ECONOMIC ANALYSIS OF MAJOR FERTILIZERS AND PESTICIDES CONSUMPTION IN ANDHRA PRADESH

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M.Sc. (Ag.)

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(AGRICULTURAL ECONOMICS)

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2015

DECLARATION

I, **Y. LATIKA DEVI** hereby declare that the report entitled "**ECONOMIC ANALYSIS OF MAJOR FERTILIZERS AND PESTICIDES CONSUMPTION IN ANDHRA PRADESH**" submitted to the "**Professor Jayashankar Telangana State Agricultural University**" for the degree of **Doctor of Philosophy in Agriculture** is the result of the original project work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

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CERTIFICATE

Ms. **Y. LATIKA DEVI** has satisfactorily prosecuted the course of project and that the report entitled "**ECONOMIC ANALYSIS OF MAJOR FERTILIZERS AND PESTICIDES CONSUMPTION IN ANDHRA PRADESH**" submitted is the result of original project work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by him for a degree of any University.

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Chairperson

CERTIFICATE

This is to certify that the thesis entitled "**ECONOMIC ANALYSIS OF MAJOR FERTILIZERS AND PESTICIDES CONSUMPTION IN ANDHRA PRADESH**" submitted in partial fulfilment of the requirements for the degree of "**DOCTOR OF PHILOSOPHY IN AGRICULTURE**" of the **Professor Jayashankar Telangana State Agricultural University**, Hyderabad, is a record of the *bonafide* research work carried out by Ms. Y LATIKA DEVI under our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the report has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of investigations have been duly acknowledged by the author of the thesis.

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Date: (***Y. LATIKA DEVI***)

Place: Hyderabad

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SYMBOLS AND ABBREVIATIONS

$	: Dollar
`	: Indian Rupee
%	:Per cent
a.i. kg ha^{-1}	: active ingredient kilogram per hectare
BHC	: Benzene Hexachloride
CGR	: compound growth rate
CI	: Cropping intensity
CV	: coefficient of variance
DAP	:Diammonium Phosphate
DDT	: Dichlorodiphenyltrichloroethane
DES	: Directorate of Economics and Statistics
et al.	: Co-workers
FAI	: Fertilizer association of India
FAO	: Food and Agriculture Organization
Fig.	:Figure
FYM	:Farm yard manure
GDP	:Gross domestic product
gm ha^{-1}	:Gram per hectare
HYV	: High yielding variety
IPM	:Integrated pest Management
K, K_2O	: Potash
Kg	: Kilogram
kg ha^{-1}	: Kilogram per hectare
MFC	: Marginal Factor Cost
ml g^{-1}	: milliliter per gram
MSP	:Minimum support price
MT	:Metric tonne
MVP	: Marginal Value product
N	: Nitrogen
NPK	Nitrogen-phosphorus-potash fertilizer nutrient
P, P_2O_5	: Phosphorous
qt ha^{-1}	: Quintal per hectare
R^2	: coefficient of determinant
RD	: Recommended dose
SAT	: Semi-Arid Tropics
SD	:Standard deviation
SRI	: System of Rice Intensification
t	: Tonne
TE	: Triennium Ending
US	: United State
viz.,	: Namely

ABSTRACT

Author	:	Y. LATIKA DEVI
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Agriculture is one of the major sector and plays a vital role in overall performance of the Indian economy. In the time of green revolution (1965-66), use of modern technology such as chemical fertilizers, pesticides, improved variety of seed including HYV seeds, machinery and extensive irrigation has started. India witness an increase in food grain production and attained a self sufficiency at around 1977. This has been achieved only through the used of HYV seed in coupled with agricultural chemicals. Of all the above inputs fertilizer is the key element to maintain the tempo of agricultural production as studies have indicated that it has contributed to about 50 per cent of increased food grain production in Asia (Hopper 1993 and FAO 1998). The importance of pesticide grew in Indian agriculture due to increased in area under HYV seeds which are easily prone to pest and disease. Therefore, the use of chemical fertilizers and pesticides has played a positive role in increasing agricultural productivity and in making India self-sufficient in food grain production. The total fertilizer consumption in Andhra Pradesh during 2001-02 in terms of nutrients (N, P, K) was 144.51 kg ha^{-1} which increase to 278.42 kg ha-^{1} in 2010-11. While the consumption of pesticides are reduced drastically in the state. As fertilizers and pesticide become one of the important components in agricultural production, its adequate supply is of great importance. Thus, fertilizers and pesticide consumption needs to be thoroughly examined, along with the factors responsible. The specific objectives of the study are:

1. To study the growth of consumption of major chemical fertilizers and pesticides in Andhra Pradesh.
2. To analyse factors affecting fertilizer and pesticide consumption.
3. To assess the impact of fertilizer use and pesticide on productivity of selected crops
4. To estimate the potential demand for chemical fertilizers and pesticide and to suggest the policy measures.

