigeon pea cultivation

The details of cost incurred and returns realized in pigeon pea cultivation by IPM and non-IPM farmers during the crop year 2013-14 is presented in Table 4.3.

It could be seen from the table that, per hectare total cost of cultivation was Rs. 40,907 in case of IPM farmers and Rs. 42,846 in case of non-IPM farmers. In both the cases, variable costs accounts for Rs. 36,280 and Rs. 38,218 with a share of 88.69 per cent and 89.19 per cent of the total cost of cultivation in the case of IPM and non-IPM farmers, respectively. Among the variable costs, the expenditure incurred on human labour was highest share (24.46%) followed by, PPC (16.04%), chemical fertilizers (15.57%), machine labour (14.89%), cost incurred on IPM components (7.33%), bullock labour (3.66%), interest on working capital (3.48%), seeds (1.96%) and FYM (1.29%). Similarly in case of non-IPM farmers the expenditure incurred on human labour was also highest (25.96%) followed by PPC (25.42%), machine labour (13.52%), fertilizers (14.06%), bullock labour (3.80%), interest on working capital (3.59%), seeds (1.57%) and FYM (1.23%).

The share of fixed cost in total cost of cultivation was 11.31 per cent (Rs. 4627) and 10.79 per cent (Rs. 4627) in case of IPM and non-IPM farmers, respectively. Among these fixed costs, rental value of land was having maximum share being Rs. 2975 in both the cases. The other minor fixed cost includes depreciation (Rs. 1125), interest on fixed capital (Rs. 420), irrigation charges (Rs. 100) and land revenue (Rs. 7.5).

Table 4.3. Cost and returns structure of pigeon pea cultivation

(Rs./ha)

Sl. No.	Particulars	IPM (n=60)	Per cent	Non-IPM (n=60)	Per cent
A.	**Variable costs**				
1.	Human labour	10007	24.46	11123	25.96
2.	Bullock labour	1497	3.66	1629	3.80
3.	Machine labour	6092	14.89	5797	13.52
4.	Seeds	800	1.96	675	1.57
5.	Farm yard manure	527	1.29	530	1.2
6.	Fertilizers	6370	15.57	6027	14.06
7.	PPC	6562	16.04	10895	25.42
8.	Cost incurred on IPM components excluding PPC	2997	7.33	0	0.00
9.	Interest on working capital (@ 12%)	1425	3.48	1542	3.59
	Total variable cost (A)	**36280**	**88.69**	**38218**	**89.19**
B.	**Fixed costs**				
1.	Irrigation charge	100	0.24	100	0.23
2.	Land revenue	7.5	0.02	7.5	0.01
3.	Rental value of land	2975	7.27	2975	6.94
4.	Depreciation	1125	2.75	1125	2.62
5.	Interest on fixed capital (@ 10%)	420	1.03	420	0.98
	Total fixed costs (B)	**4627**	**11.31**	**4627**	**10.79**
C.	**Total cost of cultivation (A+B)**	**40907**	**100**	**42846**	**100**
D.	**Returns**				
1.	Total Returns	50225		48330	
2.	Net returns	9317		5484	
3.	B:C Ratio	1.23		1.13	
4.	T test	2.06			

It could also be seen from the table that, the per hectare gross returns realized by IPM farmers were high (Rs. 50,225) compared to non-IPM farmers (Rs. 48,330). The net returns per hectare obtained by IPM farmers were high (Rs. 9317) than that of non-IPM farmers (Rs. 5484)

The average output of pigeon pea was slightly higher (9.97 q/ha) in case of IPM farmers as compared to non-IPM farmers (9.55 q/ha). There was noticeable difference in the total cost of cultivation and increased net returns realized by the IPM farmers as compared to non-IPM farmers. The B:C ratio was also high in case of IPM farmers (1.23) when compared to non-IPM farmers (1.13). The profitability of IPM practicing farmers of pigeon pea is higher as compared to the non-IPM farmers. Hence the null hypothesis is accepted. The statistical t test is conducted to know the statistical difference between IPM and non-IPM practices. The test indicated that there was a significant difference between two cultivation practices.

4.2.1 Pattern of input utilization and output obtained by sample farmers

The pattern of inputs utilized and output realized in pigeon pea cultivation by the IPM and non-IPM farmers in the study area is presented in Table 4.4. It is evident from the table that the human labour (47.47 human days), bullock labour (4.65 pair days), machine labour (15.5 hr), seeds (11.9 kg), and 5.27 quintals of farm yard manure were used as the farm inputs per hectare by the IPM farmers. On an average, 158.5 kg of fertilizers and 2.57 liters of plant protection chemicals were used by IPM farmers. Similarly, in case of non-IPM farmers also used the human labour (52.77 human days), bullock labour (5.06 pair days), machine labour (14.75 hr), seeds (12.07 kg) and 4.50 quintals of farm yard manure. About 151 kg of fertilizer and 4.35 liters of plant protection chemicals were used by non-IPM farmers. The per hectare output realized from pigeon pea cultivation was 9.97 quintals by IPM farmers while, it was 9.55 quintals of output per hectare was obtained by non-IPM farmers.

Table 4.4. Input used and output realized in pigeon pea cultivation

(Per ha)

Sl. No.	Particulars	Units	IPM (n=60)	Non-IPM (n=60)
A.	**Input used**			
1.	Human labour	human days	47.47	52.77
2.	Bullock labour	Pair days	4.65	5.06
3.	Machine labour	hr	15.50	14.75
4.	Seeds	kg	11.90	12.07
5.	Farm yard manure	q	5.27	4.50
6.	Fertilizers			
	N	kg	87.50	85.80
	P	kg	65.00	62.25
	K	kg	6	3
	Total	kg	158.5	151
7.	PPC(Plant protection chemical)	l	2.57	4.35
B.	**Output realised**			
1.	Main Product	q	9.97	9.55

Table 4.5. Cost and returns with reference to pesticide use

Farmers	Added cost of pesticide (Rs./ha)	Total gross returns (Rs.)	Rate of return (Rs.)
IPM (n=60)	6562	50225	2.41
Non-IPM (n=60)	10895	48330	1.92

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

4.2.2 Cost and returns with reference to pesticide use

The rate of returns to the usage of pesticides was calculated according to *Nguyen and Tran Thi* (2003) and the results are presented in the Table 4.5. Perusal of the table revealed that, the added cost incurred on pesticides use by non-IPM farmers was highest (Rs. 10,895) than that of IPM farmers (Rs. 6265). The total returns per hectare obtained by IPM farmers was highest (Rs. 50,225) compared to IPM farmers (Rs. 48330). The added rate of return realized from pesticides use was highest in case of IPM farmers (2.41) than that of non-IPM farmers (1.92).

4.2.3 Cost incurred in adoption of IPM module by the sample farmers

The additional cost incurred by the IPM farmers for the adoption of IPM component in pigeon pea cultivation is presented in Table 4.6. The important component of pigeon pea IPM module includes cultural practices, mechanical operations and application of plant protection chemicals. Among these three components, the expenditure incurred on synthetic plant protection chemicals was found to be highest (68.64%) in the total cost incurred on adoption of IPM module followed by cultural practices (24.45%) and mechanical operations (1.36%). In the application of plant protection chemicals, the IPM farmers had resorted to synthetic chemicals and bioagents and botanicals for controlling major insect pests of the pigeon pea crop. In the total cost of IPM module, the proportion of expenditure made on important botanicals like Neem Seed Kernel Extract (NSKE) was 4.74 per cent and use of bio-agents such as Ha. NPV and Trichoderma is negligible. Out of sixty IPM practicing farmers' summer ploughing, removal of infested plant and NSKE used by all 60 farmers, pheromone traps used by only 27 farmers and 20 farmers were used bio-agents for the management of pest.

