# PESTICIDE EXTERNALITIES IN COTTON AN ECONOMIC ANALYSIS

By

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THESIS SUBMITTED TO THE

ACHARYA N G RANGA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
MASTER OF SCIENCE IN AGRICULTURE



DEPARTMENT OF AGRICULTURAL ECONOMICS
AGRICULTURAL COLLEGE
BAPATLA - 522 101

August 1999

# CERTIFICATE

Sri **SUNEEL KUMAR Y V V** has satisfactorily prosecuted the Course of research and that the thesis entitled **"PESTICIDE EXTERNALITIES IN COTTON : AN ECONOMIC ANALYSIS"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university.

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# *Certificate*

This is to certify that the thesis entitled **"PESTICIDE EXTERNALITIES IN COTTON :-AN ECONOMIC ANALYSIS"** submitted in partial fulfilment of the requirements for the degree of Master of Science in Agriculture of the Acharya N.G. Ranga Agricultural University, Hyderabad, is a record of the bonafide research work carried out by Mr. **Y.V.V. SUNEEL KUMAR** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigation have been duly acknowledged by the author of the thesis.

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## *ACKNOWLEDGEMENTS*

*At the outset, I take this opportunity to express my great tribute to all those soldiers who lost their lives for a noble cause at the Kargil Sector.*

*I take it as a privilege to express my deep sense of greatitude and respectable regards to* ***Sri N A Choudary****, Assistant Professor, Department of Agricultural Economics, Agricultural College, Bapatla and Chairman of the advisory committee for his insightful and inspiring guidance, whole hearted co-operation and constant encouragement to embellish this investigation.*

*Diction is not enough to thank* ***Dr Y Eswara Prasad****, member of my advisory committee, Professor & Head, Department of Agricultural Economics, Agricultural College, Bapatla for his meticulous guidance, pragmatic suggessions and unintended cooperatuion during the course of investigation. I owe a lot to him for his sustained interest and timeless help in completing the research work.*

*I am grateful to the other members of my advisory committee* ***Dr A Pandu Ranga Rao****, Assoc. Professor, Department of Agricultural Economics, Agricultural College, Bapatla and* ***Sri R Srinivasulu****, Assistant Professor, Dept. of Statistics & Mathematics for their timely help and suggessions during my course of research work.*

*I am extermely thankful to* ***Sri G Sunil Kumar Babu*** *and* ***Sri C V Hanumanthaiah****, Asst.Professors, Department of Agricultural Economics, Agricultural College, Bapatla for their constructive suggestions and immense help through out the period of study.*

*It is the time to surface out my genufelt love and affectionate gratitude to my parents* ***Smt. Rama Krishnaveni*** *and Late* ***Bangara Raju****, sisters* ***Prabha*** *and* ***Geeta*** *and broters in law* ***Ramesh*** *and* ***Ramakrishna***

*who constantly inspired and moulded me into the present position and whose encouragement brings out my best in every one of my endoeavours.*

*I extend my special thanks to my classmates* ***Rama Rao*** *and* ***Naveen*** *and Jouniors* ***R P, Srihari, Apsar*** *and* ***Aparna*** *for their immense cooperation and assistance during my research work.*

*The affectionate assistance, inspiration, encouragement and co-operation extended by my roommate* ***Saleem*** *and frientds* ***Thrinath, Ravi, Ramu, Pandu, Raju[2], Koti, Sobhan, Gangu, Srinu[3], Puli, Shyam, Satya, Roy, Narsing, Dama, Badal, Sushant, Panda, TSR, DPR*** *and* ***KVGK*** *is indescribable.*

*My special thanks are due to my friends* ***Shymala, Prasanthi, Srivani, Rama, Olive, Seshikala, Sudha, Neelaveni*** *for their immense cooperation and assistance during my research work.*

*The financial help rendered by the* ***Acharya N G Ranga Agricultural University*** *in the form of stipend is greatefully acknowledged.*

*I am thank full to* ***Md Ali Akber Basha*** *for taking all pains to bring out the manuscript in an neat and appreciable manner.*

Y.V.V. Sunil Kumar

***Date :*** ***(SUNEEL KUMAR Y V V)***

## *DECLARATION*

I, Mr. **Y.V.V. Suneel Kumar** hereby declare that the thesis entitled **"Pesticide Externalities in Cotton : An economic analysis"** submitted to the Acharya N.G. Ranga Agricultural University for the degree of Master of Science in Agriculture in the major field of Agricultural Economics is the result of original research work done by me. I also declare that any material contained in the thesis has not been published earlier.

Y.V.V. Suneel Kumar

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# ABSTRACT


| | |
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| Degree to which it is submitted | Master of Science in Agriculture |
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| Year of submission | August 1999 |



Pesticides emerged as an important agricultural input as a result of green revolution followed by development of hitech technology. Pesticides plays a key role in increasing the agricultural production by controlling the pests and diseases. Even though the pesticides claimed to have contributing to food security by way of reducing crop production losses and post harvest losses, there is a growing concern about the ill effects of pesticides on human helath, natural resources and sustainability of agricultural production, which are the external effect of pesticide use. In this context an attempt is made to look into the negative effects of pesticide use with the following objectives.

1. To estimate the pesticide use efficiency and pesticide expenditure elasticity

2. To analyse the negative externalities of pesticide use - resistance externality and health hazards.

3. To study the opinion of the farmers about the negative externalities of pesticide use.

Guntur district was purposively selected as it stood first in area, production of cotton and also in pesticide consumption in Andhra Pradesh. Four mandals namely Gurajala, Veldurthi, Amaravathi and Sattenapalle were purposively selected based on area under cotton crop. Again one village from each mandal namely Gurajala, Sirigiripadu, Amaravathi and Dhulipalla were selected. A sample of 60 farmers in four villages were randomly selected based on proportionate random sampling techique and the data was collected by interviewing the sample farmers personally by using pre tested and well structured schedules. Statistical tools like tabular analysis, Cobb-Douglas production function, multiple linear regression analysis and the chi-square were used in order to fulfil the stated objectives in the present study.

The results revealed that the pesticides occupied the major portion (45.4%) in the cost of cultivation of cotton and the synthetic pyrethroids alone accounted to 41% of total expenditure on pesticides. Cobb-Douglas production function was fitted to estimate the pesticide use efficiency and its MVP/OC ratio was found to be 0.50 indicating excessive and indiscriminate use of pesticides.

Multiple linear regression was fitted to analyse the factors influencing expenditure on pesticides to which the area under cotton and pest intensity were found to be contributing positively while manures negatively to expenditure on PPC's.

Regarding resistance externality, multiple linear regression function was employed to identify the factors influencing the resistance externality cost and found that the positive influence of fertilizers and pest intensity and negative impact of manures on resistance externality cost.

Chi-square test was applied to study the awareness of the farmers regarding the negative externalities with a null hypothesis that all the farmers were aware of negative externalities. The $\chi^2$ was found to be significant at 1% level indicating that farmers were not aware of negative externalities of pesticide use in the study region inspite of so much awareness created by kisan melas and rythusadasu, AMC meetings etc.

## LIST OF SYMBOLS AND ABBREVIATIONS

| | |
|---|---|
| % | Per cent |
| Σ | Summation of |
| / | per |
| $\chi^2$ | Chi-square |
| AMC | Agricultural Marketing Committee |
| ANGRAU | Acharya N G Ranga Agricultural University |
| *et al* | and others |
| FYM | Farm Yard Manure |
| ha | Hectare |
| PPC's | Plant Protection Chemicals |
| Rs. | Indian Currency called Rupee |
| Viz | Namely |
| ZAREAC | Zonal Research Extension Advisory Committee |

# *Introduction*

# CHAPTER I

## INTRODUCTION

Green revolution after the independence have led to the change in farm methodologies to feed the ever growing population of mother India. As a result the pesticides emerged as a potential agricultural input which can be highly toxic in nature and, therefore has the potential for causing direct and substantial harm to human beings as well as the animals and plants that exist in the ecosystem.

However, out of all agricultural inputs, pesticides play the key role in increasing the agricultural production by controlling the pests and diseases. It was found that about one third of realisable global ouput is estimated to be lost annually due to insect pest, deseases and weeds. In India, crop loss due to insect pests was estimated worth Rs.6000 crores in 1983 (Atwal, 1986) which is reported to have further increased to Rs.29000 crores in early 1990's (Dhaliwal and Arora 1996).

India is the largest producer and consumer of pesticides in South Asia, and the pesticide use has been on the rise for the last three decades. Andhra Pradesh is the largest user of pesticides in the country followed by Gujarat, Maharashtra, Punjab and Tamilnadu. The pesticides use in these five states alone accounted to more than 90 per cent of the pesticides used in India (Vasant Gandhi and Patel 1997). Among all the states the pesticide use per unit area is the highest in Andhra Pradesh which alone accounts for 18% of the total pesticide use in the country (Chand and Birthal 1997).

Though pesticide use is claimed to have contributed to food security by way of reducing crop production and post harvest losses, there is a growing concern about the ill effect of pesticides on human health, natural resources and sustainability of agricultural production, which are the external effects of pesticide use. In a classic writing "*Silent Spring*", Carson (1962) warned that pesticides were being used carelessly and without sophistication which was creating hazards for non-target organisms and resulting in the technological failure of resistence, resurgence and secondary pests. Besides, indiscriminate use of pesticides reduces bio deversity and aggravates the problems of soil, water and air pollution. Modern agriculture which, by and large, is based on the use of chemicals may be a victim of its own creation if poisonous substances like pesticides continue to be used indiscriminately and without due consideration of their impact on agro ecology.

The pesticide pollution in the different parts of the country has been well documentated and even the pesticide residues in the food chain - in vegetables, eggs, fish, meat, milk and milk products, edible oils and in human breast milk have been detected in different places in the country. The most productive agricultural and aquaculture regions in the country have been showing severe pesticide pollution. Kuttand, the rice bowl of Kerala is facing serious fish diseases, which had been caused by pesticide poisoning. The fate of Chilka lake in Orissa and Kolleru region of Andhra Pradesh are no different. The pesticide residues in the water - spread of these regions have serious environmental consequences. The wild life, especially the birds and aquatic animals have been severely affected by the high doses of chemicals. The fish

are decreasing in this region because of environmental degradation, according to experts (Venkataramani 1992).

Regarding instances of pesticide poisoning, it has been estimated that there are about 7,50,000 instances of pesticide poisoning per annum in the world with about 13,800 deaths. More than half of these poisoning cases and three fourth of documented deaths takes in third world eventhough they consume only 15 per cent of total world pesticide output (Dhaliwal and Pathak 1993).

Moreover, the indiscriminate use of pesticides in agriculture have led to the emergence of more virulant pests that have developed a built - in resistance to some of the frequently used chemicals. Pests and diseases such as gall midge, brown plant hopper, bacterial blight and tungro virus of paddy, which were of minor importance before the green revolution, suddenly assumed the status of major disease : for instance *spodoptera litura* on cotton, maize and tobacco; *Pyrella* on wheat, maize, sorghum; apple scab and codling moth on apple and Karnal bunt on wheat (Mehrotra 1991).