Over the last three decades (1981-2011), N, P, K and NPK in absolute quantity and its per hectare consumption observed an increasing trend with fluctuation in some years. The absolute NPK consumption was found to be increased by four times while per hectare consumption, by five times. The per hectare nitrogen consumption was more compared to phosphorous and potassic fertilizer in all the study years. The compound growth rate of absolute N,P,K and NPK for the state as a whole was 4.09, 5.18, 7.59 and 15.12 respective while for per hectare was 3.98, 5.06, 7.46 and 4.62 over the study

year. The ratio of per hectare consumption of N:P:K was 12:4:1 and 4:2:1 during 1981-82 and 2010-11 respectively showing convergence towards recommended practice.

The per hectare consumption of NPK, N, P and K was increased in all districts over the study years (1981-2011). The per hectare consumption of NPK was 58.32 during TE 1981-84 which increased to 235.46 kg ha^{-1} in TE 2008-11. In TE 1981-84, the per hectare NPK consumption was range from 166.17 kg ha^{-1} (Nizamabad) to 15.10 kg ha^{-1}(Adilabad). Similarly, in TE 2008-11 there it was range from 473.63 kg ha^{-1} (Ranga reddy) to 95.71 kg ha^{-1} (Vishakhapatnam) during the same period. Among the districts highest increased in NPK consumption was observed in Adilabad and Ranga Reddy while lowest increase in Adilabad. The variation of NPK per hectare consumption was reduced overtime. Among the nutrient fertilizer, potash has highest variation among the districts while nitrogen has less variation. This shows nitrogen was most familiar among the farmers compared to other fertilizer nutrients. This might be due to easy availability of nitrogen base fertilizers.

Over the three decades (1981-2010), all the districts have shown positive growth in per hectare consumption of NPK, N, P and K fertilizer. Among the districts, highest growth in consumption of nitrogen and phosphorous fertilizer was recorded in Ranga Reddy district followed by Adilabad. For potash, Vizianagaram recorded the highest positive growth by Srikakulam.

During the TE (1981-84), almost all the districts consumed more NPK in rabi season than kharif season. While during the TE (2008-11), most of the districts (9 districts) consumed more NPK during kharif season. The per cent difference in NPK used in two seasons was 31.99 per cent during TE (1981-84) which decreased to 6.14 per cent during TE (1981-84).

Both absolute and per hectare consumption of pesticide showed a negative growth rate of -10.28 per cent and -12.47 per cent during this two decades, which shows decrease in consumption over the year. The per hectare consumption of pesticides was 0.87 a.i. kg ha^{-1} during 1989-90 which reduced to 0.11 a.i. kg ha^{-1} (2009-10). In both the TE period, Guntur shared the highest consumption of pesticide followed by Khammam.

In the farmers sample data, the land use intensity was 121.59 per cent during 2010-11. Paddy and cotton (Bt) were the two main crops of the sample farmers in Andhra Pradesh occupying about 70 per cent of gross cropped area. Maize and blackgram crops were the other main crops, which covered about 4.66 per cent and 4.44 per cent of gross cropped area, respectively. Soybean and chilli occupied less than 2 per cent of gross cropped area. Per hectare consumption of total NPK, N, P and K was 196.07, 103.91, 59.98 and 32.18 kg ha^{-1} respectively. Out of the total fertilizer consumption in terms of NPK, the highest was consumed by paddy (64.93 %) followed by cotton (Bt) (11.78%) and maize (5.57 %). Deviation in per hectare fertilizers consumption was less in major crop while it was more in pulses and minor crops. The highest total pesticide per hectare was consumed by cotton (1.90 a.i. kg ha^{-1}) followed by paddy (1.87 a.i. kg ha^{-1}), maize (1.72 a.i. kg ha^{-1}), groundnut (1.39 a.i. kg ha^{-1}) and redgram (0.92 a.i. kg ha^{-1}). In most of the crops, share of insecticide was more compare to other category of pesticides.