4.2.4 Resource use efficiency in pigeon pea production among IPM and non-IPM farmers

The Cobb-Douglass production function was estimated to study the

Table 4.6. Components of IPM module and additional cost incurred by IPM farmers

(N=60)

Sl. No.	Particulars	Units	Physical Qty.	Cost (Rs./ha)
A.	**Cultural components**			
A	Deep ploughing during summer	No.	1	2285 (24)
B	Physical shaking of crop plants	No.	1	52 (0.45)
	Subtotal			**2337 (24.45)**
B.	**Mechanical components**			
A	Pheromone traps	No.	2.57	130 (1.36)
	Subtotal			**130 (1.36)**
C.	**Chemical components**			
1.	**Bioagents and botanicals**			
a.	Trichoderma	G	0.12	5 (0)
b.	Ha.NPV	L	0.62	67 (0.7)
c.	NSKE	L	2.52	455 (4.74)
	Subtotal			**530 (5.5)**
D.	**Total cost of IPM excluding synthetic PPC**			**2997 (31.46)**
E.	**Synthetic chemicals**			
1.	Chemical pesticides	l	4.77	6562 (68.64)
F	**Total**			**9560 (100)**

Note: Figures in parentheses indicate percentage to total cost

Table 4.7. Resource use efficiency in the production of pigeon pea by IPM and non-IPM farmers

Sl. No.	Particulars	Parameter	IPM-farmers (n=60)		Non-IPM farmers (n=60)	
			Regression Coefficients	MVP:MFC Ratios	Regression Coefficients	MVP: MFC Ratios
1.	Intercept	A	2.03 (0.634)	-	2.49 (0.781)	-
2.	Seed	X_1	-0.003 (0.074)	-0.20	0.18*** (0.093)	13.26
3.	FYM	X_2	-0.01** (0.005)	-13.27	0.0006 (0.006)	1.13
4.	Fertilizers	X_3	-0.12* (0.031)	-1.23	-0.12*** (0.006)	-1.03
5.	Human labour	X_4	0.99* (0.185)	4.98	0.204 (0.073)	0.92
6.	Bullock labour	X_5	0.13* 90.0360	5.41	0.0008 (0.147)	0.03
7.	PPC	X_6	-0.01 (0.107)	-0.10	0.67* (0.007)	2.95
8.	R^2		0.93		0.86	
9.	Returns to scale (□b_i)		0.96		0.93	

*= significant at 1% probability level

**= significant at 5% probability level

***= significant at 10% probability level

Note: Figures in parentheses are standard errors.

resource use efficiency and influence of inputs on pigeon pea yield and the results of the analysis are presented in Table 4.7.

Perusal of the table revealed that, the co-efficient of multiple determination (R^2) was found to be 0.93 and 0.86 that means 93 per cent and 86 per cent of the variation in the dependent variable is explained by the independent variables included in the model in case of IPM and non-IPM farmers, respectively.

In case of IPM farmers, the regression co-efficient for human labour (0.99) and bullock labour (0.13) were found to be positive and significant at one per cent probability level. Whereas, the regression co-efficient for seed (-0.003), FYM (-0.01), fertilizers (-0.12) and PPC (-0.01) were found negatively non-significant except for FYM and fertilizers.

Similarly, in case of non-IPM farmers the regression co-efficient for PPC (0.67) was positively significant at one per cent probability level. The regression co-efficient for seed (0.18), FYM (0.0006), human labour (0.204) and bullock labour (0.0008) were also positive but found non-significant except for seed which was significant at ten per cent level of significance. Whereas, the regression co-efficient for fertilizer (-0.12) was negative and found significant at ten per cent probability level.

In case of both IPM and non-IPM farmers the sum of regression co-efficient was less than unity, which indicated decreasing returns to scale. This unveiled that if quantity of all the inputs were increased by one per cent, the yield of pigeon pea would increase by 0.96 per cent and 0.93 per cent in case of IPM and non-IPM farmers, respectively.

It could also be seen from the table that, the MVP: MFC ratio was found negative in case of seed (-0.20), FYM (-13.27), fertilizers (-1.23) and PPC (-0.10) in case of IPM farmers which indicated the over-utilization of these resources in the pigeon pea cultivation. Whereas, the ratio for human (4.98) and bullock labours (5.41) were found positive and indicated that there is still scope to increase these resources in the pigeon pea cultivation.

In case of non-IPM farmers, the MVP: MFC ratio was negative for fertilizer (-1.03) and for human labour (0.92) and bullock labour (0.03) was found less than unity which indicated that, these three resources were over-utilized. But, the ratio for seed (13.26), FYM (1.13) and PPC (2.95) was found more than unity which indicated that these resources were underutilized.

4.2.5 Partial budget analysis of benefits associated with IPM package of pigeon pea

In order to know the profitability of IPM, partial budgeting analysis was carried out and the results are presented in the Table 4.8. The results revealed that, the added cost incurred by the IPM farmers for its adoption was Rs. 2997 whereas, the IPM adopters gets the benefit of Rs. 4332 as a reduced costs, added returns of Rs. 1895 due to adoption of IPM. Thus, the total credit due to adoption of IPM technology was Rs. 6227 and the net gain obtained from the IPM package of pigeon pea was Rs. 3230.

4.3 Frequency, quantity and type of pesticide used in pigeon pea cultivation

Information on frequency, quantity and type of pesticides per hectare used in pigeon pea cultivation are presented in Table 4.9. The table delineates that IPM farmers used the contact insecticides with an average frequency of 1.50 times at the rate of 0.72 liter, which accounted for a cost share of Rs. 862, and systemic insecticide spraying average frequency of 1.83 times with a quantity of 1.05 liters includes a cost of Rs. 1232. Whereas, in case non-IPM farmers, sprayed 2.54 times at the rate of 1.17 liter per hectare with a cost of Rs. 1397 and systemic pesticide spraying frequency of 1.70 times and a quantity of 0.92 liters which includes a cost of Rs. 1100. The difference between non-IPM to IPM farmers with respect to average frequency, quantity and its cost was 1.04 times, 0.45 liters and Rs. 535, respectively. They use the same contact insecticides with average frequency of 2.54 times at the rate of 1.17 liter with a cost of Rs. 1397. Hence, there was observed a remarkable difference between IPM and non-IPM farmers with respect to frequency, quantity, and its costs were 1.04 times, 0.45 liter and Rs. 535, respectively in case of contact insecticides. Similarly, the difference

Table 4.8. Partial budgeting analysis of benefits associated with IPM package of pigeon pea

(Rs./ha)

Sl. No.	Debit (Rs.)		Credit(Rs.)	
a.	Added cost due to IPM	Rs.2997	Reduced cost due to IPM	Rs.4332
b.	Reduced returns	Rs. 0	Added returns	Rs.1895
c.	Total Debit = a + b	Rs.2997	Total credit = a+ b	Rs. 6227
1.	Net gain = total debit – total credit =			Rs.3230

Table 4.9. Frequency, quantity, type and cost of PPC used in pigeon pea cultivation

(N=120)

Pesticides	IPM (n=60)			Non IPM (n=60)			Difference		
	Freq (No.)	Qty (l/ha)	Cost (Rs./ha)	Freq (No.)	Qty (l/ha)	Cost (Rs./ha)	Freq (No.)	Qty (l/ha)	Cost (Rs./ha)
A. Insecticides									
1. Contact	1.50	0.72	862	2.54	1.17	1397	1.04	0.45	535
2. Systemic	1.83	1.05	1232	1.70	0.92	1100	-0.13	-0.12	-132
B. Fungicides	0.00	0.00	0	0.10	0.10	190	0.10	0.1	190

Table 4.10. Frequency distribution of sample farmers by pesticide use intensity

(N=120)

Pesticide use intensity (l / ha)	IPM (n=60)	Yield of IPM farmers (q/ha)	Non-IPM (n=60)	Yield of non-IPM farmers (q/ha)
<2.5	13	9.42	0	0
2.5 - 5.0	45	10.17	30	9.19
5.1 - 7.5	2	9.50	26	9.81
>7.5	0	0	4	10.45

for systemic insecticides was -0.13 times, -0.12 liters and Rs. -132, respectively. The frequency, quantity and type of pesticides used are not followed as per recommendations in pigeon pea production, hence, the null hypothesis is accepted.

4.3.1 Frequency distribution of sample farmers according to pesticide use intensity

Frequency distribution of farmers by pesticide used intensity per hectare was presented in Table 4.10. It revealed that out of 60 IPM farmers, thirteen farmers used less than 2.5 liter, forty five farmers used pesticides in ranges between 2.5 to 5 liters and only two farmers were sprayed at 5.1 to 7.5 liters and they obtained average yield of 9.42 quintals, 10.17 quintals and 9.50 quintals per hectare, respectively. While in case of non-IPM farmers, thirty farmers were sprayed in ranges between 2.5 to 5 liters, twenty six farmers used pesticides in ranges between 5.1 to 7.5 liters and four farmers applied more than 7.5 liters of pesticides. Similarly the average yield obtained was 9.19, 9.81 and 10.45 quintals per hectare, respectively.