## 1.1 Problem Statement

Cotton is one of the important commercial crops grown in the Guntur district of Andhra Pradesh. Guntur district occupied first position in the area of cotton crop (1,92,424 hactares) in the state and pesticide consumption was also found to be the highest. The farmers in this region were with misconception of realising higher returns through higher doses of chemicals, and there is a practice of monocropping of cotton by the farmers

since the cotton perceived as white gold by the farmers, not only escalated the cost of cultivation of their crops but also resulted in the pest resistance, pest resurgence and secondary pest out breaks, virtually through them into the ditch of problems. Earlier, no study has been conducted to analyse the ill effect of the pesticides use and the possible health problems being faced by the farmers in the district. In this context an attempt is made to look into the negative effects of pesticide use i.e., externalities with the following objectives.

1. To estimate the pesticide use efficiency and pesticide expenditure elasticity

2. To analyse the negative externalities of pesticide use - resistance externality and health hazards.

3. To study the opinion of the farmers about the negative externalities of pesticide use.

## 1.4 Limitations of the Study

The study pertains to the agricultural year 1997-1998 and is limited to 60 randomly selected farmers due to paucity of time and other resources. Hence various conclusions drawn and the explanation of various aspects of the problem have been based on the behavior of the sampled farmers and the availability of data during the reference period. The farmer respondents were not in habit of maintaining records of their income and expenditure. The entire information was provided by recollecting the past events leading to recall bias.

## 1.5 Plan of the Thesis

This dissertation consists of six chapters.

Chapter I - Introduction, objectives, scope and limitations

Chapter II - Review of past work done pertaining to the present study

Chapter III - Materials and methods used for the study

Chapter IV - Agro-economic features of the study

Chapter V - A critical analysis of the results and discussion

Chapter IV - Summary

# *Review of Literature*

# CHAPTER - II

## REVIEW OF LITERATURE

A very limited number of studies are available on externalities arising due to pesticide use. The major difficulty in the studies of externalities is the inadequacy of relevant data and paucity of standard methodologies to estimate them. The available literature with regard to externalities and other objectives of the study are revewed under the following heads.

**2.1 Economics of Pesticide Use**

**2.2 Externalities of Pesticide use**

**2.3 Health hazards (or) Effect of Pesticides**

### 2.1 Economics of Pesticides Use

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

Ghodake, Sirohi and Jha (1973) conducted a simple economic analysis of pesticide use in cotton in Haryana at Regional Research Station of

IARI. It was found that pesticides were highly productive inputs and their recommendations based on the maximisation of physical product were improper. It was also found that the optimum quantities are much lower, however they have not considered the uncertainty and externalities in the use of pesticides.

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

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

Prabhu (1985) examined the relevance of the notion of "optimal " pesticide use derived with in the production function frame work for the analysis of pesticide use behaviour of cotton cultivators in Coimbatore district of Tamilnadu. It was argued that production function frame work based on the assumptions of perfect certainty and complete suitability of inputs, were not suitable for yield saving inputs like pesticides, the use of which is influenced by uncertainty regarding yield and technical complementality with yield

increasing inputs. The argument was substained by the conclusions derived from empirical production function.

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

Eswaraprasad *et al* (1988) estimated resource use efficiency of various resources in cotton farms in Guntur district of Andhra Pradesh. They used Cobb-Douglass production function for estimating resource use efficiency and found that the marginal value product for pesticides and fertilizers were significantly lower than the opportunity cost. They concluded that the excessive use of these two inputs in cotton farms resulted in the lowering of marginal value products.

Pandurangadu (1988) made an attempt to determine the pesticide use efficiency in major commercial crops in the Guntur district of Andhra Pradesh. He found that the elasticities of pesticides were negative on large and medium farms while it was positive on small farms of cotton. It was concluded that the MVP/OC ratio for pesticides was found to be less than

unity and significant on pooled farms of cotton, clearly indicating the excessive and indiscriminate use of pesticides in cotton farming.

Nagraj, Khan and Karnool (1988) made an attempt to estimate the resource use efficiency of different crops in different cropping systems in the Tungabhadra command area in Karnataka. It was found that the ratio of MVP to factor costs for plant protection chemicals was found to be 6.2148 in paddy followed by land (2.4504) and human labour (2.7763). It was suggested that there was a scope to increase the gross returns from paddy in the command area by using more of these resources keeping other variables at their respective geometric mean levels of use.

Nagraj, Khan and Vijaykumar (1994) estimated the resource use efficiency in cotton in Tungabhadra Command area in Karnataka. The command area is divided into head, middle and tail reach and it was found that the regression coefficient for plant protection chemicals in head reach (0.3110) and in tail reach (0.5990) are significant. The ratio of MVP/FC was also found to be more i.e. 4.5534 in head reach and 7.2622 in tail reach. It was concluded that the farmers in the head reach of the canal should reduce the use of human labour and machine labour and the farmers in middle reach should increase the use of inputs like seeds, manures and fertilizers, plant protection chemicals and bullock labour for realising higher net returns.

Shanmugam (1994) estimated the technical use efficiency in rice cultivation in Ramanathpuram district of Tamilnadu. The allocative efficiency was found to be 0.75 indicating that the output can be increased by 25% by

optimum allocation of all inputs. The allocative inefficiency measures were found to be 0.16 and 0.11 for plant protection and labour respectively. It was concluded that the farmers in that region were adopting the principle of economic threshold level in applying pesticides.

Rajasekharan and Krishnamoorthy (1998) estimated technical efficiency of pesticides in rice production in Kole lands of Kerala. It was found that farm specific technical efficiencies ranged from 0.49 to 0.92 with a mean of 0.79. They concluded that absence of proper scientific knowledge emerged as one of the determinant of technical efficiencies and over use of pesticides.

## 2.2 Externalities of Pesticide Use

Langham and Edward (1969) tried to identify and estimate externalities in pesticide use. They indicated that externalities can not be studied meaningfully, independently of the system which generated them. They defined three participants : Consumers, producers and others. The measures choosen to determine the effect of various policies on the participants were consumer surplus, producer surplus and dollar measure of external effects on the group termed as others. Their objective in measuring externalities was to obtain structural estimates of the function.

$$C(t) = h \{Z_1(t), Z_2(t)\}$$

Where C(t) was a net dollar measure of externalities in period "t" and $Z_1(t)$ and $Z_2(t)$ were organic phosphates and chlorinated hydrocarbons respectively both in Pounds of 100 per cent active ingredient.

Richardson and Badger (1974) presented a methodology for analysing external as well as internal effects of using pesticides in agriculture. They used an environmental impact matrix for the analysis of pesticides use in cotton on Oklahoma farmers. The major parameters considered in the impact matrix were economic environmental quality and social well being. Each major parameter was subdivided into component parts relevant to pesticide use in cotton in the study area and an inter disciplinary research group developed appropriate weighing factors for the variables under each parameter.

Park (1986) examined the problems of measuring the externalities of pesticide usage in agriculture. The negative externalities considered were the effect on human health, on fish and wild life and environment in general. The study highlighted the difficulties in evaluating economically the environmentally, social and economic costs and argued that interdisciplinary research teams were required to asses conditions and to identify policy alternatives.

Wynes and Edwards (1990) reported that private net returns were similar for both conventional and chemical free farming. The study indicated that favourable change in net externality would be expected from a movement towards chemical free farming. Major positive externalities of chemical free farming were improved soil quality, reduced soil erosion, improved water quality, improved human health, reduced susceptability to harsh seasons, reduced risk of pest adaptation to farm management techniques, increased personal satisfaction and so on.

Bowles and Webster (1995) opined that the benefit of pesticides may be estimated in terms of avoided crop losses from pests, diseases and weeds. They argued that the farm level costs includes not only cost of pesticides and their application but also social costs due to externality ie., those effect outside the market mechanisms. It was concluded that the effects of pesticides on the environment and human health should be taken into account in assessing their optimum levels of usage by society. It was also suggested that altenative approaches may be required which estimate these effects in non economic terms and which compared them to the economic benefits of pesticides.

Aruna Kumara (1995) made an attempt to estimate the externalities due to pesticide use in cabbage in Karnataka. The major externalities found were resistance externality and health hazards. It was observed that the fertilizers and pest intensity were contributing positively to the resistance externality. Further it was noticed that 76 per cent of the sample farmers experienced the health problems due to the constant use of pesticides.

James (1995) conducted a simple cost/benefit analysis of granular carbofuran use on rapeseed in Canada. The economic benefit of insect control (crop gain) was compared to economic cost song bird (insect control) and it was found that the value of the break even kill rate (1.8 birds/ha), where the economic cost and benefit were equal, was very close to the medium kill rate (1.5). Finally it was concluded that the economic benefit of granular carbofuran use in rape seed was significantly over estimated.

Steiner *et al* (1995) opined that valuing the costs of externalities of agricultural production was still in the infancy and much of the basic

knowledge and research methodology was needed to understand the effects of externalities in US Agriculture. They further argued that even when the effects of externalities were reasonably well understood, calculating their costs to society remains a different task. They finally concluded that some of the costs can in principle be quantified, but many other involve non market goods and depend on highly controversial judgement such as the monetary value of human life and the externality cost can be calculated on location specific basis, but it was currently not possible because of lack of information.

Uri (1997) argued that the pesticides developed and used in future will emerge against the backdrop of the externalities associated with the use of pesticides and government policies designed to control these externalities. In the final analysis, it was concluded that, farmers choice on pesticides will be influenced by the prevailing costs and benefits of pesticides and their externalities and three areas were identified that serve potentially to impact pesticides use which inturn will affect the development of new pesticides. They were pesticide regulation, the management of ecologically based systems and consumer demand for environmentally friendly products.

Vasant Gandhi and Patel (1997) found that farmers perception of significant impact of pesticides on environment seems to exit but was limited to his immediate surroundings of labour, other human beings and animals. It does not go beyond this to the effects on water, air and residues in the produce. Farmer awarness about these effect as well as when and how to use pesticides was very limited. Further it was also found that pesticide use levels were determined significantly by the extent of irrigation. The levels were also related

to location, being higher in Andhra Pradesh (Guntur) and Punjab (Ferozpur) as compared to Gujarat (Ahmedabad). It was also found that the intensity of use was higher on small farmers. Education of the farmers seems to reduce the expenditure on pesticides. However, it was found that young farmers appear to spend more on pesticides.

## 2.3 Health Hazards (or) Effects of Pesticide Use

Howitt and Moore (1975) conducted a survey of 1416 California farm workers indicated significant under reporting of pesticide injure in official information sources. Institutions for internalization of externalities were operating inefficienctly due to an imprecise data problem. Seventy per cent of farm workers had never heard of workmans insurance and 20 per cent could not understand pesticide warning labels.

Yown, Gilstrap and Teetes (1990) made an attempt to examine the awareness of pesticide hazards, the need for additional pesticide regulations at national and international levels, the need to regulate sales and importation, exportation of pesticides, and the potential dangers of changing diversified, traditional agricultural practices to pesticide development. It was concluded that pesticides were serious potential health hazards because of illegal marketing of pesticides, low literacy rates and poor user understanding of pesticides dangers.