Among the factors which affects the paddy yield, NPK was the most important factor followed by land and seed quantity. The major factor which affect yield of maize was the quantity of seed and per hectare fertilizer consumption. For groundnut crop, most important input was human labour followed by seed and area while pesticides and fertilizers was non significant. For cotton crop human labour was the most important factor while increase in the cost of pesticide had negative effect on yield and NPK has positive impact on yield but it was not an important factor in increasing the yield.

The most important determinant for fertilizer consumption among the farmer was area under fertilizer intensive cropped followed by relative price of output to

fertilizer price and wages. Similarly, the important determinant of expenditure on pesticide was quantity of NPK consumption among the study crops.

At state level, the determinant of fertilizer consumption was price of fertilizer, irrigation and output price. Between the input and output price, former was the most powerful factor in influencing fertilizer consumption. So it is necessary to prioritize reduce input price policy mechanism over higher output prices as high output price benefit a small proportion of farmer while low input price will increase fertilizer consumption on millions of small and marginal farmers.

The study shows that consumption of fertilizer will increase while pesticides demand will reduce in future.

The conclusion and policy recommendation is that effort should be made to reduce disparities of consumption of fertilizer and pesticides among the districts by taking up programme like timely supply of inputs in remote areas, extension services for the use of inputs in a scientific line. Soil testing facilities should be provided to the farmers so that optimum quantity might be use by farmers. Facility should be made ready to provide required input amount to the farmers in future. Input price should be kept in affordable level to all farmers.

Chapter I

INTRODUCTION

Agriculture is one of the major sectors and plays a vital role in overall performance of the Indian economy. At the time of Independence, (1950-51) agriculture was contributing major share to the GDP of about 56.5 per cent. However, its contribution was reduced to 14.6 per cent in 2009-10. But, it has been an important sector in the country which supports 70 per cent of population directly or indirectly depend on it during early 1950s. The eleventh plan (2007-12) estimated that agricultural sector still provides employment to 57 per cent of India's work force and is the single largest private sector. More over it has been the important source of supply of raw materials to agro based industries. In recent years, the importance of food processing industries are being increasing recognized both for generation of income and employment. Its share in total exports was 10.59 per cent in 2009-10. The role of agriculture in India is not only restricted to its contribution to national income and employment but also extends to food security of the nation. It is expected that the total food requirement would be 322 million tonnes in 2025.

The population of India in 2001 census was 1027 million, which increased to 1210.19 million in 2011 census. The decadal growth rate was 17.64 per cent. To feed the ever-increasing population, productivity of agriculture has to increase. The agricultural production can be increased either by bringing more area under the plough or by increasing productivity. Cultivated land area has been shrinking due to increase in population and demand for other purposes. Owing to the limited net cultivatabe area, the only option available to increase the productivity is by using modern technology in an efficient way. The modern technology includes HYV seed, fertilizer, plant protection chemicals, irrigation etc.

During green revolution (1965-66), use of modern technology such as chemical fertilizers, pesticides, improved variety of seed including HYV seeds, machinery, extensive irrigation has started. And India witness an increase in food grain production and attained self sufficiency at around 1977. The total food grain production in 1960-61 was 82 million tonnes which increased to 235 million tonnes in 2008-09. This has been achieved only

through the use of HYV seed coupled with agricultural chemicals. Of all the above inputs fertilizer is the key element to maintain the tempo of agricultural production as studies have indicated that it has contributed about 50 per cent of increased food grain production in Asia (Hopper 1993 and FAO 1998). The importance of pesticides grew in Indian agriculture due to increased in area under HYV seeds which are prone to pests and diseases. So, the use of chemical fertilizers and pesticides has played a positive role in increasing agricultural productivity and in making India self-sufficient in food grain production. Optimum crop production depends on inputs such as commercial fertilizer and pesticide. Today's technology-based agricultural practices have had a huge effect on increased food production across the prairies.