4.4 Actual use *vis-a-vis* recommended dose of pesticide use by sample farmers

The recommended quantity of pesticide requirement for pigeon pea production was presented in Table 4.11 for non-IPM farmers, which revealed that the recommended dose of Flubendimide (0.30 l/ha), Clorophyiphos (0.80 l/ha), Profenophos (0.80 l/ha), Rhynaxypyr (0.06 l/ha), Monocrotophas (0.60 l/ha), Diclorovas (0.80 l/ha), Dimithoate (0.68 l/ha) and Spinosad (0.06 l/ha) whereas the farmers actually used Flubendimide (0.67 l/ha), Clorophyiphos (1.85 l/ha), Profenophos (1.70 l/ha), Rhynaxypyr (0.40 l/ha), Monocrotophas (1.65 l/ha), Diclorovas (2.15 l/ha), Dimithoate (1.74 l/ha) and Spinosad (0.23 l/ha) extra cost incurred due to excess use of insecticides (Rs.770), (Rs.1050), (Rs.1350), (Rs.1800), (Rs.2275), (Rs.843), (Rs.1940) and (Rs.1700) respectively. Similarly for fungicides the recommended dose and actual dose used was 0.05 liter and 0.10 liter per hectare, which incurred a cost of Rs. 80 and Rs. 190 per hectare, respectively.

Table 4.11. Actual use vis-a-vis recommended dose of pesticide by sample farmers

(N=120)

Pesticides	Recommended		Actually used		Difference	
	Qty. (l/ha)	Cost (Rs./ha)	Qty. (l/ha)	Cost (Rs./ha)	Qty. (l/ha)	Cost (Rs./ha)
1. Non-IPM						
A. Insecticides						
a. Flubendiamide	0.30	625	0.67	1395	0.37	770
b. Cloropyriphos	0.80	800	1.85	1850	1.05	1050
c. Profenophos	0.80	1200	1.70	2550	0.90	1350
d. Rhynaxypyr	0.06	600	0.40	2400	0.36	1800
e. Monocrotophas	0.60	1300	1.65	3575	1.05	2275
f. Diclorovas	0.80	500	2.15	1343	1.35	843
g. Dimethoate	0.68	1245	1.74	3185	1.06	1940
h. Spinosad	0.06	600	0.23	2300	0.17	1700
B. Fungicides	0.05	80	0.10	190	0.07	110
2. IPM						
A. Insecticides						
a. Flubendiamide	0.30	625	0.42	875	0.12	250
b. Cloropyriphos	0.80	800	1.12	1120	0.32	320
c. Profenophos	0.80	1200	0.95	1425	0.15	225
d. Rhynaxypyr	0.06	600	0.21	2100	0.15	1500
e. Monocrotophas	0.60	1300	1.13	2448	0.53	1148
f. Diclorovas	0.80	500	1.45	906	0.65	406
g. Dimethoate	0.68	1245	1.69	3143	1.01	1899
h. Spinosad	0.06	600	0.18	1800	0.12	1200

Similarly, in case of IPM farmers, it was manifested from table that the recommended dose of Flubendimide (0.30 l/ha), Clorophyiphos (0.80 l/ha), Profenophos (0.80 l/ha), Rhynaxypyr (0.06 l/ha), Monocrotophas (0.60 l/ha), Diclorovas (0.80 l/ha), Dimithoate (0.68 l/ha) and Spinosad (0.06 l/ha) whereas the farmers actually used Flubendimide (0.42 l/ha), Clorophyiphos (1.12 l/ha), Profenophos (0.95 l/ha), Rhynaxypyr (0.21 l/ha), Monocrotophas (1.13 l/ha), Diclorovas (1.45 l/ha), Dimithoate (1.69 l/ha) and Spinosad (0.18 l/ha) extra cost incurred due to excess use of insecticides (Rs.250), (Rs.320), (Rs.225), (Rs.1500), (Rs.1148), (Rs.406), (Rs.1899) and (Rs.1200) respectively.

4.4.1 Farmer's response towards pesticide use

It could be seen from Table 4.12 that among the IPM farmers, majority of the farmers (97%) reported that pesticides use was adequate, followed by quality of pesticide (62%) and awareness about labels (92%) and expiry date (57%) and farmers bought from registered company (87%). Similarly, in case of non-IPM farmers, 98 per cent were opined the adequacy of pesticides use, quality of pesticides (47%), bought from registered company (68%) and awareness about labels (73%) and its expiry date (38%).

4.4.2 Use and maintenance of sprayer

From Table 4.13 indicated that two different types of sprayer were used by farmers in the study area. On overall, about 47 per cent of the farmers used knapsack sprayer and remaining 53 per cent of the farmers used power sprayers.

About 98 per cent of the farmers washed sprayer after its use and hardly 2 per cent of them did not wash sprayer after use. Nearly 89 per cent of the farmers let the washed water on the farm and remaining 11 per cent of the famers allowed washed water into irrigation channel. About 65 per cent of the farmers were used to throw pesticide bottle in fields itself and only 3 per cent of them were used to sell the bottles. None of the farmers were burying pesticide bottles in fields. About 32 per cent of the farmers used bottles for their self use.

Table 4.12. Awareness of pesticide use by farmers

Information on Pesticides Usage	IPM (n=60)		Non-IPM (n=60)	
	Yes	No	Yes	No
Pesticide used is adequate	58 (97)	2 (3)	59 (98)	1 (2)
Bought from registered company	52 (87)	8 (13)	41 (68)	19 (32)
Quality was good	37 (62)	23 (38)	28 (47)	32 (53)
Bought packed pesticides	60 (100)	0 (0)	60 (0)	0 (0)
Labels were seen by respondents	55 (92)	5 (8)	44 (73)	16 (27)
Aware of expiry date	34 (57)	26 (43)	23 (38)	37 (62)

Note: Figures in the parentheses indicate percentage to respective sample size

Table 4.13. Use and maintenance of sprayer by sample farmers

Sl. No.	Particulars	Pigeon pea farmers		
		IPM (n=60)	Non-IPM (n=60)	Total (N=120)
1.	**Type of sprayer used**			
a.	Knapsack sprayer	27 (45)	30 (50)	57 (47)
b.	Power sprayers	33 (55)	30 (50)	63 (53)
2	**Washing sprayer after use**	**60 (100)**	**58 (97)**	**118 (98)**
3	**Disposal of washed water**			
a.	To field	55 (92)	52 (87)	107 (89)
b.	To irrigation channel	5 (8)	8 (13)	13 (11)
4	**Disposal of pesticide empty containers**			
a.	In field	40 (67)	38 (64)	78 (65)
b.	Sell	2 (3)	2 (3)	4 (3)
c.	Burying in field	0 (0)	0 (0)	0 (0)
d.	Self use	18 (30)	20 (33)	38 (32)

Note: Figures in the parentheses indicate percentage to respective sample size

Table 4.14. Pesticide handling practices followed by sample farmers

Sl. No.	Particulars	Farmers		
		IPM (n=60)	**Non-IPM (n=60)**	**Overall (N=120)**
1	**Direction of PPC application**			
a.	Along the wind	6 (10)	4 (6)	10 (8)
b.	Across the wind	45 (75)	42 (70)	87 (72.5)
c.	Do not consider wind direction	9 (15)	14 (23)	23 (19)
2	**Use of protective coverings**			
a.	No protective covering	35 (58)	32 (53)	67 (55)
b.	Use of hand gloves	10 (17)	15 (25)	25 (21)
c.	Use of face masks	5 (8)	9 (15)	14 (12)
d.	Use of both hand gloves and face masks	10 (17)	4 (7)	14 (12)
3	**Hand washing practice after pesticide application**			
a.	Wash hands	60 (100)	60 (100	120 (100)
b.	With soap	55 (92)	58 (97)	113 (94)
c.	With mud	5 (8)	2 (3)	7 (6)
4	**Take bath after spraying**	**60 (100)**	**56 (93)**	**116 (97)**
5	**Pesticide and water mixing practices**			
a.	Use of wooden stick	20 (33)	30 (50)	50 (42)
b.	Use of sprayer lancer	5 (8)	0 (0)	5 (4)
c.	By pouring PPC into half-filled pesticide sprayer with water	35 (58)	30 (50)	65 (54)
6	**Measurement of pesticides**			
a.	Measuring jar	10 (16)	5 (8)	15 (12.5)
b.	Pesticide bottle cap	40 (67)	32 (53)	72 (60)
c.	On average basis	10 (16)	23 (38)	33 (27.5)

Note: Figures in the parentheses indicate percentage to respective sample size

4.4.3 Pesticide handling practices

The pesticide handling practices followed by sample farmers were presented in Table 4.14. In total, most of the farmers (72.5%) applied chemicals across the wind direction. It also revealed that 8 per cent of the farmers applied pesticides along the wind direction. About 19 per cent of farmers did not consider the wind direction. This might be due to unawareness about importance of wind direction. It was interesting to note that 55 per cent of the farmers were not using any protective coverings. This shows the lack of knowledge of the farmers about its ill effects. From the survey, it was revealed that none of the farmers used shoes during chemicals spraying, whereas 21 per cent of the farmers used hand gloves, around 12 per cent of them were using face masks and 12 per cent of farmers used both hand gloves and face masks while spraying.