Godon, Lajoie and Touez (1991) conducted a study in 34 drainage basins in Queber to analyse the relationship between mortality data for cancers of the brain and lymphatic tissue and leukemia, and the spatial distribution of

agricultural pesticide use. The basins were grouped in three categories (low, intermediate and high) according to levels of exposure to pesticides. It was found that there was a relatively high risk in basins which were highly exposed to pesticides compared to those with low exposure. It was concluded that there was potential relationship between the use of pesticides in agriculture and cancer of the lymphatic tissue.

Gupta (1992) made an attempt to examine the various hazards due to pesticide usage and the precautions to be taken while dealing with the pesticides. It was found that the number of poisoning cases were highest in Maharashtra (16,992) and in Andhra Pradesh it was 745. It was concluded that the prevention of pesticide hazarads was the most important factor for which mass education of workers and cultivators was urgently needed to make them aware of the potential hazards of pesticides.

Harper and Zilberman (1992) opined that key problem in pesticide regulation was uncertainty about health risks. They examined the trade offs between economic benefits and worker health safety using an empirical illustration. Alternative decision rules for regulation under certainty like a) a safety fixed rules, which protects individuals from excessive health risks and b) uncertainty adjusted cost benefit analysis, which evaluates aggregate trade offs between health and economic welfare were considered. They concluded that these criteria may lead to opposite policy conclusions, suggesting that the most appropriate public policy was a safe minimum standard which allows weighing of costs and benefits only after some minimum acceptable level of health safety has been assured.

Beach and Carlson (1993) opined that farmers may value water quality and user safety characteristics of herbicides as they select among producers to obtain weed control. Expenditures per application in US corn and soybean herbicide markets were explained by several safety characteristics in the farm decision model indicates that not all safety aspects of pesticies use were external to farmers. It was concluded that leaching potential and user toxicity were significant, but their elasticities were small relative to broad leaf and grass weed control efficiency.

Litchenberg *et al* (1993) opined that the government agencies frequently tried to protect the public from industrial hazards by separating the two, in time and space. They developed a methodology of one such policy, re-entry regulation of pesticides. Re-entry regulation was shown to provide a national incentive for preventive application of pesticides, a practice usually attributed to risk aversion (or) inadequate information. The trade offs between farm worker poisoning and lost growers revenue were shown to be substantial. It was concluded that weather dependent, location specific re-entry regulation appears superior to the uniform regulation now in effect.

Antle and Prabhu (1994) integrated production data from a farm level survey with health data collected from the same population of farmers to measure the impacts of farmer health on productivity in two rice producing regions of Phillippines. The relationships were then used in simulation analysis to integrate the health and productivity trade offs implied by a policy to restrict pesticide use. Results showed that pesticides use has a negative effect on productivity and that there were likely to be social gains from a reduction of

insecticide use in Phillippines Rice production. They concluded with a decision of the implications of the findings for pesticide policy in developing countries and for allocation of resources in agricultural research.

# *Materials and Methods*

# CHAPTER III

# MATERIALS AND METHODS

The present study was conducted in the Guntur district of Andhra Pradesh. The detailed sampling procedure for selection of mandals, villages and farmers, concepts and terms used, various analytical tools both statistical and functional models employed are discussed in detail in this chapter. This chapter is divided into the following heads.

1. Sampling procedure

2. Conceptual framework

3. Empirical frame work.

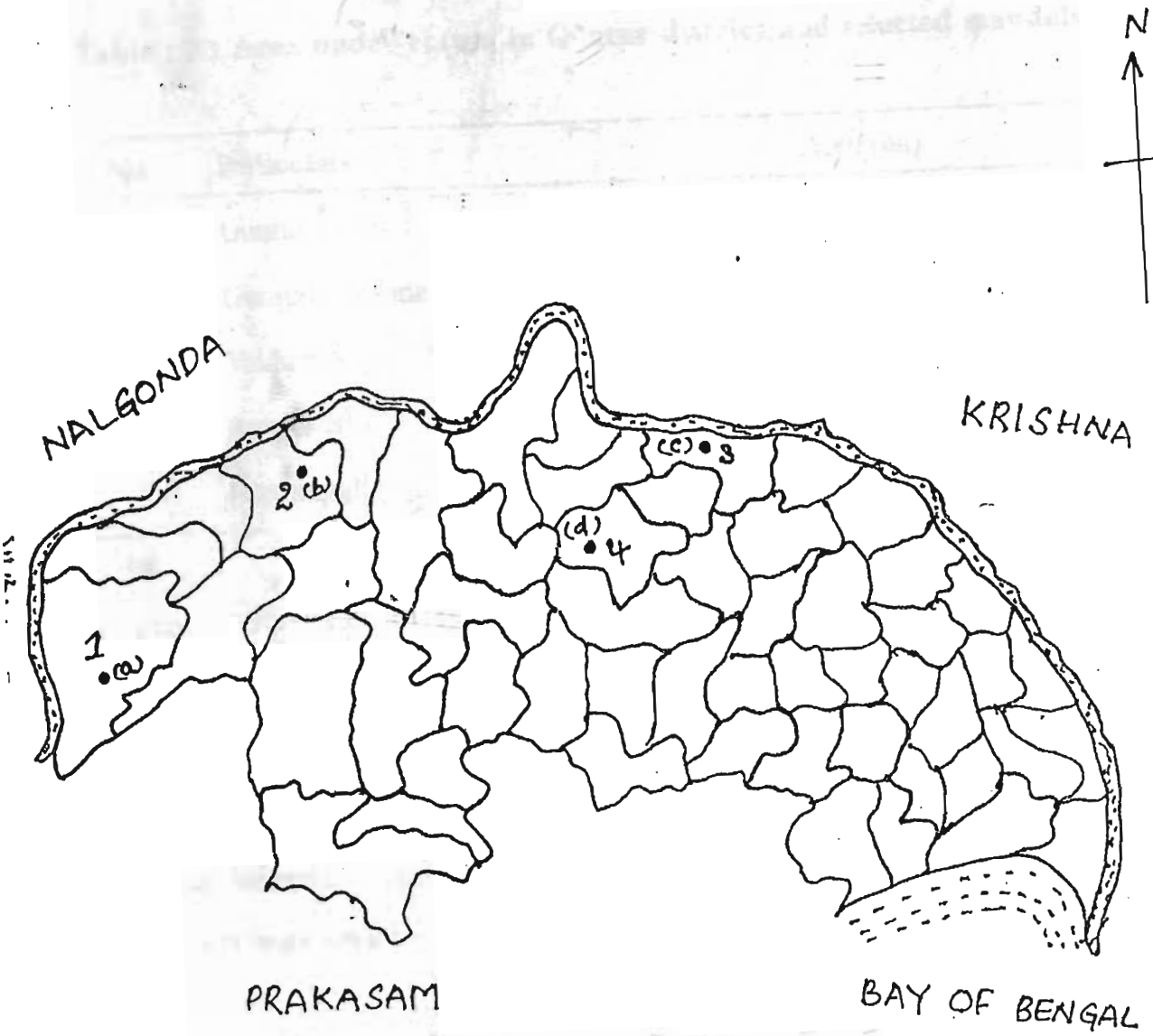
## 1.1 Sampling Procedure

### 1.1.1 Selection of the District

Guntur district was purposively selected for the study as the area (1,92,424 hactares), and the pesticide consumption (53,24,320 lit) was also very high in the district during 1994-1995.

### 1.1.2 Selection of Mandals

Four mandals namely Gurajala, Veldurthi, Amaravathi and Sattenapalle were purposively selected as they occupy the first four positions in area under cotton crop respectively in the district (Table 3.1).




Selected Mandals :-

1. Veldurthi.
2. Gurajala.
3. Amaravathi.
4. Sattenapalle.

Selected Villages :-

a) Singiripadu
b) Gurajala
c) Amaravathi
d) Dhulipalla.

Fig: 1 Guntur District map showing selected mandals and villages.

**Table : 3.1 Area under cotton in Guntur district and selected mandals**

| S.No. | Particulars | Area (ha) |
|---|---|---|
| 1. | Guntur District | 1,87,212 |
| 2. | Gurajala Mandal | 10,327 |
| 3. | Veldurthi | 10,251 |
| 4. | Amaravathi | 7,194 |
| 5. | Sattenapalle | 7,174 |

Source : CPO'S Office, Guntur

### 1.1.3 Selection of the Villages

One villiage from each mandal namely Gurajala, Sirigiripadu, Amaravathi and Dhulipalla were selected at random from four mandals of Gurajala, Veldurthi, Amaravathi and Sattenapalle respectively and a sample of 60 farmers were selected by using proportionate random sampling technique (Table 3.2).

**Table : 3.2 List of selected villages along with number of respondents.**

| S.No. | Particulars | No. of Farmers | % to Total |
|---|---|---|---|
| 1. | Gurajala | 17 | 28 |
| 2. | Sirigiripadu | 15 | 25 |
| 3. | Amaravathi | 18 | 30 |
| 4. | Dhulipalla | 10 | 17 |
| | Total | 60 | 100 |

## 1.2 Collection of Data

Data pertaining to cotton crop were collected through survey method by personally interviewing the sample farmers, through pretested and well Structured schedules. The secondary data related to Agro-Economic aspects of the study area were collected from CPO's Office, and Mandal Offices of Guntur.

## 2. Conceptual Frame Work

Externality has been defined in several ways by economists. According to Hardwick, Khan and Langmead 1996* defined as " Externalities are those gains and losses which are sustained by others as a result of actions initiated by producers (or) consumers or both and for which no compensation is paid.

Externalities may be positive or negative and when there is a negative externality, there exists a divergence between the private and social costs and the marginal social costs includes both marginal private cost and marginal externlity cost.

Presence of externality cost results in two optimalities, one for the society and another for the private. The social optimum being always less than the private optimum.