Maintenance of soil fertility is essential to sustain agricultural production. Soil degradation, mainly the decline in soil organic matter both in quality and quantity, is one of the major reasons linked to stagnation and decline in yields in most of intensive agriculture areas in India. The response of additional fertilizer application to food grain production has shown a distinct declining trend in recent years: the increased use of synthetic fertilizers no longer contributes to higher soil productivity. The average crop response to fertilizer use was around 25 kg of grain per kg of fertilizer during 1960s, the said value has reduced drastically to eight kg ha^{-1} only during late 1990s. High use of chemical fertilizers is mostly associated with high level of water consumption and micro-nutrient deficiency in soil leading to decline in water table and further deterioration of the soil.

Pesticides have been introduced during the mid-sixties on a large scale along with other inputs for propagating green revolution package in Indian agriculture. The main intention of the introduction of pesticides was to prevent and control insect pests and diseases in the field crops and of course, initially the use of pesticides reduced pest attack and paved way for increasing the crop yield as expected. With the introduction of new varieties of various crops which are highly susceptible to pests and diseases, the use of pesticides has become a part of crop production technology. Constant use of chemical pesticide in development of the resistance to pesticides. So farmers are forced to use more pesticide to control the insect pest incidence. Adoption of HYVs technology gave path to increase in pesticide demand in Indian agriculture, due to increase in plant diseases. To remove pest problem, pesticides and insecticides demand has been increased, at greater extent, over a period of time. Pesticides not only contaminate the ecosystem but also bio

accumulates in the food chain and can be traced in plant and animal tissues causing serious health hazards. As per World Health Organization estimates, pesticides lead to one million pesticide poisoning cases and 20,000 deaths every year globally.

With the use of fertilizers and pesticides comes the increasing environmental concern over potential contamination of soils, surface water and groundwater. But to increase productivity and to feed the large population and maintain self sufficiency, it is not appropriate to depend on the increased fertilization or reduced fertilizer use as there are concerns on productivity, sustainability and environmental degradation.

Since the adoption of new agricultural strategy during 1960 onwards, the consumption of chemical fertilizers has been growing rapidly. Fertilizer consumption was around 67 thousand tonnes in early 1950s and picked up very fast during mid 1950s. By early 1960s consumption of NPK crossed 400 thousand tonnes and at the time of onset of green revolution consumption of fertilizer approached 1 million tonne and increased to 26.48 million tonnes in 2009-10. On per hectare basis, fertilizer consumption in India increased from 0.5 kg in early 1950s to 7 kg at the time of onset of green revolution. Similarly, it further increased to 140.15 kg ha^{-1} in 2008-09. Since the introduction of the Green Revolution, synthetic fertilizer consumption has increased from a mere 66 thousand tonnes in 1950-51 to a staggering 26486 thousand tonnes in the year 2008-09, a 400 fold increase.

Similarly, pesticide use in India dates back to the year 1948 when DDT and BHC were imported for malaria and locust control. India is now the second largest manufacturer of pesticides in Asia after China and ranks twelfth globally (Mathur, 2010). Among the predominant classes of pesticides used in India are insecticides, which account for 75 per cent of total consumption, followed by fungicides (at 12 %) and herbicides (at 10 %). Furthermore, 54 per cent of the total quantity of pesticides used in the country is used in cotton, with 17 per cent in rice and 13 per cent in vegetables and fruits (Devi, 2007). Pesticide consumption in India has increased from 43584 tonnes in 2000-01 to 55540 tonnes in 2010-11 (Source: Ministry of Statistics and Programme Implementation, Govt. of India, 2013). However, average per hectare pesticide consumption in India (0.5 kg ha^{-1}) compared with averages in other Asian countries like Korea (6.60 kg ha^{-1}) and Japan (12.0 kg ha^{-1}) are quite low. According to the pesticide industry statistics, India spends only $ 3

ha^{-1} on pesticides as compared to \$24 ha^{-1} spent by Philippines, \$255 ha^{-1} spent by South Korea and \$633 ha^{-1} by Japan.

The major states which had per hectare fertilizer consumption higher than all India average included Punjab (208 kg), Andhra Pradesh ((193.5 kg), Haryana (178.6 kg), Tamil Nadu (176.5), Uttar Pradesh (141 kg), West Bengal (139.2 kg), Karnataka (130.2 kg), Bihar (120.4 kg) and Gujarat (119.2 kg). The total nutrient consumption during kharif 2010-11 was 13924.12 thousand tonnes recording an increase of 8.68 per cent over kharif 2009-10. The rabi total nutrient consumption was 13674.77 thousand tonnes in 2009-10 which increase by14.2 per cent in 2010-11. The irrigated area, which accounts for 40 per cent of the total agricultural area, receives 60 per cent of the fertilizer applied. There is a discrepancy in the distribution of fertilizers to irrigated and un irrigated crops.