All farmers washed their hands after spraying. In the total sample farmers, around 94 per cent of them washed their hands with soap and remaining 6 per cent of them washed their hands with mud. About 97 per cent of the farmers have taken bath soon after spraying and remaining hardly 3 per cent of them did not bath immediately after spraying.

With regard to mixing of the pesticides with water was concerned, majority of the farmers (54%) mixed chemicals with pouring water and 42 per cent of farmers have used wooden stick for mixing. Remaining 4 per cent of them used sprayer lancer method. For measuring the chemicals, out of total respondents, 12.5 per cent of them used pesticide measuring jar, while 60 per cent of them were used bottle cap and remaining 27.5 per cent of farmers used to measure the spraying chemicals on an average basis.

4.4.4 Sources of information about pesticides use by the sample farmers

The sources of information about pesticides use for the farmers were presented in Table 4.15. In case of IPM farmers, majority of (53 per cent) the farmers have got information about pesticide usage from pesticide shop dealers, followed by 17 per cent from their own experience, 14 per cent from extension workers, 7 per cent each from neighbouring farmers, staff of Karnataka State Department of Agriculture (KSDA) and State Agricultural Universities (SAUs), whereas most of the non-IPM farmers (63 per cent) have got information on usage of pesticide, from pesticide shop dealers, followed by neighbouring farmers (20%), 12 per cent from of their own experience and 5 per cent from staff of Agricultural University and Agricultural Department.

Table 4.15. Sources of information about pesticides use for farmers

Sl. No.	Sources	IPM (n=60)	Non-IPM (n=60)	Overall (N=120)
1.	Pesticide dealers	32 (53)	38 (63)	70 (58)
2.	Own experience	10 (17)	7 (12)	17 (14)
3.	Neighbours	5 (8)	12 (20)	17 (14)
4.	Extension workers	8 (14)	0 (0)	8 (7)
5.	KSDA and SAUs	5 (8)	3 (5)	8 (7)

Note: Figures in the parentheses indicate percentage to respective sample size.

5. DISCUSSION

The results of investigation presented in the previous chapter are discussed in this chapter under the following heads. The main focus here is to throw light on some of the causes responsible for the major outcomes observed in the investigation.

5.1 Socio-economic characteristics of the sample farmers

5.2 Cost and returns structure of pigeon pea cultivation

5.3 Frequency, quantity and type of pesticide used in pigeon pea cultivation.

5.4 Actual use *vis-a-vis* recommended dose of pesticide in non-IPM farmers

5.1 Socio-economic characteristics of the sample farmers

The information on the family type of sample farmers indicated that, higher proportion of nuclear family type was observed in case of IPM farmers (51.67%) as compared to non-IPM farmers (35%). While, joint family type was observed more in case of non-IPM farmers (65%) than that of IPM farmers (48.33%).

The results revealed from Table 4.1 that, majority of the sample farmers belongs to middle aged group in IPM (55%) and non-IPM farmers (56.67%), while old age farmers were more in case of IPM farmers (28.33%) as compared to non-IPM farmers (25%) and less of young aged group (16.67%) in IPM as compared to the non-IPM (18.33%) farmers, which clearly indicated that, the age is nowhere influencing the decision making of the pigeon pea farmers in the implementation of IPM practices but, the middle aged IPM farmers had positive attitude towards IPM practice.

With respect to family size of the respondents, higher proportion of farmers belongs to medium size family (43.33%) in case of IPM farmers as compared to non-IPM (36.67%) farmers. This might be due to their awareness about the increased cost of living and difficulties in maintenance of large family and they might have found medium size families to have comfortable life.

It could be observed from the table that, majority of the sample farmers were found illiterates in both IPM (41.67%) and non-IPM (35%) farmers' category. To understand the concept of IPM practice, farmers should at least acquire primary or middle school level of education which could enhance the adoption rate.

The distribution of the total land for the IPM farmers indicated that, the higher proportion of the land (79.01%) was cultivated under rainfed condition and relatively lesser proportion of land (20.99%) was under irrigated condition. Similarly, in case of non-IPM farmers also same trend was observed with the distribution of land holding. The area under pigeon pea was observed more in case of non-IPM farmers (3.18ha) than of IPM farmers (2.91 ha).

With respect to distribution of sample farmers based on their holding size indicated that, the majority of the sample farmers belonged to large size group in both the cases. This clearly indicated that large farmers adopted IPM practices in a better manner when compared to small and medium farmers. The reason was that the large farmers find opportunities to contact concerned authorities to overcome the problems encountered while adopting of IPM practices.

5.1.1 Cropping pattern of sample respondents

The results of cropping pattern of the sample farmers revealed that major crops grown by the sample respondents in the study area were pigeon pea, cotton, green gram in *kharif* season, whereas cotton, sorghum, bengal gram and wheat in *rabi* season (Table 4.2).

Pigeon pea occupied major portion of total cultivable area both in case of IPM (2.91 ha) and non-IPM farms (3.18 ha) followed by cotton, green gram and bengal gram. Since the study area is a hub of horticultural crops like grapes, some of the sample farmers grow grapes with average area of 0.04 hectares. The results depicted that farmers cultivated a number of crops like cereals, pulses, commercial crops, oil seeds and horticultural crops in both the practices. Thus, IPM has not changed the cropping patterns of the farmers in comparison to non-IPM farmers.

5.2 Cost and returns structure of pigeon pea cultivation

The details of cost incurred, gross and net returns realized in pigeon pea cultivation by IPM and non-IPM farmers are shown in Table 4.4. In case of IPM farmers, per hectare total variable cost incurred was Rs. 36280 which accounted for more than three-fourth of the total cost of cultivation (88.69%). Among various components of variable cost, the expenditure incurred on human labour alone accounted for major share (24.46%) followed by PPC, fertilizers and IPM component. This was due to usage of more labours for collection and destruction of pod borer larvae and physical shaking of plant to dislodge larvae and removal of diseased plants. Similar pattern of expenditure was reported by Chanderkant (2008), where labour constituted major proportion of the cost of cultivation in IPM (Rs. 12, 373) and non-IPM farms (Rs. 14,671), respectively.

Similarly, in case of non-IPM farmers, per hectare total variable cost incurred (Rs. 38,911) had accounted more than three-fourth of total cost of cultivation. Among various components of variable cost, the expenditure incurred on human labour (24.11%) was highest. This was due to use of more doses of pesticides application coupled with increase in wage rate.

Expenditure on spraying of chemicals (PPC) was very low among IPM farmers (Rs. 6562) as compared to non-IPM farmers (Rs. 10895). This clearly indicates that IPM farmers are having good knowledge about the consequences of pesticides use on the farm. In other words, farmers have realized that with small quantity of PPC application, they can get higher returns than those who use PPC frequently. The results are on par with the findings of Moorthy *et al.* (2004), Singh and Singh (2005), Singh *et al.* (2007) and Chanderkant (2008) in case of tomato, cotton, paddy and pigeon pea, respectively.

The gross return per hectare obtained by the IPM farmers (Rs. 50, 225) was marginally higher than that of non-IPM farmers (Rs. 48,330). Similarly, net returns were also more in case of IPM farmers (Rs. 9317) than that of non-IPM farmers (Rs. 4791). This might be due to the fact that relatively less cost of cultivation and higher gross returns. The benefit cost ratio was slightly higher (1.23) in case of IPM farmers than that of non-IPM farmers (1.11).