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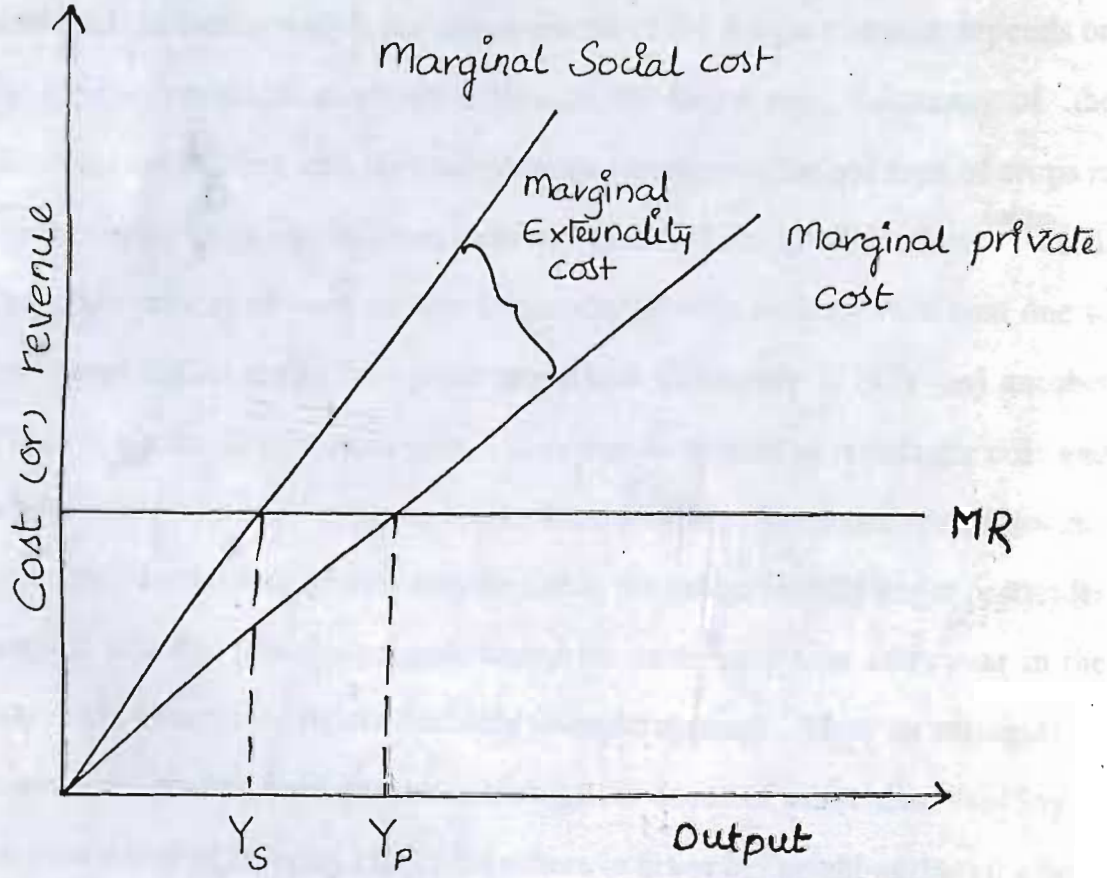
Hardwick P Khan B and Langmead J 1996 An introduction to motern economics. Fourth edition published under ELBS with Longman by British Government pp : 208-229




$Y_S$ = Social optimum $Y_P$ = Private optimum

Fig 2: Effect of externality cost on the optimum production

### 2.1.1 Resistance Externality

The constant use of pesticides would result in the development of resistant strains of the pests eradicating the susceptable ones (Metcalf, 1975). However the rate at which the development of the resistant strains depends on the type of chemical used, its action on the target pest, frequency of the chemical use, nature and number of crops raised per year and type of crops in neighbouring farm, use of plant nutrients and the farm in which they were used. The management of such strains is associated with higher PPC's cost due to the use of higher doses of plant protection chemicals (PPC's (or) another effective chemical of higher cost. This can be termed as resistance cost and can be studied under the frame work of externality. The basic reason for the evolution of resistance strains may be due to the indiscriminate use of pesticides coupled with the practice of cultivating the same crop year after year in the same field because of its profitability (monocropping). Thus in anticipation to get more profits, each farmer is using over doses of pesticides resulting in the production of external effects on others in his or her neighbourhood, which may be dealt as the resistance externality.

## 3. Empirical Frame Work

### 3.1 Definition of the Variables

The definition of the variables and the analytical tools employed in the present study are given below.

**Expenditure on Human Labour**

The labour input is measured in terms of man days and woman days and the expenditure on human labour is computed by taking the current wage rates prevailing in the village.

**Seed Cost**

It is the expenditure incurred by the farmer on the cotton seeds.

**Expenditure on Farm Yard Manure (FYM)**

The quantity of FYM used in the cotton cultivation is measured in terms of cart loads and truck loads. The costs are computed by taking the actual market price prevailing in the village.

**Expenditure on the Fertilizers**

The expenditure on the fertilizers in cotton cultivation is computed by taking the prices paid by the farmers.

**Expenditure on PPC's**

It is the value of the PPC's used, which is computed at the prices paid by the farmers.

**Expenditure on Traction Power**

It includes both bullock power and Tractor power, that is utilized in the cotton cultivation. Their costs are computed by taking the prevailing market prices in the village situation.

**Total cost of cultivation**

The total cost includes the cost of human labour, bullock labour, traction power, manures, fertilizers, PPC's and seeds. However, the over head costs are not considered in the study.

**Gross Income**

The gross income is calculated at post harvest prices that are realised by the cotton farmers.

**Total Family Income**

Includes the income from the crop enterprise and other subsidiary enterprises that were actually owned by the farmers.

**Pest Intensity**

It is the quality variable used, indicating two intensities of pest infestation i.e., low and high as perceived by the farmers. For empirical purposes, it is assumed as dummy variable taking the values "0" and "1" for low and high pest intensity respectively.

**Resistance Externality Cost**

The gap between the cost incurred by PPC's by the farmer and the estimated expenditure on PPC's as recommended by the Acharya N G Ranga Agricultural University, Rajendranagar, Hyderabad.

## 3.2 Techni — ques used

### 3.2.1 Tabular Analysis

Tabular analysis was used to compute sample means and percentages to study the general characteristics of sample respondents, agro-economic features, cost of cultivation of cotton, pesticide handling practicies etc.

### 3.2.2 Statistical Tools

Cobb - Douglas production function was fitted to estimate the pesticide use efficiency and multiple linear regression analysis was used to examine the pesticide expenditure elasticity and also resistance externality. Chi-square analysis was employed to study the awareness of the farmers regarding the negative externalities of the pesticide use.

#### 3.2.2.1 Gross Income Function

The following gross income function in log form was fitted mainly to estimate the pesticide use efficiency and to asses the importance of the PPC's. The factors have been analysed for their significance by fitting both multiple linear regression equation and Cobb - Douglas production function and the best fit among these two was discussed based on the value of $R^2$ and "t" values of the variables.

$$\ln Y = \ln a + b_1 \ln x_1 + b_2 \ln x_2 + b_3 \ln x_3 + b_4 \ln x_4 + b_5 \ln x_5 + b_6 \ln x_6 + b_7 \ln x_7$$

where

Y = Gross income (Rs)

$x_1$ = Area under cotton crop (hectare)

$x_2$ = Expenditure on fertilizers (Rs)

$x_3$ = Expenditure on human labour (Rs)

$x_4$ = Expenditure on PPC's (Rs)

$x_5$ = Expenditure on seeds (Rs)

$x_6$ = Expenditure on traction power (Rs)

$x_7$ = Expenditure on manures (Rs)

$R^2$ was calculated by using the following formula.

$$R^2 = \frac{\text{Regression sum of squares (R.S.S)}}{\text{Total sum of squares (TSS)}}$$

Adjusted $R^2$ was calculated by

$$\bar{R}^2 = 1 - \frac{E S S / N - n}{T S S / N - 1}$$

Where

E S S = Error sum of squares

= T S S - R S S

$$RSS = \Sigma[bi \,.\, \{\Sigma(\ln xi)(\ln Y) - \frac{\Sigma(\ln xi)\,\Sigma(\ln Y)}{N}\}]$$

TSS = Total sum of squares

N = Sample size

$$TSS = \Sigma(\ln Y^2)$$

$$= \Sigma(\ln Y^2) - \frac{\Sigma(\ln Y)^2}{N}$$

The following student "t" test was used to know the significance of individual variable

$t = bi/SE(bi)$

Where,

bi = Elasiticity of Y with respect to $x_i$

SE (bi) = Standard Error of bi and

i = 1 to n

The pesticide use efficiency can be estimated by working out marginal value product with the help of the following formula.

$$MVP = \frac{\bar{Y}}{\bar{X}_i} \times bi$$

Where

MVP= Marginal value product

$\bar{Y}$ = Geometric mean of gross income (Rs)

$\bar{X}i$ = Geometric mean of $i^{th}$ variable (Rs)

bi = Regression coefficient

### 3.2.2 PPC's Expenditure Function

A linear regression model was used for estimating PPC expenditure coefficient.

$$Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5$$

Where

$Y$ = Expenditure on PPC's (Rs)

$x_1$ = Area under cotton crop (hactares)

$x_2$ = Expenditure on fertilizer (Rs)

$x_3$ = Expenditure on manure (Rs)

$x_4$ = Total family income (Rs)

$x_5$ = Dummy for pest intensity ("0" for low and "1" for high)

$R^2$ was calculated by using the following formula.

$$R^2 = \frac{\text{Regression sum of squares (R.S.S)}}{\text{Total sum of squares (TSS)}}$$

Adjusted $R^2$ was calculated by

$$R^2 = 1 - \frac{ESS / N - n}{TSS / N - 1}$$

Where

ESS = Error sum of squares

= TSS - RSS

$$RSS = \Sigma\left[bi \cdot \left\{\Sigma(xi\ Y) - \frac{\Sigma(xi)\,\Sigma(Y)}{N}\right\}\right]$$

TSS = Total sum of squares

N = Sample size

TSS $= \Sigma (Y^2)$

$$= \Sigma (Y^2) - \frac{\Sigma (Y)^2}{N}$$

The following student "t" test was used to know the significance of individual partial regression coefficient

$t = bi/SE\ (bi)$

Where,

bi = Elasiticity of Y with respect to $x_i$

SE (bi) = Standard Error of bi and

i = 1 to n

### 3.2.3 Resistance Externality Function

A linear regression model was fitted to analyse the externality cost.

$$Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4$$

Where

Y = Resistance externality cost (Rs)

$x_1$ = Expenditure on fertilizers (Rs)

$x_2$ = Expenditure on manures (Rs)

$x_3$ = Total family income (Rs)

$x_4$ = Dummy for pest intensity ("0" for low and "1" for high).

$R^2$ was calculated by using the formula given earlier.

**Chi-squre Test**

To know the opinion of the farmers regarding the negative externalities due to pesticide use, a non parametric test i.e. $\chi^2$ was used (r x c type of contengency table) with the following hypothesis.

| | |
|---|---|
| Null hypothesis | All the farmers in the study area were aware of negative effects of pesticide use. |
| Alternative hypothesis | Atleast one farmer is not aware of the negative effects of pesticide use. |

The chi-square value is calculated by using the following formula.

$$\chi^2 = \Sigma \frac{(O-E)^2}{E}$$

Where

O = Observed frequency

E = Expected frequency

# *Agro-Economic Features*

# CHAPTER IV

# AGRO - ECONOMIC FEATURES

The performance of any crop depends not only on the physical evnironment but also on agro-climatic conditions of that region, in which it is grown. Thus, the nature of cultivation practices differ from region to region. Hence a brief descripton about the study area also is presented below to have a better understanding about the region.

## 4.1 Guntur District

Guntur district is divided into three revenue divisions with 57 mandals having a total geographical area of 11,33,000 hactares. There are 728 revenue villages and 729 villages in the District. Its four boundaries, on the north Krishna and Nalgonda districts, on the west Mahaboobnagar and Prakasam, on the East Krishna distrct and Bay of Bengal are situated. It is situated between 15°18' and 16°41' north latitude and 70°10' and 80°55' Eastern longitude.

### 4.1.1. Demographic Particulars

Demographic trends in the district are presented in Table 4.1. The total population of this district as per 1991 census was 41,06,999. It is observed that the rural population is 29,20,299 and it is more than double to that of urban population of 11,86,700. The density of population per square kilometer was worked out to be 361. There are 970 women per thousand men in the district.