A per hectare usage of pesticides was highest in Punjab (923 gm ha^{-1}), is closely followed by its neighboring agriculturally advanced state i.e. Haryana (843 gm ha-1). Other states like, Andhra Pradesh (548 gm ha^{-1}), Tamil Nadu (410 gm ha^{-1}), Karnataka (216 gm ha^{-1}) and Gujarat (47 gm ha^{-1}) use much lesser quantities (Agnihotri, 2000).

Over the decades, Andhra Pradesh has witnessed a gradual transformation in the agriculture sector. The state enjoys a position of pre-eminence in respect of crop production. Andhra Pradesh is set to scale new heights in agriculture during the 12^{th} Five Year Plan, especially with renewed focus on micro irrigation, SRI cultivation micronutrient application, development of dry land agriculture, Farm mechanization increasing storage capacity and other agriculture related strategies**.**

The total fertilizer consumption in Andhra Pradesh during 2001-02 in terms of nutrients (N, P, K) was 144.51 kg ha^{-1} which increase to 278.42 kg ha^{-1} in 2010-11. The nutrient-wise consumption was 1966 thousand tonnes of nitrogen, 1032 thousand tonnes of phosphorous and 498 thousand tonnes of potash during 2010-11. During the year 2001-02, the pesticide consumption in the State was 3850 tonnes technical grades which reduced to 1350 tonnes technical grades in 2009-10 (Source: Agriculture Department).

The domestic production of fertilizer faces short of requirement. In the case of potassic fertilizers the entire quantity is imported. Imported urea also increases subsidy as its landed cost is higher than the domestic controlled selling price. During 2009-10, India

imported 3488.1 thousand tonnes of nitrogen, 2499 thousand tonnes of phosphorus and 2539 thousand tonnes of potassic fertilizer (Jayathi et al, 2013). Phosphatic and potassic fertilizer were decontrolled in August, 1992. Only urea continues to operate under a price control system and requires a heavy subsidy for keeping consumer price low.

The government had issued the fertilizer control order 1995 under the Essential Commodities Act which regulates quality, price, trade and distribution of fertilizers in the country. The state governments are primarily responsible for ensuring the quality of fertilizers being manufactured and sold in their states through appointment of enforcement agencies.

In Andhra Pradesh, though the continued increase in fertilizer use per hectare of gross cropped area is witness, the current rate of fertilizer consumption was 278.42 kg ha^{-1} in 2010-11, but there is lots of variation among the districts. Even the success achieved, over a period of time is not uniform and has been confined to only a few parts of the state. Hence, it is necessary to identify consumption pattern of fertilizer in the state of Andhra Pradesh.

Though there are a number of studies on fertilizer at the national level, the studies at the disaggregated level are only a few. The exercise at national level in any case is expected to give us some broad perspectives in to the trends in fertilizer and pesticide consumption and nature and extent of the impact of various factors on fertilizer consumption. This has to be supplemented by region wise studies, because the total fertilizer consumption figure gives only a consolidated picture of disaggregated data from different regions. In case of pesticide consumption only few studies in national level are done. Regions may differ widely in respect of soil, climatic conditions, irrigation, adoption of HYVs, the size of farm and so on. All these differences are concealed in the national estimates and make them inappropriate for use in region specific situation.

Analysis of district wise data on fertilizer consumption will be useful because it can reveal the degree of variation in the growth of fertilizer and pesticide consumption across the districts. The consumption over a period of time provides an understanding of forces behind the growth of fertilizer and pesticides and reveals the practices of districts which have remained outside the main stream of past growth in this vital agricultural input. This

in turn will indicate the nature of policy required to achieve rapid growth in fertilizer consumption.

The studies on the quantitative assessment of determinant of fertilizers and pesticides are very essential for perspective planning. In the content of fertilizer industry, demand estimation is vital to monitor supply side, to plan the expansions of domestic capacities, to decide the volume of imports, to create the infrastructure for movement and storage and to know the magnitude of efforts to be put in to achieve desirable targets. Fertilizer and pesticides use decisions at the farmers level is a complex process. To start with, the farmers has to decide whether or not to use fertilizer and pesticides. This is followed by the decisions of which crops to be cultivated, amount of fertilizes and at what rates. The capital rationing and other factors often necessitate decisions on how much crop area to used. It is generally noticed that farmers are not using recommended levels of fertilizers and pesticide for the crops under cultivation.