5.2.1 Pattern of input utilization and output obtained by sample farmers

The pattern of inputs utilized and yield realized in pigeon pea cultivation by the IPM and non-IPM farmers in the study area is presented in Table 4.3. It can be observed from the table that among various inputs used in pigeon pea cultivation, the IPM farmers used more of machine labour, chemical fertilizers and organic manures, whereas non-IPM farmers used more of seeds, human labour and bullock labour. The IPM farmers engaged on an average 47.47 man days of human labour, as against 52.77 man days of the non-IPM farmers. Similarly, IPM farmers engaged 4.65 pair days of bullock labour as compared to 5.06 pair days in case of non-IPM farmers. IPM farmers engaged 15.50 hours of machine labour as compared to 14.75 hours in case of non-IPM farmers. The usage of more labour in case of non-IPM farms was mainly due to cultural practices like harrowing, weeding and spraying. But except deep summer ploughing in case of IPM practices all other practices remains same and no additional labour is required for practicing of IPM at various stages of Pigeon pea cultivation. IPM famers applied on an average, 5.27 quintals of FYM while it was 4.50 quintals in case of non-IPM farmers. The quantity of utilization on these components was relatively higher in case of IPM farmers as compared to non-IPM farmers.

Even though the IPM farmers used more quantity of FYM than non-IPM farmers the use of chemical fertilizers (158.5 kg/ha) by IPM farmers was found to be higher than that of non-IPM farmers (151kg/ha).Since the farmers were using lesser quantity of FYM than the recommended quantity, so the farmers are using more of conventional fertilizers which will contribute more for their returns. Both IPM and non-IPM farmers have used improved variety, but the seed rate is more in case of non-IPM due to different methods of sowing. For example tractor drawn sowing practice needs more seeds then bullock drawn sowing practice. The analysis of yield realized in Pigeon pea cultivation revealed that, the IPM farmers (9.97 q/ha) were harvested more quantity of yield as compared to non-IPM counterparts (9.55 q/ha). As a result, the returns obtained by IPM farmers were higher than those of non-IPM farmers. The higher yield levels of IPM farmers could be attributed mainly due to the effectiveness of IPM technology in the control of pests as well as the balanced use of other inputs including recommended package of practices. Similar results were also observed by Moorthy *et al.* (2004), Singh *et al.* (2005) and Chanderkant (2008).

5.2.2 Cost and returns with reference to pesticide use

The cost incurred on pesticides use for IPM farmers was Rs. 6562 per hectare and rate of returns was marginally higher (Rs. 2.41) in case of IPM farmers than that of non-IPM farmers (Rs. 1.20). Whereas, cost incurred per hectare on pesticides use by non-IPM farmers was highest (Rs. 10895) due to more number of doses of chemical application (Table 4.5).

5.2.3 Additional cost incurred in adoption of IPM module by the IPM farmers

An additional cost incurred per hectare for adoption of pigeon pea IPM module includes expenditure on cultural practices, mechanical operations and plant protection chemicals (Table 4.6). It was observed that almost IPM components were incorporated in the IPM technology in the process of pigeon pea cultivation. The IPM farmers had incurred an additional cost of Rs. 9560 per hectare as total IPM component cost. In order to reduce the expenditure on the purchase of synthetic chemicals the IPM farmers have taken up cultural and mechanical operations along with the bio agents and botanicals as plant protection chemical components to minimize the pest load on the crop.

Among the cultural operations, the major proportion of the IPM component cost was incurred on summer ploughing followed physical shaking of crop plants. All these cultural practices were performed by using machine and human labours. Therefore, the mechanical components, biological and botanical agents act as important cost effective activities of the pigeon pea IPM module, which ensured better sustainability in reaping a higher yield level of the IPM farmers. These results were corroborated with the previous research findings of Gajanana *et al.* (2004).

5.2.4 Resource use efficiency in pigeon pea production of IPM and non- IPM farmers

The production function estimates for IPM and non-IPM farmers in pigeon pea production are presented in Table 4.7. The results revealed that the value of co-efficient of multiple determination (R^2) was found to be 0.93 and 0.86 in case of IPM and non-IPM farmers, respectively. This revealed that the independent variables included in the model have explained 93 and 86 per cent of variation in the dependent variable of IPM and non-IPM farmers, respectively. However, there was considerable difference in the extent of influence of different factors on pigeon pea yield. The elasticities of human and bullock labours were positively significant indicated that, an increase in the use of these resources over and above their present level may result in substantial increase in gross returns of IPM farmers.

The plant protection chemical components used by non-IPM farmers in pigeon pea production were found positive and statistically significant. Since the non-IPM farmers were used only pesticides for effective management of pest and disease incidences, though it was significant but dosage of pesticides use was not followed as per the recommendation for its optimum use, still there would be scope for decrease in expenditure made on PPC. This will have negative effect on the net returns as well as health conditions of labours involved in spraying operations and further, it lead to environmental pollution.

In case of IPM farmers, the sum of regression co-efficients was less than unity, indicated decreasing return to scale. This means that if all the inputs were increased by one per cent, the yield of pigeon pea would decrease by 96 per cent. This was mainly due to excess use of fertilizers, FYM, seed and PPC. Similarly, the sum of regression co-efficients in case of non-IPM farmers was also found to be less than one (0.93), indicated decreasing returns to scale. Hence, there will be no scope to increase the pigeon pea production by increasing other inputs. But, Returns to scale in case of IPM farmers is more than non-IPM farmers, thus IPM technology needs to be extended to those farmers who have not adopted so far and farmers should made aware of recommended dosage of PPC use with the help of extension personnel. This would, on one hand, cut down the plant protection chemicals costs of non-IPM farmers and on the other hand, increase their pigeon pea yield through IPM technology and efficient use of other resources.

It could also be seen from the table that, the MVP: MFC ratio in case of IPM farmers was found negative in the case of seed, FYM, fertilizers and PPC which indicated that over-utilization of these resources in the pigeon pea cultivation. Whereas, the ratio for human and bullock labours were found positive and indicated that there is still scope to increase these resources in order to optimize the pigeon pea yield.

In case of non-IPM farmers, the MVP: MFC ratio was negative for fertilizer and for human labour and bullock labour was found less than one 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. But, the ratio for seed, FYM and PPC was found more than unity indicating that these resources were under-utilized and there was scope for maximizing returns by increasing the use of these resources. The results of the above findings are in line with that of Udaykumar (2009) with respect to over-usage of PPC in paddy.

5.2.5 Partial budget analysis of IPM and non-IPM for pigeon pea cultivation

The partial budgeting analysis was carried out to know the feasibility of IPM technology in pigeon pea cultivation (Table 4.8). The IPM appeared to be an effective alternative technology to chemical pest control. Since the overall, monitory benefits of IPM technology realized by the IPM adopted farmers was Rs. 3230 per hectare. The results of the present study were similar with previous findings obtained by Brithal *et al.* (2000) and Razack (2000).

5.3 Frequency, extent, type and cost of PPC used in pigeon pea cultivation

The frequency, quantity, type and cost of PPC used in pigeon pea cultivation in case of both IPM and non-IPM farmers is presented in Table 4.9. It could be seen from the table that, there was positive a difference in frequency, quantity and cost involved in usage of contact insecticides and fungicides between non-IPM and IPM farmers. The non-IPM farmers used more quantity of contact insecticides (0.45 lit/ha) and fungicides (0.1 lit/ha) than that of IPM farmers, whereas the usage of systemic insecticides (-0.12 lit/ha) was more in case of IPM farmers as compared to non-IPM farmers. This was mainly due to the fact that IPM farmers control the chewing and biting type of insects with the help of cultural and mechanical practices and if the population of insect exceeds they go for spraying contact insecticides and for sucking type of insects, they use systemic insecticide. The results of the study are in line with that of Singh *et al.* (2007) in case of paddy, vegetables and cotton cultivation.