**Table 4.1 Demographic features of Guntur district.**

| Particulars | Population in 1991 | % to total |
|---|---|---|
| Males | 20,84,480 | 50.75 |
| Females | 20,22,519 | 49.25 |
| Rural | 29,20,299 | 71.11 |
| Urban | 11,86,700 | 28.89 |
| Total | 41,06,999 | 100.00 |
| Density/sq km | 361 | --- |
| Females/1000 males | 970 | --- |

Source : Chief Planning Officer's Office, Guntur.

### 4.1.2 Literacy Status

Literacy rate of the district is 92.39 per cent. It is clear from the table 4.2 that the male literates were 10,03,130 i.e. 48.12 per cent and female literates were 6,17,234 i.e. 30.52 per cent. In rural population 43.09 per cent of males and 24.82 per cent of females are literates. In urban population the

male literates are 3,63,523 i.e. 60.56 per cent and female literates are 2,60,730 i.e. 44.46 per cent.

**Table (4.2) Literacy Status of Guntur District, 1991.**

| Particulars | Actual population | No.of literates | % of literacy |
|---|---|---|---|
| Male | 20,84,840 | 10,03,130 | 48.12 |
| Female | 20,22,519 | 6,17,234 | 30.52 |
| **Rural** | | | |
| Male | 14,84,213 | 6,39,607 | 43.09 |
| Female | 14,36,086 | 3,56,504 | 24.82 |
| **Urban** | | | |
| Male | 6,00,267 | 3,63,523 | 60.56 |
| Female | 5,86,433 | 2,60,730 | 44.46 |

Source : Deputy Director of Planning and Statistics, Guntur.

### 4.1.3 Climate and Rainfall

The climate is generally very warm and the temperature is very high on the upland tract. During the Agricultural year 1997-1998, the total rainfall was 850.1 mm which is slightly lower than the normal rainfall (889.1 mm) and the total rainy days were found to be 61. Out of total rain fall 68.74 per cent rainfall was received from North West Mansoons which accounts for 584.4 mm. Out of total rainy days (61) 38 rainy days were from South West Mansoons which accounts for 62.29 per cent. The least rainfall was received from winter showers which accounts to 0.74 per cent. The major portion of the rainfall was received from South West and North East Mansoons which accounts to 93.98 per cent.

**Table : 4.3** Rainfall pattern of Guntur District : 1997-1998.

| Mansoon | Normal rainfall (mm) | Amount of rainfall (mm) | % to Total | No.of rainy days | % to Total |
|---|---|---|---|---|---|
| South West Monsoons | 559.4 | 584.4 | 68.74 | 38 | 62.29 |
| South East Monsoons | 251.8 | 214.6 | 25.24 | 18 | 29.50 |
| Winter Showers | 7.9 | 6.3 | 0.74 | 2 | 3.27 |
| Summer Showers | 70.0 | 44.8 | 5.28 | 3 | 4.94 |
| Total | 889.1 | 850.1 | 100.00 | 61 | 100.00 |

Source : Joint Director of Agriculture, Guntur

### 4.1.4 Soils

Guntur district has three types of soils viz., Sandy soils (6%) , Red loamy soils (24%) and Black soils (70%). From this it is evident that most of the soils are black cotton soils in the district.

### 4.15 Irrigation

Guntur district gets water from Krishna Delta system for irrigation. In uplands, rainfall is supplemented by flow irrigation from tanks and lift irrigation from river banks. In the coastal belt the soils are sandy and the level of water table will be very high i.e. 2-3' in winter and 4-6' in summer below the surface. The vast stretch of sands in the coastal belt was a peculiar system of irrigation through splash watering. The details of sources of irrigation in Guntur district were given in Table 4.4

**Table 4.4 Source of irrigation in Guntur district. 1997-1998.**

(Area in hs)

| S.No. | Irrigation source | Irrigated | Irrigated dry | Total |
|---|---|---|---|---|
| 1. | Krishna - Western delta | 1,72,000 | 27,000 | 1,99,000 |
| 2. | Guntur channel | 6,000 | 4,000 | 10,000 |
| 3. | Nagarjuna Sagar Right Canal | 1,02,000 | 1,68,000 | 2,70,000 |
| 4. | Others | 20,000 | 22,000 | 42,000 |
| | Total | 3,00,000 | 2,21,000 | 5,21,000 |

Source : Joint Director of Agriculture Office, Guntur.

### 4.1.6 Cropping pattern

This gives an idea of the crops grown in the study area. The details are given in Table 4.5. It is clear from the table that among the various food crops grown rice occupies prime place and accounts for 54.59 per cent of the area. The total food crops accounts to nearly 68.8 per cent of the gross sown area, while non food crops account for 31.2 per cent.

**Table 4.5 Abstract of the main crops grown in Guntur district (Kharif 1997-1998).**

| S.No. | Crop | Area (ha) | Production (000' tonnes) |
|---|---|---|---|
| 1. | Rice | 2,87,326 | 818 |
| 2. | Maize | 1,732 | 3 |
| 3. | Redgram | 27,940 | 13 |
| 4. | Greengram | 7,279 | 1 |
| 5. | Blackgram | 6,597 | 1 |
| 6. | Groundnut | 294 | -- |
| 7. | Sesamum | 4,719 | -- |
| 8. | Castor | 1,335 | 3 |
| 9. | Chilli | 26,182 | 61 |
| 10. | Cotton | 1,62,858 | 441* |
| | Total | 5,26,262 | |

Source : JDA Office, Guntur.
*Cotton : Bales of 170 kg

### 4.1.7 Land Utilisation

Analysis of land use in any area is very important as it gives a wide picture of land use, available fallows and net area sown and consequent economics contributing to the economic growth of the zone. The land utilization pattern in Guntur district are furnished in the Table (4.6).

From the table, it is clear that the net area sown in the district is 6,25,000 hectares accounting for 55.21 per cent of the total geographical area. Barren and uncultivated land, land put to non agricultural use and cultivable waste accounted for 3.61, 13.76 and 3.88 per cent respectively.

**Table 4.6 Land use pattern in Guntur district**

| S.No. | Classification | Area in ha | % to total area |
|---|---|---|---|
| 1 | Forest | 1,56,000 | 13.76 |
| 2 | Barren and uncultivable land | 41,000 | 3.61 |
| 3 | Land put into non-agricultural use | 1,56,000 | 13.76 |
| 4 | Permanent pastures and other grazing lands | 24,000 | 2.11 |
| 5 | Miscellaneous trees | 42,000 | 3.70 |
| 6 | Cultivable waste | 44,000 | 3.88 |
| 7 | Other fallow lands | 28,000 | 2.47 |
| 8 | Current fallow lands | 17,000 | 1.50 |
| 9 | Net area sown | 6,25,000 | 55.21 |
| 10 | Total geographical area | 11,33,000 | 100.00 |
| 11 | Area sown in kharif | 5,63,000 | |
| 12 | Area sown more than once | 2,40,000 | |

Source : Joint Director of Agriculture, Guntur

## 4.2 Agro - Economic Frame work of selected Mandals

The selected mandals i.e. Gurajala, Veldurthi, Amaravathi and Sattenapalle are major cotton growing mandals in Guntur district. The details of the mandals are given below.

### 4.2.1 Gurajala

The mandal is sorrunded by Dachepalli, Karampudi, Durgi and Rentachintala mandals with a total geographical area of 24,839 hactares. The total population of the mandal as per 1991 census was 57,270. There are 982 females for every 1000 males.

### 4.2.2 Veldurthi

The total poplation of the mandal as per 1991 census was 40,210 and it is surrounded by Durgi and Macharla mandals with a total geographical area of 41,551 hactares. There were 961 females for 1000 males.

### 4.2.3 Amaravathi

Thullur, Thadikonda, Pedakakumanu and Krosur mandals farms the four boundaries of Amaravathi mandal with a total geographical area of 19,251 hactares. The total population of the mandal as per 1991 census was 59, 696. There were 958 females for every 1000 males.

### 4.2.4 Sattenapalle

It is surrounded by Peda Kakumanu, Medikondur, Phirangipuram, Muppalla, Rajupalem and Krosur with a total geographical area of 16513 hactares. The total population of the mandal as per 1991 census was 7,266. There are 979 females for every 1000 males.

### 4.2.5 Land Utilization Pattern in the Selected Mandals

The land utilization pattern in the four selected mandals Gurajala, Veldurthi, Amaravathi and Sattenapalle are indicated in Table (4.7). The net sown area was highest in the Gurajala mandal followed by Sattanapalle, Veldurthi and Amaravathi mandals.

Table : 4.7 Land use pattern in selected mandals (acres)

| S.No. | Particulars | Gurajala | Sattenapalle | Amaravathi | Veldurthi |
|---|---|---|---|---|---|
| 1 | Forest | 4,912 | 1,639 | 1,207 | 31,607 |
| 2 | Barren and uncultivable land | 4,525 | 5,204 | 458 | 9,121 |
| 3 | Land put to non-agricultural use | 5,403 | 4,521 | 10,840 | 8,548 |
| 4 | Permaneut pastures and other grazing lands | 1,113 | 1,422 | 451 | 3,291 |
| 5 | Miscellaneous trees | 10 | 3,495 | 296 | 3,572 |
| 6 | Cultivable waste | 21 | 1,455 | 330 | 10,968 |
| 7 | Other fallow lands | 10 | 126 | 242 | 400 |
| 8 | Current fallows | 2,675 | ---- | 634 | 1,274 |
| 9 | Net area sown | 43,470 | 41,282 | 33,669 | 35,102 |
| | Total geographical area | 62,149 | 59,145 | 48,129 | 1,03,878 |

Source : CPO'S Office, Guntur.

# *Results & Discussion*

# CHAPTER V

# RESULTS & DISCUSSION

The present study emphasises mainly on the externalities due to pesticide use. The data collected was tabulated, analysed and the results were discussed under the following heads.

**5.1 General Characteristics of the Sample Farmers**

**5.2 Pesticide use Pattern of the Sample Farmers**

**5.3 Cost and Returns of the Sample Farmers**

**5.4 Expenditure Elasticity of Pesticide use in Cotton**

**5.5 Externalities in Pesticide use in Cotton**

**5.6 Opinion of the Farmers about the Externalities**

## 5.1 General Characteristics of the Sample Farmers

The general characteristics of the respondents are presented in Table 5.1. The average size of the family was found to be around five with two males, two females and two children. The average area under cotton crop was 2.41 hectares ranging from 1.1 to 6 hectares.

Regarding literacy status of the sample farmers (Table 5.2), 46.47 per cent of the farmers had secondary education and only 5 per cent of selected farmers were illiterate. The farmers who had college education accounted to

**Table : 5.1 General characteristics of sample farmers**

| S.No. | Particulars | Average |
|---|---|---|
| 1. | Age of respondents | 42 |
| 2. | Family composition : | 5.12 |
| | a. Males | 2.05 |
| | b. Females | 1.57 |
| | c. Childern | 1.5 |
| 3. | Size of the farm | 2.41 ha |

**Table 5.2 Educational status of the sample farmers**

| S.No. | Education upto | Number | Percentage |
|---|---|---|---|
| 1 | Illiterate | 3 | 5.00 |
| 2 | Primary | 16 | 26.67 |
| 3 | Secondary | 28 | 46.67 |
| 4 | College | 13 | 21.66 |

21.66 per cent and it is heartening to note that 91 per cent of the sample farmers were literate. The average age of the sample farmers was 42 years with a range of 28 to 58 years. The other crops that are grown generally by the sample famers are rice, chillies and soybean.