5.3.1 Frequency distribution of sample farmers by pesticide use intensity

Distribution of sample farmers according to intensity of pesticides use is presented in Table 4.10. This revealed that majority of them were used pesticides in the range between 2.5 to 5.0 l/ha in case of IPM farmers for which they got maximum quantity of output 10.17 qtl/ha as compared to non-IPM farmers. The yield obtained was more (10.45 qtl/ha) when they have used more than 7.5 l/ha quantity of pesticides. Though the less number of farmers who were used more than 7.5 l/ha of pesticides, but this might be due to more incidences of pest and disease. The study conducted by Santkumar and Dhandapani (2000) in cotton growing region of Nanded district reported that most of the farmers used pesticides in the range between 3 kg and 3.5 kg active ingredient per ha. The study suggests that the farmers need education about different non-chemical control methods and should be encouraged to adopt integrated pest management practices. Savita *et al.* (2012) suggested that farmers should be trained about adoption of integrated pest management (IPM) practices in paddy cultivation in TBP area.

5.4 Actual use *vis-a-vis* recommended dose of pesticide in non- IPM farmers

The information on the recommended quantity of pesticide use for pigeon pea and the actual quantity used by the non-IPM farmers is presented in Table 4.11. In both IPM and non-IPM farmers, the sample farmers were used excess quantity of pesticides than the recommended dose of pesticides. There was noticeable difference in case of non-IPM farmers than that of IPM farmers. This was due to risk aversive nature of farmers to avoid crop loss due to pest infestation but in economic sense, any increase in higher use of pesticides than the recommended level is really uneconomical and irrational one. Moreover, in the process of overusing pesticides leads to environmental problems. Thus, the farmers are need to be educated about the recommended dose of pesticide use in order to avoid problems related to environment, human health, animal health and other beneficial insects. The above results were in concurrence with results obtained by Sudha (2014).

5.4.1 Awareness of pesticide use

Among the two categories of farmers, even though majority of the farmers in both the category opined that pesticide use was adequate (Table 4.12). But still they were not aware about expiry date and its proper usage of pesticides in case of IPM farmers (43 per cent) and non-IPM farmers (62 per cent). IPM farmers (62 per cent) also expressed that the quality of pesticide was good since, most of the pesticides are of new molecules and showed good controlling capacity towards pest. Thus, the farmers have to be educated about expiry date, labels and adequacy of pesticide use. This will help the farmers in minimization of cost on PPC, improvement in quality of the product and also reduction in the ill effects on health hazards on human being, animals and other beneficial insects.

5.4.2 Use and maintenance of sprayer by sample farmers

An opinion survey was conducted to know the usage of sprayers and maintenance of sprayers and the results are presented in Table 4.13. It could be seen from the table that majority of the respondents used power sprayer (53%) and knapsack sprayers (47%) for spraying of pesticides. With respect to maintenance of the sprayer, majority of the respondents opined that, they used to wash their sprayer immediately after its usage (98%), followed by disposal of washed water and empty pesticide containers in the field itself. The disposal of washed waters and empty containers in the field may lead to contamination of pesticides residue in the soil which may further lead to negative effect on soil health and also affect some of the beneficial micro flora or microbes present in the soil. Most of farmers throw the empty containers in field; it will not only effect on crop environment but also on animal health which will graze the land along the bunds of the farm.

5.4.3 Pesticide handling practices followed by sample farmers

It was observed from the Table 4.14 that most of the farmers opined that they are used to spray the chemicals across the wind direction (72.5%) which will increase farmers' exposure to chemicals. This is the wrong method of applying PPCs and enhances the probability of causes of poisonous effects by way of inhalation of chemicals either directly or indirectly. This may be due to crop sowing direction of the farmers as they usually sow the crop in East-West direction. About 55 per cent of the respondents did not use any protective coverings like hand gloves and facemasks. This may increase the chances of exposure of farmers/farm labourers to lethal chemicals.

Other than these practices the majority of the respondents (54%) mixed the chemicals by pouring chemical into half-filled tank of water and later on, filling the tank with reaming required water, followed by mixing with wooden stick (42%). Nearly 60 per cent of the respondents were used pesticide bottle cap for measuring pesticides which is wrong method. On an average basis, 27.50 per cent of farmers followed without using any standard measuring instrument. Only few of them were used measuring jar (12.5%) for measuring pesticides which is correct method to measure the pesticides. The volume of water used by the farmers was rough approximation which often did not yield the required dilution as per scientifically 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 whereas, over dose would result in greater health hazard.

5.4.4 Sources of information about pesticides use for farmers

The sources of information which influenced farmers in their application of pesticides were very diverse and it is presented in Table 4.15. About 58 per cent of sample farmers got the information from pesticide shop dealers followed by their own experience, contact with neighbouring farmers, extension workers and staff of Karnataka State Department of Agriculture and State Agricultural Universities.

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 far as crop wise consumption is considered. 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 1st among all pigeon pea growing countries in respect of area while yield levels were low at 656 Kgs per hectare. Among the states in India, Karnataka occupies 2nd position with respect to area and production of pigeon pea. In Vijayapura district the area under pigeon pea is 1,83,550 hectare with production of 1,40,256 metric tonnes during 2013-14. The farmers in the district are under the misconception that higher returns could be realized 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 economic evaluation of pesticide use has been dealt by many researchers, micro level empirical studies in the study area are limited. Such studies provide insights into economics of pesticide use in pigeon pea. Results of the study would be useful to both policy makers and farmers of the study area in understanding the nature and economics of pesticide use.

In view of these issues, the present study is a modest attempt to analyze the economics of pesticide use in pigeon pea crop in Vijayapura district. The specific objectives of the study are:

1. To study the socio-economic conditions of pigeon pea growers in the study area;
2. To analyse the profitability of IPM and non-IPM practices in pigeon pea;

3. To study the frequency, extent and type of pesticides use in pigeon pea production; and

4. To compare actual use and recommended dose pesticide application and estimate its impact on pigeon pea yield.

Methodology

Vijayapura district was selected purposively as the area under pigeon pea is 1,83,550 ha. The pigeon pea production in district is 1,40,257 tonnes. Five taluks namely Vijayapura, Sindigi, Indi, Muddebihal and Basavana Bagevadi were purposively selected since the pigeon pea is grown across the district. Four villages from each taluk were selected based on predominance of pigeon pea area. A sample of 6 farmers were randomly selected out of which, three each are IPM and non-IPM from each of the villages. The required information on pigeon pea cultivation was gathered with the help of pre-tested and well-structured schedules through personal interview method. Thus, the total sample for the study was 120 farmers. The data were collected pertained to the crop year 2013-14. Secondary data on area, production, productivity, cropping pattern, rainfall, area under pigeon pea and other necessary data were collected from District Statistical Office (DSO), Vijayapura.

Tools of analysis

Budgeting technique was used to compute the cost, returns, and profits. Tabular presentation method was employed to work out sample means and percentages with respect to the general characteristics of sample farmers. The Cobb-Douglas production function was estimated to study the resources use efficiency and to analyze the influence of inputs on pigeon pea yield in Vijayapura district. Partial budgeting technique was used to compare the IPM and non-IPM pigeon pea farms in order to arrive at meaningful results.

Major findings

The majority of IPM farmers were belonged to nuclear family (51.67%), middle aged group (55%), medium sized (43.33%), illiterate (41%) and large farmers (46.67%), whereas majority of non-IPM farmers belonged to joint family (65%), middle aged (56.67%), large size farmers (40%), illiterate (35%) and large farmers

(56.67%).

Cropping pattern

The area under redgram was lower in case of IPM sample farmers (2.91 hectares) compared to non-IPM farmers (3.18 hectares) in *kharif.*

Input used and output realized

Human labours, bullock labour, seeds and PPC were used more in non-IPM farms, while machine labour and fertilizers were used more in IPM farms. Yield was more in case of IPM farms.

Cost and returns structure

The hectare cost of cultivation of pigeon pea in IPM farms was lowest (Rs.40,907) than that of non-IPM farms (Rs. 42,846). The per hectare returns of pigeon pea in IPM farms was comparatively higher (Rs. 50,225) than that of non-IPM farms (Rs. 48330). The additional cost on non-IPM was Rs. 2,115 per hectare and net additional benefits from IPM was Rs. 4,010. Returns per rupee of investment realized from IPM farms were higher (1.23) as compared to non-IPM farms (1.13).

Human labour (28%) constituted the lion share in the total cost of cultivation in both IPM and non-IPM farms. Plant protection components accounted for the highest share in the total cost of cultivation in case of non-IPM farms (29%) whereas, it was only (19%) in IPM farms. In case of IPM farms per hectare pigeon pea yield was marginally higher (9.97 quintal) as compared to non-IPM farms (9.55 quintal).

In pigeon pea IPM module components excluding synthetic PPC the summer ploughing accounted for the highest share (24%) in the total cost of cultivation in case of IPM farms.

Resource use efficiency

The production function estimates indicated that output elasticities of FYM, fertilizers, human labour and bullock labour have significant influence on the pigeon pea yield in case of IPM farms. Whereas in case of non-IPM farms, seed, fertilizers and PPC were found to be significant. Plant protection chemicals had negative influence (-0.10) in case of IPM farms while it was positive (2.95) in case of non-IPM farms.

The production function estimates indicated that output elasticities of human labour and bullock labour have significant influence on the pigeon pea yield in case of IPM farms, whereas in case of non-IPM farms, seed and PPC were found to be positively significant. In case of IPM farms, fertilizers and FYM were negatively significant.

The ratios of MVP to MFC were greater than one for seeds, FYM and PPC in case of non-IPM farms while it was more than one for human labour and bullock labour in case of IPM farms, indicating that there is a scope for using additional units of these inputs to increase gross returns.

Partial budgeting

Total debit on IPM model was found to be Rs. 2,997 and total credit from IPM model was observed to be Rs. 6,227 with a net gain of Rs. 3,230 per hectare.

Frequency, quantity, type and cost of pesticide

IPM famers used less contact insecticides than that of non-IPM farmers with a marginal differences in case of frequency (1.04 times), quantity (0.45 liter) and cost (Rs. 535).

Frequency distribution of pesticides use intensity was maximum (2.5 to 5 liters per hectare) with respondents of 45 members and 30 members in IPM and non-IPM farms, respectively

IPM farmers used more of systemic pesticide and non-IPM farmers used more contact insecticides in their actual consumption as compared to recommended dose. In both the farms, use of fungicides and herbicides were negligible.

Awareness of pesticide use about adequacy, registered product, labels and expiry date was more in case of IPM farmers than that of non-IPM farmers.

In overall, most of the farmers use power sprayers for spraying of chemicals. Majority of the farmers have washed their sprayer after its use. Most of the farmers dispose-off the washed water and pesticide empty containers in field itself.

Majority of the respondents applied plant protection chemicals across the wind direction, which is the wrong way of application. However, it was observed that usage of protective coverage's like hand gloves, shoes and face masks were neglected by the sample farmers. This increased the intensity of probability of exposure to health hazards and environmental pollution.

Majority of farmers mixed the chemical pesticides by pouring water for half-filled sprayer tank, followed by wooden stick and spray lancer. Most of the farmers (72%) have used pesticide bottle cap for mixing pesticides which is not accurate method. Few of them used measuring jar for measuring pesticides. Majority of farmers got information from pesticide dealers.

Policy implications

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

1. There has been a positive impact of IPM in pigeon pea in terms of enhancement of productivity (0.42 q/ha) and net returns (Rs. 4010/ha), reduction in the frequency and quantity of use of chemical pesticides and hence, on their cost (Rs. 1,336/ha), as well as eco-friendliness. Thus, there is a dire need for promotion of this IPM technology in all the pigeon pea growing areas of the study region through outreach activities by governmental and non-governmental organizations. Towards fostering the adoption of IPM technology in the study area, large scale demonstrations on IPM technology may be organized by the State Department of Agriculture.

2. The resource use efficiency analysis clearly indicated that the MVP to MFC ratio was negative for chemical fertilizers, plant protection chemicals, seeds and farm yard manure. Thus, judicious use of these resources would decrease their cost and hence, increase the net returns from the cultivation of pigeon pea. For this to happen, farmers need to be educated through training and awareness programmes of the State Agriculture Department by way of pre-sowing campaigns at taluk or block levels.

3. The usage of pesticides was on the higher side in case of both IPM and non-IPM farmers in the study area. This is not only uneconomical but also would lead to other ill effects of pesticide residues. In this context, government or farm universities may arrange workshops on IPM technology involving progressive/successful farmers in order to enable effective exchange of information. In addition, development of Farmers' Interest Group (FIG) or Farmers' Field School (FFS) would be effective for improving the knowledge related to IPM technology. Thus, the Department of Agriculture may provide necessary support in their plans for organizing FIGs or FFS on IPM in pigeon pea cultivation areas.

4. There is an urgent need to take the remedial measures to redesign the pesticide containers which are eco-friendly and which can be easily decomposed after their usage. This would help reduce their residual effect on the environment and thereby minimize the health hazards of the pesticide residues.

5. The extent of adoption of bioagents and botanicals, such as Trichoderma, Ha.NPV and NSKE, was found to be low in the study area. Since the use of these agents and botanicals has a positive impact on pigeon pea yield and ecosystem, there is a need to take up the extensive training programmes on the use of these inputs.

6. The extension unit and Department of Agriculture has to bring awareness among the farmers about no cost or low cost IPM components for the farmers who are not using synthetic chemicals for improvement of Pigeon Pea yield.

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Appendix I: Package of practices for Pigeon pea (per hectare)

Seed rate	**:** 10-12 kg (sole crop)
	6-8 kg (inter crop)
Biofertilizers	**:** Rhizobium 500 g
Farm yard manure	**:** 6 tonne
Chemical fertilizers	**:** Nitrogen- 25 kg
	Phosphorus-50 kg
	Sulphur- 20 kg
	Potassium-125 kg (only for red soil)
Yield	: 10-12 quintal per hectare

Recommended pesticides,

Wlit	–2 g captan 80 WP or thiram 75 WP or 2.5g carboxin, or 4 g trichoderma,
Cyst nematode	– Seed treatment with 50g neem seed powder
Leaf spot	– Seed treatment with 2g captan 80 WP or thiram 75 WP
Phytopthora leaf spot	– Seed treatment with 4g metalaxyl MZ 72 WP (per kg)
Sterility mosaic disease	– dicofol 18.5 EC @ 2.5 ml/l, oxydemeton methyl 50 EC @ 1.5 ml/l

Chilli-Garlic kerosene extract - @ 30ml per litre per hectare

Neem Seed Kernel Extract (NSKE) – 50 ml per litre per hectare

Source: Package of Practice, UAS, Dharwad (India).

Appendix II: Area, production and productivity of pigeon pea in Vijayapura district (1998-99 to 2013-14)

Year	Area (ha)	Production (Metric Tonnes)	Productivity (kg/ha)
1998-99	20286	2428	120
1999-00	14304	5191	363
2000-01	20462	11197	547
2001-02	30781	18013	585
2002-03	18001	6037	335
2003-04	21604	5418	251
2004-05	36948	7055	191
2005-06	38153	15404	404
2006-07	48162	20818	432
2007-08	78533	34394	438
2008-09	48686	19287	396
2009-10	104091	31050	298
2010-11	189677	107215	565
2011-12	189677	31050	164
2012-13	186199	107219	575
2013-14	183550	140257	746

Source: District Statistical Office, Vijayapura, 2014

Appendix III:

SCHEDULE FOR DATA COLLECTION

REASERCH PROBLEM: ECONOMICS OF PESTICIDE USE IN PIGEON PEA IN VIJAYAPURA DISTRICT, KARNATAKA.