## 5.2 Pesticide use Pattern of the Sample Farmers

The pesticide use pattern of the sample farmers provides the clear understanding about the pest intensity and why the farmers are in the habit of applying higher doses of pesticides. The major pests noticed on cotton were sucking pest complex in early stages (white fly and leaf hoppers) and in the later stages the boll warms (*Helicoverpa armigera* and *Spodoptera litura*)

### 5.2.1 Frequency of Pesticide Application

The average frequency of pesticide applications made by the sample farmers was 24 sprays with a range of 18-35 sprays during the crop period of 150 to 160 days when compared to 11 sprays (need based application) as recommended by ANGRAU. It was accounted to more than one application a week. The average frequency of pesticide application was observed to be more than twice when compared to the latest recommendations of ANGRAU. This could be one of the reasons for the pests developing resistance against many of the existing pesticides and depletion of natural enemies of pests in the field. Venkataramani (1992) reported that the indiscriminate use of pesticides have led to the emergence of more virulent pests that have developed a built in resistance to some of the frequently used chemicals in the cotton belts of Prakasam and Guntur districts of Andhra Pradesh.

### 5.2.2 Different types of Pesticides used by the Sample Farmers

The various types of pesticides used by the farmers are presented in Table 5.3. It was clear that 96 per cent of the sample farmers were using synthetic pyrethroids in the forms of Cypermethrin 10 EC and Cypermethrin 25 EC as these are commonly available in Guntur district. Further, eighty per cent of the farmers were adopting the organophosphorus pesticides in the forms of Nuvacron, Rogor and Ekalux. It was also observed that 41 per cent of the farmers were in the habit of applying cyclodiene group of pesticides in the form of Thiodon. However, it was noticed that only 35 per cent of farmers applied fungicides and none used herbicides.

## 5.3 Costs and Returns of Cotton Cultivation

An over view of the Table 5.4 provided the costs and returns of cotton per hectare which indicates an idea of expenditure on various material costs. It is evident that pesticides occupied a major portion (45.4 per cent) among the input costs indicating the extent of consumption of pesticides by the farmers which may ultimately result in development of pest resistance. Again among the pesticides, the synthetic pyrethroids alone accounted to 41 per cent of total pesticide cost resulting in the build up of resistance in the pests. The expenditure on pesticides was more when compared to study conducted by Subba Rao *et al* (1987) on cotton growers where the pesticide expenditure was 20-25% of total operational cost in Guntur district of Andhra Pradesh. This clearly indicates that the cotton farmers in Guntur district are spending more and more amount on pesticides in order to reap the profits even after a decade. It means that they have not changed their attitude of

**Table 5.3 : Major pesticides used by cotton farmers**

| S.No. | Name of pesticide | Farmers Number | Reporting percentage |
|---|---|---|---|
| 1 | Thiodon | 25 | 41.67 |
| 2 | Cypermethrin 10 EC | 58 | 96.67 |
| 3 | Cypermethrin 25 EC | 55 | 91.67 |
| 4 | Nuvacron | 48 | 80.00 |
| 5 | Rogor | 28 | 46.67 |
| 6 | Orthane | 37 | 61.67 |
| 7 | Corobon | 34 | 56.67 |
| 8 | Ekalux | 32 | 53.33 |
| 9 | Dithane M 45 | 21 | 35.00 |

**Table 5.4 : Costs and returns from cotton cultivation (per ha)**

| S.No. | Particulars | Amount (Rs) | % to the total |
|---|---|---|---|
| 1 | Seeds | 2057.75 | 5.0 |
| 2 | Manures | 1667.78 | 4.1 |
| 3 | Fertilizers | 5792.80 | 14.2 |
| 4 | Human labour | 8842.92 | 21.7 |
| 5 | PPC's | 18497.17 | 45.4 |
| 6 | Traction power | 3910.31 | 9.6 |
| 7 | Total cost | 40768.73 | 100.0 |
| 8 | Gross income | 66928.03 | |
| 9 | Net income | 26159.30 | |

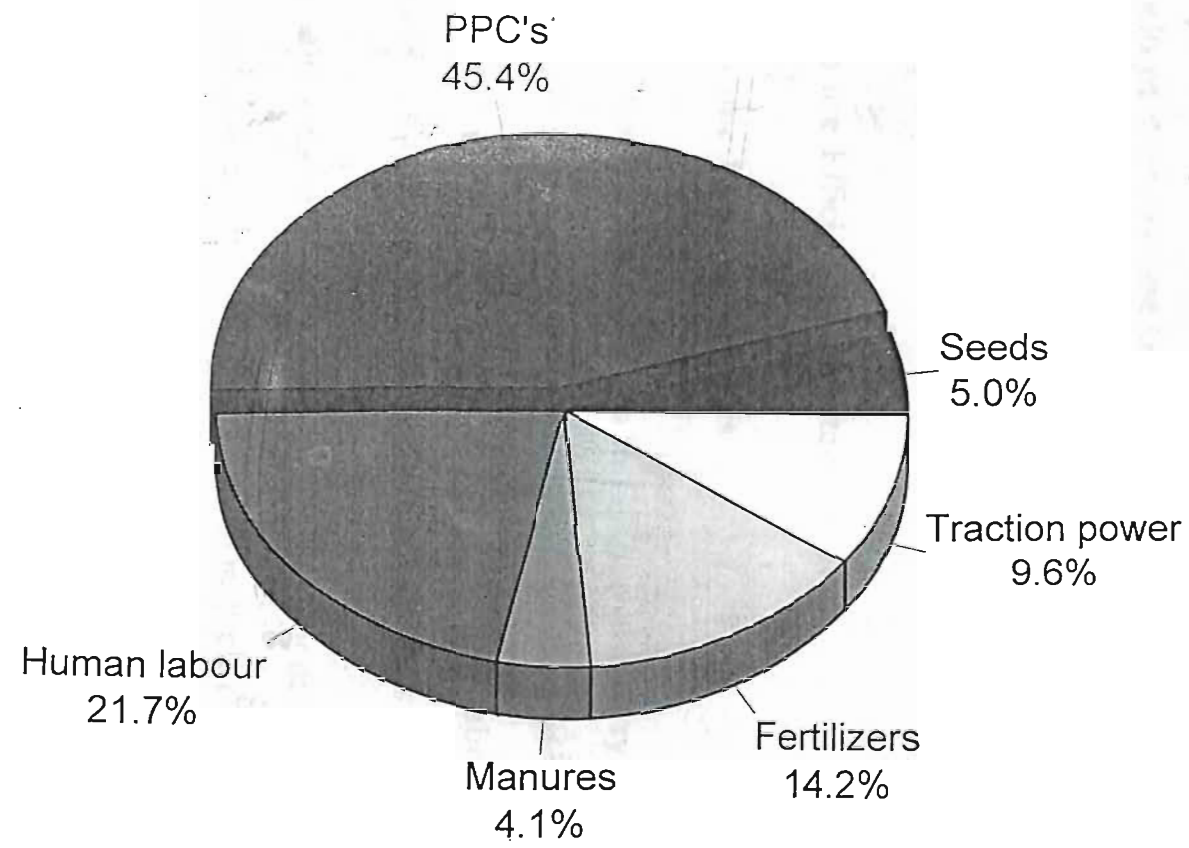



Fig : 3. COST COMPONENTS OF COTTON CULTIVATION.

investiment on pesticides. This pointed out that there was an indiscriminate and repeated application of pesticides in the study area causing externalities. This is in accordance with the opinion of Venkataramani (1992) indicating that in cotton belts of Prakasam and Guntur districts of Andhra Pradesh the repeated and indiscriminate use of synthetic pyrethroids had resulted in the development of new races of *Helicoverpa* and several insects developing resistance to insecticides.

### 5.3.1 Resource use Efficiency on Cotton

#### 5.3.1.1 Gross Income Function Analysis

Cobb-Douglas production function was employed to carry out gross income function analysis with gross income (Rs) as dependent variable and the area under cotton crop (ha), fertilizers (Rs), human labour (Rs), PPC's (Rs), seeds (Rs), traction power (Rs) and manures (Rs) as factors.

The results obtained from the multiplicative production function analysis are furnished in Table 5.5. The coefficient of multiple determination ($R^2$) indicated that nearly 96 per cent of variation in gross income was contributed by the explanatory variables included in the function.

A perusal of the table clearly revealed that variables viz., the area under cotton crop, fertilizers and pesticides were positively contributing to the gross income and were significant at 5 per cent level of probability. The elasticity coefficient of area under cotton crop, fertilizers and pesticides were 0.3165, 0.2583 and 0.1386 respectively which indicated that one per cent increase in area under cotton crop, expenditures on fertilizers and pesticides

**Table 5.5 : Elasticity coefficients of Factors influencing gross income**

| S.No. | Variable | Regression coefficient | Standard Error | "t" value |
|---|---|---|---|---|
| 1 | Area under cotton crop (ha) | 0.3165** | 0.1294 | 2.444 |
| 2 | Expenditure on fertilizers (Rs) | 0.2583** | 0.1115 | 2.316 |
| 3 | Expenditure on human labour (Rs) | 0.1077 | 0.1049 | 1.026 |
| 4 | Expenditure on PPC's (Rs) | 0.1386** | 0.0618 | 2.241 |
| 5 | Expenditure on seeds (Rs) | 0.0791 | 0.0606 | 1.306 |
| 6 | Expenditure on traction power (Rs) | 0.2766*** | 0.1655 | 1.671 |
| 7 | Expenditure on manures (Rs) | -0.1604 | 0.1181 | 1.358 |

| | |
|---|---|
| Intercept | : 4.815 |
| Standard error of estimation | : 0.087 |
| $R^2$ | : 0.964 |
| $\overline{R}^2$ | : 0.959 |
| $\Sigma bi$ | : 1.0164 |

** Significant at 5% level of probability

*** Significant at 10% level of probability

would result in increasing the gross income by 0.32, 0.26 and 0.14 per cent respectively keeping all other factors at constant level.

Similarly the elasticity coefficients of traction power (0.2766) was positive and significant at 10% suggesting that one per cent increase in the traction power would increase the gross income by 0.28 per cent. Further the variables human labour and cost of seeds were though contributing positively to the gross income, however, not significant. It was also found that manures had contributed negatively to the gross income contrary to the theory but the same was not significant. However, the returns to scale was found to be 1.016 indicating the constant returns to scale.

The results obtained were in accordance with the results conducted on cotton farmers in Guntur district by Eswaraprasad *et al* (1988) and Pandurangadu (1988) for the variables pesticides, fertilizers and human labour. The result of traction power was in accordance with the result obtained by Pandurangadu (1988).

Prabhu (1985) critcised the production function approach of estimating the marginal productivity and optimum quantity of pesticide use since the PPC's were yield saving inputs when compared to fertilizers and seeds which were yield increasing inputs and thus PPC's cannot be compared to the yield increasing inputs, which appears to be lacuna of production function approach.

### 5.3.1.2 Marginal Value Products (MVP) of Various Variables

The production function analysis used to determine the efficiency of resource use which requires the estimation of marginal value products of the resources. In fact, the Cobb-Douglas frame work is estimated at geometric mean levels and the knowledge of the marginal returns of resources is useful because it gives the level at which it is economical for producers to adopt new technology and to have resource judgement. The general approach for judging the efficiency of resource use has been the comparison of marginal value product with opportunity cost. If the ratio is less than one it indicates much of the particular input is being used and vice versa. Maximum efficiency of resources occur when the returns from additional input i.e., marginal value product to opportunity cost ratio was equal to unity.

It was observed from the Table 5.6 that the ratio of marginal value product to opportunity cost (i.e. MVP/OP) was found to be higher than the unity for seeds, fertilizers and traction power indicating that increase in the use of these inputs secure higher returns. The ratio was found to be less than unity for PPC's (0.5014), human labour (0.81) and manures (-6.43) revealing that these resources were used excessively. It clearly shows that the pesticides are used excessively and indiscriminately resulting in externalities.

These results were in conformity with the results obtained by Eswaraprasad *et al* (1988) and Pandurangadu (1988) for the variables pesticides and human labour and the result of fertilizers was in contradiction with the results of Eswaraprasad *et al* (1988).

**Table 5.6 : Marginal value product to opportunity cost**

| S.No. | Particulars | MVP | OC | MVP/OC | Resource use efficience |
|---|---|---|---|---|---|
| 1 | Seeds | 2.57 | 1.00 | 2.57 | Under utilization |
| 2 | Manures | -6.43 | 1.00 | -6.43 | Excessive use |
| 3 | Fertilizers | 2.98 | 1.00 | 2.98 | Under utilization |
| 4 | Human labour | 0.81 | 1.00 | 0.81 | Excessive use |
| 5 | PPC's | 0.50 | 1.00 | 0.50 | Excessive use |
| 6 | Traction power | 4.73 | 1.00 | 4.73 | Under utilization |

Having studied the factors influencing the gross income of cotton it would be necessary to probe further to analyse expenditure elasticity of pesticides, an important variable in the present study.

## 5.4 Expenditure Elasticity/Coefficient of Pesticides use in Cotton

Multiple linear regression model was fitted considering the expenditure on pesticides as dependent variable and area under cotton, fertilizers, manures, total family income and pest intensity (0-1 dummy) as independent variables. It was evident from Table 5.7 that the area under cotton crop and pest intensity were positively contributing to expenditure on PPC's and were significant at one and 10% level of probability respectively. The regression coefficient of area under cotton crop was 7368.3 indicating an increase in one hectare area under cotton crop there would be an additional expenditure of Rs.7368.3 on PPC's. Similarly the pest intensity (0 - 1 dummy) was found to be positively contributing to expenditure on PPC's which was significant at 10% level of probability. It clearly indicated that the farmers in the study area were incurring more on pesticides when high pest menace was noticed in the field.

The regression coefficient of manures was negatively significant (-3.873) at 1% level suggesting that an increase in the expenditure on manures results in the reduction of PPC's expenditure by Rs.3.873. Hence application of manures would result in reduction of expenditure on plant protection. This is in conformity with the opinion of James Cook and K F Backer (1983) that "Organic amendments can favour biological protection of the plant. The biological control achieved with organic amendments results in part, from

**Table 5.7 : Regression coefficients of Factors effecting expenditure on PPC's**

| S.No. | Variable | Regression coefficient | Standard Error | "t" value |
|---|---|---|---|---|
| 1 | Area under cotton crop (ha) | 7368.3* | 2041.0 | 3.610 |
| 2 | Expenditure on fertilizers (Rs) | 0.881 | 0.8385 | 1.051 |
| 3 | Expenditure on manures (Rs) | -3.873* | 1.0598 | 3.655 |
| 4 | Total family income (Rs) | -0.0158 | 0.0271 | 0.584 |
| 5 | Pest intensity (Dummy "0" for low, "1" for high) | 6610.4*** | 2613.2 | 2.530 |

Intercept : 3944.21

Standard error of estimation : 7342.35

$R^2$ : 0.8950

$\overline{R}^2$ : 0.8550

* Significant at 1% level of probability

*** Significant at 10% level of probability

enhanced competition among the micro-organisms for nitrogen, carbon or both and may be expressed as fewer propagules germinated (or) less pre-penetration growth of the pathogen in the infestation court".

However, the regression coefficients of other variable i.e., expenditure on fertilizers and total family income were not contributing significantly to the expenditure on PPC's. These were in accordance with the results obtained by Aruna Kumara (1995) for the cabbage in Mullur Taluka of Karnataka where in it was indicated that the variables, manures and pest intensity contributed positively to the expenditure on PPC's. However the total family income was positive and significantly contributing to the expenditure of PPC's while in our study the same was influencing negatively but not significant.

## 5.5 Externalities due to Pesticides use in Cotton

Externalities as defined earlier are those gains and losses which are sustained by others as a result of actions initiated by producers or consumers or both and for which no compensation is paid. The externalities which were conceptualised in the study were resistance externality and health costs, and the estimated externalities are discussed here under.

### 5.5.1 Resistance Externality

Resistance externality was assumed to be linear function of expenditure on fertilizers, manures, total family income and pest intensity (Dummy variable).

**Table 5.8: Regression coefficients of Factors influencing resistance externality cost**

| S.No. | Variable | Regression coefficient | Standard Error | "t" value |
|---|---|---|---|---|
| 1 | Area under cotton crop (ha) | 2.6910* | 0.3496 | 7.696 |
| 2 | Expenditure on fertilizers (Rs) | -3.1980* | 1.0166 | 3.146 |
| 3 | Total family income (Rs) | -0.0092 | 0.0270 | 0.342 |
| 4 | Pest intensity (Dummy "0" for low, "1" for high) | 7194.2** | 2614.8 | 2.751 |

| | |
|---|---|
| Intercept | : 2599.38 |
| Standard error of estimation | : 7391.907 |
| $R^2$ | : 0.7870 |
| $\bar{R}^2$ | : 0.7720 |

* Significant at 1% level of probability

** Significant at 5% level of probability

Resistance externality cost is the difference between the actual expenditure incurred by the farmers on plant protection chemicals and recommendations by ANGRAU.

The coefficient of multiple determination ($R^2$) was 0.78 which indicating 78 per cent variation in the resistance externality cost was explained by explanatory variables included in the function (Table 5.8). The regression coefficient for fertilizers was 2.691 which was significant at one per cent level indicating that for an additional rupee increase in expenditure on fertilizers result in Rs.2.7 increase in the resistance externality cost. From this it is evident that the higher doses of fertilizers makes the plant succulent and attracts more pests resulting in the higher pest intensity consequently higher doses of pesticides are required which may result in the development of resistance in the pest. There by, increasing the resistance externality cost. Hence, the farmers should be advised to cut down the expenditure on fertilizers.

Similarly, the regression coefficient for pest intensity (7194.2) was significant at 5 per cent level indicating that as the pest intensity was more, the farmers resort to higher and higher doses of PPC's to control them as cotton in the study area was considered as white gold which result in the build up of resistance, thus providing scope for increasing the resistance externality cost.

Further, the regression coefficient of manures was negative and significant at one per cent level suggesting that for every rupee spent on manures resulted in decrease of Rs.3.2 in resistance externality cost. Thus FYM, the organic amendments help in the development of good soil health

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and its quality reduces the resistance externality cost by reducing the expenditure on the PPC's.

The results are in confirmity with the results obtained by Aruna Kumara (1995) for the variables fertilizers, manures and pest intensity and in contradiction for total family income.

### 5.5.2 Health Cost

Having analysed the resistance externality in cotton it is necessary to study effect of PPC's on the health of the farmers. From the data it was noticed that about 81 per cent of farmers experienced the health problems out of which 14 per cent of the farmers have been taken curative measures and on an average the sample farmers incurred Rs.105 on medicines during the crop season. These were the explicit costs incurrred by the respondents in addition to the costs of butter milk and other items (coconuts etc) taken by the farmers before and after spraying. About 27 per cent of the farmers reported that they take rest on an average minimum period of two hours which accounts to the wage loss of Rs.11 per day. All these costs could be attributed to health costs that were incurred by the sample farmers.

## 5.6 Opinion of the Farmers about Negative Externalities

One of the objectives of the study was to document the experiences of the farmers in handling of pesticides, health hazards due to pesticides use and finally to know the awareness of the farmers with regard to negative effects of pesticides usage.

### 5.6.1 Handling of Pesticides

An examination of Table 5.9 revealed that about 72 per cent of farmers applied pesticides along the wind direction which was a safety method since in this method the exposure to the chemicals was less. In this method there was a less possibility of inhalation of the pesticide droplets and hence reducing the danger of poisoning due to PPC's. It was also noticed that 3.3 per cent of the farmers were applying pesticides across the wind direction and 23 per cent of farmers said that they have not considered the direction in which spraying was done.

It was incredible to notice that 75 per cent of farmers were not aware of prophylactic doses and similarly 53 per cent were ignorant of the recommended doses of pesticides inspite of so much awareness created by ANGRAU and state government through ZREAC meetings, Kisan Melas, Rytu Sadassu, AMC meetings etc. So, there was a every possibility of application of over doses (or) sub lethal doses of pesticides which was not a correct procedure as it might be a reason for the development of resistance in the pest population.

It was noticed that 73 per cent of the farmers were not following any safety measures while taking the spraying operation and hence there was every possibility of contact of pesticides with the body resulting in the health hazards. Most of the farmers (76.6%) were washing their hands after spraying and very few farmers (8.4%) were taking bath after pesticide application.

Regarding mixing of the pesticides with water, it was observed that 78 per cent of farmers were using stick for mixing the pesticides which was

**Table 5.9 : Pesticide handling practices of sample farmer**

| S.No. | Particulars | Farmers number | Reporting percentage |
|---|---|---|---|
| 1 | Direction of pesticide application | | |
| | a. Along the wind direction | 43 | 71.7 |
| | b. Against the wind direction | 1 | 1.7 |
| | c. Across the wind direction | 2 | 3.3 |
| | d. No consideration | 14 | 23.3 |
| 2 | Safety masures while spraying | | |
| | a. Use of gloves | 1 | 1.7 |
| | b. Use of shoes | 0 | 0 |
| | c. Use of face mask | 2 | 3.3 |
| | d. Washing hands | 46 | 76.6 |
| | e. Taking bath after spray | 5 | 8.4 |
| | f. No protective cover | 44 | 73.3 |
| 3 | Pesticide and water mixing practices | | |
| | a. By hand | 13 | 21.7 |
| | b. By using stick | 47 | 78.3 |
| 4 | Measurement of pesticides | | |
| | a. Pesticide bottle cap | 39 | 65 |
| | b. Measurement jar | 7 | 11.7 |
| | c. Match box | 14 | 23.3 |

found to be safe as it reduces the contact with the body. About 21.7 per cent of the farmers using their hands for mixing the pesticides which may result in health hazards as the pesticides are in direct contact with skin.

About 65 per cent of the farmers were using the pesticide bottle cap for measuring the pesticides which was not a correct measure since there was possibility of over dosage (or) sub lethal dosage of pesticides resulting in build up of resistance in the pests. During investigation it was also found that only 11 per cent of the respondents were using the measuring jars.