I. GENERAL INFORMATION: DATE:

1. Name of the respondent: ___________ **Contact No.** 2. Village taluk: ____________

3. Age: ___________________ 4. Type of family: joint/nuclear

5. Social Participation: Member of Panchayat/ Sugar Factory/other

6. Education: i. primary ii. High-school iii. College IV. Illiterate V. Degree

7. Religion: Hindu/Muslim/Christian/others.

8. Caste: GM/OBC/SC/ST.

9. Occupation: main, subsidiary.

Family composition

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

I- Illiterate, P- Primary, M- Middle, H- High school, D-Degree

II. Farm inventory

A. Land holdings:

Sl. No.	Particulars	Irrigated		Dry land		Total area	Irrigation	
		Area (acres)	Land Value (Rs. /ac)	Area (acres)	Land Value (Rs. /ac)	(acres)	Source	No.
1	Area Owned							
2	Leased in							
3	Leased out							
4	Fallow land							

*1-River; 2- open well; 3- Canal; 4- Tube well; 5- Tank; 6- Others

B. Farm inventory

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

C. Livestock/ Animal inventory

Sl. No.	Items	No	Purchase price (Rs.)	Present Value (Rs.)	Income (Rs.)	Expenditure (Rs.)	Net income (Rs.)
1	Cows						
2	Buffaloes						
3	Bullocks						
4	Sheep/goat						
5	Poultry						
6	Others						

D. Source of Income

Sl. No.	Source	Annual Income
1	Agriculture	
2	Dairy	
3	Business	
4	Salary	
5	Wages	
6	Others	

E. 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							

III. Detail cost of cultivation of IPM and Non- IPM sample farmers

Crop: __________ Variety: __________ Area (ac) :____________

Season: _________ Soil type: ________ Source of irrigation: _______

Category of farmer: __________ Date of sowing: __________ IPM/Non-IPM

If yes, Cost incurred in adoption of IPM module by IPM farmers in pigeon pea

(Rs/ha)

Sl. No.	Particulars	Units	Cost
I	**Cultural components**		
A	Summer ploughing		
B	Use of resistant varieties (MTU-1001, Rashi)		
	Sub Total		
II	**Mechanical components**		
A	Removal of pest infested plant part		
B	Erection of Pheromone traps		
	Sub Total		

Sl. No.	Particulars	Units	Cost
III	**PPC Components**		
1	Bio agents and botanicals		
A	NSKE **(**Neem Seed Kernal Extract, 5%)		
B	Trichogramma cards		
C	Use of predator (Mirid bug /Wolf spider)		
	Sub Total		
2	**Synthetic chemicals**		
A	Chemical pesticides		
1			
2			
3			
	Sub Total		
	Total		

A. Labour use in different operations

Sl. No.	Name of the operation	No. of times	Family				Hired			
			M	W	BP	ML	M	W	BP	ML
1	Land preparation									
	a) Ploughing									
	b) Harrowing									
2	Transportation of FYM									
3	Spreading of FYM									
4	Harrowing									
5	Sowing									
6	Fertilizer application									
7	Hand weeding									

Sl. No.	Name of the operation	No. of times	Family				Hired			
			M	W	BP	ML	M	W	BP	ML
8	Inter cultivation									
9	Irrigation									
10	PPC application									
11	Herbicide application									
12	Watch and ward									
13	Harvesting									
14	Threshing& winnowing									
15	Drying, Packing									
16	Transportation									
17	Marketing									
	Total (A)									

Note: Wage rates per day: Men: _________ Women: _______ BP: _______ML:__________

B. Input used in production

Sl. No.	Inputs	Frequency (No/crop)	Quantity (qntl)	Rate (Rs/qntl)	Amounts (Rs.)
1	**Seeds**				
2	**Manure/ FYM**				
3	**Chemical Fertilizer**				
A					
B					
C					

Sl. No.	Inputs	Frequency (No/crop)	Quantity (qntl)	Rate (Rs/qntl)	Amounts (Rs.)
4	**Bio Fertilizer**				
A					
B					
C					
5	**Herbicides**				
A					
B					
C					
6	**PPC**				
A					
B					
C					
D					

C. Others

Sl. No.	Inputs	Amounts (Rs.)
A	Irrigation	
B	Electricity charges	
C	Land revenue	
D	Land rent	
E	Maintenance of machinery	
F	Interest on borrowed funds	

D. Gross returns

Sl. No.	Crop	Area (ha)	Production (qtls)	Price/qtls	Total costs (Rs.)	Total returns (Rs.)
1						
2						
3						
4						
5						
6						
7						

IV. General awareness:

1. Since how many years you are growing pigeon pea crop?
2. Since when you have been using pesticides?
3. What are the major Pests, Diseases and Weeds?

Major pests	Method use to control	Quantity used	Cost incurred
Major insects			
1			
2			
3			
4			
Major diseases			
1			
2			
3			
4			
Major weeds			
1			
2			
3			
4			

4. Do you think that quantity of pesticide used is adequate?
Yes/No

a. Do you purchase/bring the pesticides of registered company? Yes /No

b. whether the quality of pesticide is appreciable?

Adulterated/pure

If yes substantiate?

i. This much of pesticides are able to control pests.
ii. I will be getting higher retruns for this quantity of PPC
iii. Any other.

5. Do you know the recommended level of pesticide use in pigeon pea 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. Pests are getting resistance to pesticides.

If < RD, Reasons

i. due to lack of funds
ii. lack of technical knowledge
iii. lack of availability of PPC
iv. unaware/aware of effectiveness of pesticides
v. aware of the bad effects of pesticides
vi. less incidence of pest
vii. any other

6. Do you 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 of pesticide	Quantity (Litre/kg)	Value (Rs.)
1 2 3 4 5				

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

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

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

10. If yes what do they indicate?

Red

Yellow

Green

11. Pesticide application procedure (interview with person employed for Application)

Equipment used	Area covered/day	Safety measures	Direction of Application	Washing pesticide spraying equipment, after use
1. Knapsack sprayer		1. Use hand 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	
3 Duster		4. Take bath		
4 Soil application		5. Wash hands a. With mud b. Soap c. Other material		
5. Any other				

Disposal of washed Water	Disposal of Pesticide bottle/Bags	Activities during application	Time of application
1. Infield	1. In field	1. Drinking water or beverages	Morning (AM) ________hrs To__________ hrs (PM)
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 you like to follow them? Why?

13. Information sources of farmers regarding pesticide application

    a) Neighbouring farmers b) Agriculture extension persons c) Television d) Radio e) News paper f) Input dealer g) Experience h) Others (ADA/AO/Scientist/relatives)

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?

17. How many days after you leaving animals for grazing along the bunds?

18. Do you find any bad effect on animals/birds due to pesticide use?

19. Constraints faced in using IPM.

    a.
    b.
    c.

20. Suggestions to oer come these problems

Appendix IV: Correlation Test carried out for multicollinearity

Non-IPM

	seed	FYM	fertilizers	human labur	bullock labour	ppc
Seed	1					
FYM	0.779846	1				
fertilizers	0.874825	0.879278	1			
human labor	0.897798	0.787124	0.887527	1		
bullock labour	0.689706	0.504588	0.705522	0.68939708	1	
Ppc	0.888746	0.822166	0.906975	0.954943196	0.738436552	1

IPM

	seed	FYM	fertilizers	human	bullock	ppc
seed	1					
FYM	0.000222	1				
fertilizers	0.010087	0.01523	1			
human	0.038404	0.835966	-0.0178	1		
bullock	0.139094	0.504244	0.029369	0.684275	1	
ppc	0.033708	0.772288	0.033044	0.94981	0.779806	1

ECONOMICS OF PESTICIDE USE IN PIGEON PEA IN VIJAYAPURA DISTRICT, KARNATAKA

AMBANA GOUDA DURGAD

2015

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Major Advisor

ABSTRACT

The present study was conducted to analyze the economics of pesticide use in pigeon pea crop in Vijayapura district during 2013-14. Multistage sampling procedure was employed for selection of district, taluks (5), villages (20) and sample farmers (120) which composed of 60 IPM and remaining 60 non-IPM farmers. For conducting this study, Vijayapura district was purposively selected based on highest area under pigeon pea in UAS Dharwad jurisdiction. Budgeting technique was used to estimate the total cost and returns. Cobb-Douglas production function was employed to analyse the resource use efficiency. The majority of farmers belonged to large farmers (46.67%) and (56.67%) and area under pigeon pea (2.91 hectares) and (3.18 hectares) in IPM and non-IPM farmers, respectively.

The pesticide share in total cost was highest in case of non-IPM farmers (29%) and it was only (19%) in IPM farmers. B:C ratio was higher in IPM farms (1.23) as compared to non-IPM farms (1.12). IPM famers used less contact insecticides than non-IPM farmers with a marginal differences in case of frequency (1.04 times), quantity (0.45 litre) and cost (Rs. 535). Frequency distribution of pesticides use intensity was maximum (2.5 to 5 liters per hectare) with 45 and 30 sample farmers observed in IPM and non-IPM farms, respectively. IPM farmers used more of systemic pesticide while, non-IPM farmers used more of contact insecticides. Most of the farmers used power sprayers for spraying of chemicals and dispose-off the washed water and pesticide empty containers in field itself. The MVP to MFC ratio was negative for chemical fertilizers, plant protection chemicals and seeds, judicious use of these resources would decrease production cost. The farmers should be educated to identify the threshold level of pest infestation and to take measures only after that instead of blindly following the neighbouring farmers while spraying pesticides.