## 5.6. Exposure to Pesticides

Generally the farmers do not observe the labels of the pesticide containers which includes the date of manufacture, trade mark, price etc. because of illiteracy. But in the study area it was observed that majority of the farmers (60 per cent) were cautious while purchasing pesticides and it was reported that they look for the trade mark and price, since 91 per cent of the sample farmers were literate. It was found that all the farmers purchased the pesticides in the sealed containers. But, about 15 per cent of farmers know the importance of the colour symbols on the containers, clearly indicating that most of the farmers do not know the importance of colour symbols which indicate the danger of toxicity to the human and livestock. Thus, a major portion of the farmers were exposed to the dangerous chemicals resulting in the health problems.

### 5.6.3 Re-entry Intervals

Re-entry interval is the time needed to allow a chemical to dissipate in the environment. About 95 per cent of farmers do not know the re-entry concept and enter into the pesticide sprayed field to perform the routine farm operations which makes them to get exposed to pesticides which may cause short or long term health problems.

### 5.6.4 Exposure to Pesticides

Farmers exposed to the pesticides during the application of pesticides apart from exposure during the handling, mixing and washing the equipment. It was observed that on an average 53 days farmers were involved in the spraying operation during the crop period of 150-160 days. This indicates the magnitude of exposure to PPC's by the farmers. In addition, farmers were also exposed to PPC's when they were involved in plant protection activities of other crop enterprises. All these may lead to the greater probability of possible health problems.

### 5.6.5 Health of the Farmers

Because of the use and handling of hazardous pesticides, about 81 per cent of the farmers experienced health problems and the common health problems faced by the farmers were head ache, vomiting, body pains, stomach ache etc. and the same are indicated in Table 5.10. Similar health problems were reported by Antle and Pingali (1994) among the farmers of the rice growing regions of Phillippines.

**Table 5.10 : Health problems experienced by sample farmers**

| S.No. | Health problem | Farmers number | Reporting % |
|---|---|---|---|
| 1 | Head ache | 44 | 73.66 |
| 2 | Vomiting | 28 | 46.66 |
| 3 | Body pains | 51 | 81.00 |
| 4 | Stomach ache | 32 | 53.33 |
| 5 | Tiredness | 47 | 78.00 |

### 5.6.6 Farmers opinion regarding Negative Externalities of Pesticide Use

To know the farmers awareness towards the negative effects of pesticide usage, a non parametric test i.e. chi-squre was employed. The following items were included in chi-squre test, the effects of which were explained earlier (Table 5.11). The $\chi^2$ test was employed with following hypothesis.

| | |
|---|---|
| Null hypothesis | All the farmers in the study area were aware of negative effects of pesticide use. |
| Alternative hypothesis | Atleast one farmer is not aware of the negative effects of pesticide use. |

The chi-square value (102.8) was found to be significant at one per cent level of probability and hence it was concluded that the farmers were not aware of the negative effects of pesticide use. Even though some of the farmers were aware of the ill effects of the pesticides use, they were not so innovative to take precautionary measures as most of the farmers were middle aged (average age of 42 years). So there was every possibility of excessive use of pesticides, development of resistance in pests and possible health harzards to the farmers which were already pointed out in the present study.

**Table 5.11: Farmers awareness about negative externalities due to pesticide use**

| S.No. | Particulars | $(O-E)^2/E$ Value |
|---|---|---|
| 1 | Prophylactic dose | |
| | a. aware | 2.8866 |
| | b. not aware | 1.8172 |
| 2 | Recommended doses | |
| | a. aware | 1.0023 |
| | b. not aware | 0.6309 |
| 3 | Higher doses of PPC's result in buld up of resistance in pests | |
| | a. aware | 0.4362 |
| | b. not aware | 0.2746 |
| 4 | Look at the lables on the pesticide containers | |
| | a. Yes | 7.0902 |
| | b. No | 0.0378 |
| 5 | Higher dose of PPC's killing the natural enimies | |
| | a. Yes | 0.3430 |
| | b. No | 0.2159 |
| 6 | Purchase of known brand of PPC's | |
| | a. Yes | 0.6001 |
| | b. No | 0.0378 |
| 7 | Aware of importance of colour symbols on PPC containers | |
| | a. aware | 8.6744 |
| | b. not aware | 5.4609 |
| 8 | Practice of safety manures while spraying | |
| | a. Yes | 2.2240 |
| | b. No | 1.4001 |
| 9 | Disposal of PPC contaiminated water | |
| | a. To the field | 8.2895 |
| | b. To the irrigation source | 5.1872 |
| 10 | Direction of srpaying operation | |
| | a. Along wind direction | 16.9470 |
| | b. No consideration | 10.6689 |
| 11 | Aware of reentry concept | |
| | a. Aware | 17.5682 |
| | b. Not aware | 11.0600 |

$\Sigma \frac{(0-E)^2}{E} = 102.80^*$ * Significant at 1 per cent level of probability

# Summary

# CHAPTER VI

## SUMMARY

Pesticides emerged as an important agricultural input as a result of green revolution. India is the largest producer and consumer of pesticides in South Asia and among the different states in our country Andhra Pradesh occupies first position in the pesticide consumption. Among different crops, cotton which accounts for 4% of area consumes about 40 - 50% of the total pesticides used in India. Now-a-days there was a growing concern about the pesticides and their impact on the environment. Pesticide is the only agricultural input which can be highly toxic in nature and, therefore has potential for causing direct and substantial harm to human beings as well as the animals and plants that exists in the eco-system. On the other hand control of pests continues to be crucial for the farmers and excessive and indiscriminate use of pesticides resulted in pest resurgence, pest resistance and secondary pest out breaks. In this context an attempt is made to study the externalities due to the pesticide use with the following objectives.

1. To estimate the pesticide use efficiency and pesticide expenditure elasticity

2. To analyse the negative externalities of pesticide use - resistance externality and health hazards.

3. To study the opinion of the farmers about the negative externalities of pesticide use.

## Methodology

Guntur district was selected purposively as it stood first in the consumption of pesticides in Andhra Pradesh, mainly due to the extensive cultivation of commercial crops. Among various commercial crops cotton ranked first in terms of their contribution to total area under commercial crops and hence it was purposively selected for the study. Four mandals namely Gurajala, Veldurthi, Amaravathi and Sattenapalle were purposively selected as they occupy the first four positions in area under cotton crop. One village from each mandal viz., Gurajala, Sirigiripadu, Amaravathi and Dhulipalla were selected from the mandals Gurajala, Veldurthi, Amaravathi and Sattenapalli respectively based on the area under cotton crop. A sample of 60 farmers were selected by using proportionate random sampling technique and the sample farmers were interviewed personally with pretested and well structured schedules. The data collected was pertaining to the agricultural year 1997-98.

## Tools of Analysis

Tabular analysis was used to compute sample means and percentages to study the general characteristics of sample respondents, cost of cultivation of cotton, pesticide handling practices etc. Cobb - Douglas production function was fitted to estimate the pesticide use efficiency and multiple linear regression analysis was used to examine the pesticide expenditure elasticity and also resistance externality. Chi-square analysis was employed to study the awareness of the farmers regarding the negative externalities of the pesticide use.

## Major Findings

Following are the major findings emerged out of the study.

The average size of the family was around five members and the average area under rainfed cotton crop was 2.41 hactares indicating that sample constitutes all groups of farmers i.e. small, medium and large. The average age of the farmers was found to be 42 years and about 91 per cent of the sample farmers were literate.

About 96 per cent of farmers were using synthetic pyrethroides. The average fequency of pesticide application was found to be 24 sprays during the crop period of 150 - 160 days, which was found to be more than twice as per the need based recommendations of Acharya N G Ranga Agricultural University.

The average cost of production of cotton was found to be Rs.40,768.93 per hectare out of which the cost of pesticides accounted to 45.4 per cent. The area under cotton crop, expenditure on fertilizers, expenditure on PPC's and expenditure on traction power were contributing positively and significantly to the gorss income. The marginal value product of pesticides was found to be 0.50 indicating the excessive use of pesticides.

The area under cotton crop and pest intensity (dummy variable) were contributing positively and significantly to the expenditure on PPC's. The expenditure on manures was found to be negatively contributing to the expenditure on PPC's.

The resitance externality was found to be major externality to which expenditure on fertilizers and pest intensity were contributing positively and their regression coefficients were 2.691 and 7194.2 respectively. The expenditure on manures was influencing negatively to the resistance externality cost and its regression coefficient was found to be -3.198.

About 81 per cent of sample farmers experienced health problems out of which 14 per cent of farmers took curative medicines incurring Rs.105 (on an average). It was reported that 27 per cent of farmers took 2 hours rest after spraying and they were incurred a wage loss of Rs. 11 per day.

It was observed that 72 per cent of the farmers applied pesticides along the wind direction, about 3.3% of farmers were applying across the wind direction and 23 per cent of farmers were not considering the direction in which they were spraying.

It was reported that 75 per cent of farmers were not aware of the prophylactic doses and 53 per cent of farmers were ignorant of the recommeded doses of pesticides. Hence there was an every possibility of application of over (or) sub lethal doses of pesticides.

It was noticed that 73 per cent of respondents were not following any safety measures while spraying and 78 per cent of farmers were using stick for mixing the chemicals with water. It was also observed that 65 per cent of farmers were using pesticide bottle cap for mixing the pesticides.

It was found that about 60 per cent of farmers looked at the pesticide bottle lables and about 15 per cent of farmers know the importance of colour symbol on it.

Majority of the farmers (about 95 per cent) were not known about the re-entry interval concept and it was also found that about 53 days on an average the farmers were exposing themselves to dangerous chemicals while spraying during the crop period of 150 to 160 days.

It was reported that about 81 per cent of farmers experienced health problems and the major health problems noticed were body pains, tiredness, head ache and stomach ache.

Chi-square test was employed to know the awareness of the farmers regarding the negative externalities with a null hypothesis that all the farmers were aware of negative externalities. Chi-square was found to be significant at one per cent level of probability indicating that farmers were not aware of negative externalities of pesticides use.

**Suggestions**

1. Since the monocropping of cotton for the past several years was found to be responsible for the build up of pest population on this crop, farmers should replace cotton with equally remunerative crops like sunflower, turmeric, maize etc.

2. Research results conducted on forntline and first line demonstration on integrated pest management should be popularised on top priority.

3. Emphasis has to be given on the neem based products, botanicals and biocides in controlling the pest problems on cotton.

4. Use of natural enemies of clrop pests such as parasites and predators and a variety of biocontrol agents such as beneficial bacteria and viruses have to be encouraged.

5. Poor handling of poisons, inhalation of the poisons in the form of fine drop lets and penetration through skin have led to the several health problems. So farmers should be educated on dangers of the chemicals and right methods of handling them. Farmer training classes may be conducted on negative externalities in the villages.

6. Extension education programmes should be conducted to educate the farmers with respect to the importance of colour symbol printed on the labels of the pesticide container and re - entry periods.

7. Extension efforts should be focussed towards the popularisation of safe and sustainable farming systems.

8. Finally the government should revaluate the pesticides and permit the use of only selective and non-persistant chemicals in the country.

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