As fertilizers and pesticides become one of the important components in agricultural production, its adequate and timely supply is of great importance. Thus fertilizers and pesticides consumption needs to be thoroughly examined, along with the factor responsible. The present study has been taken to fill the existing research knowledge gap with respect to district wise consumption pattern of chemical fertilizers and pesticides and to study various factors influencing the consumption pattern at macro and micro level. The results of the study will help formulating suitable policy measures to ensure reduction of variation in fertilizers and pesticide consumption pattern.

The specific objectives of the study

1. To study the growth of consumption of major chemical fertilizers and pesticides in Andhra Pradesh.

2. To analyse factors affecting fertilizer and pesticide consumption.

3. To assess the impact of fertilizer use and pesticide on productivity of selected crops

4. To estimate the potential demand for chemical fertilizers and pesticide and to suggest the policy measures

Hypotheses:

1. Consumption of chemical fertilizers and pesticides are increasing over the years.
2. Chemical fertilizers and pesticides are mainly used in high value crops and irrigated area.
3. Chemical fertilizers and pesticides increase the productivity of the selected crops.
4. The potential demand for chemical fertilizers and pesticides is high.

Limitation of the study

The data used is of secondary in nature and cross sectional primary data (from CCS) but when the suggestions are to be drawn for other states the relevant data should not be neglected to draw valid conclusions. Due to limitation of time the probe was limited to district level and could not go beyond that except for CCS data. One should be careful when generalizing the results.

For convenience in understanding, the entire thesis has been presented in five chapters. Namely,

1. Introduction
2. Review of Literature
3. Methodology
4. Results and Discussion
5. Summary and Conclusions

Chapter II

REVIEW OF LITERATURE

For any investigation, the findings of earlier studies may possibly give insights of the problem and sets direction for the research problem. An extensive review of literature must therefore be undertaken in order to have a perfect knowledge of the various concepts related to the study and to understand key areas already covered and know the areas to be focused further. In this chapter, an attempt has been made to review the literature of the past research work in India and abroad relevant to the present study. The review has been presented under the following heads.

2.1 Growth and consumption pattern of chemical fertilizers and pesticides

2.2 Factors influencing use of chemical fertilizers and pesticides

2.3 Impact of chemical fertilizers and pesticides on yield/ crop production.

2.4 Projection for chemical fertilizers and pesticides.

2.1 Growth and pattern of consumption of chemical fertilizers and pesticides

Jha and Sarin (1981) made a district level analysis on fertilizer consumption in Semi-Arid Tropics (SAT) of India using the data for the period from 1969-70 to 1978-79. The study indicated that over 62 per cent of the total fertilizer (N and P_2O5 and K_2O) used in the SAT districts was consumed in the 78 irrigated districts which had only 35 per cent of the SAT cropped area. Thus fertilizer consumption was mainly concentrated in irrigated districts. The average level of fertilizer consumption per hectare of cropped area was 57 kg in the irrigated and 18 kg in the non-irrigated districts. Considerable variation was noted in fertilizer consumption between districts even within irrigated and non -irrigated categories. The irrigated SAT districts showed better performance in terms of growth in the total fertilizer consumed during the study period.

Krishnamacharyulu and Muralidhar (1981) estimated the growth rates of per hectare fertilizer use in 18 major states of India using the data for the period from 1968-69 to 1978-79. They observed significant and positive growth rate for all the states except Kerala and

Assam. Using the Spearman's rank correlation they examined shifts in the relative position of the states in per hectare fertilizer use with reference to base year 1968-69. They noticed that no state had shown any significant shift in its fertilizer use status. While computing the coefficient of variation for each year to determine the inter state disparities in fertilizer use, they found that there were large scale inter state variations in the levels of fertilizer use and it did not show any tendency of narrowing down over the period.

Nagaraj (1982) trend in fertilizer consumption in India for the year 1951-52 to 1980-81. The trend analysis revealed a definite deceleration in aggregate fertilizer consumption since mid-sixties. There is a wide gap and diverging gap between the targeted and actual levels of fertilizer. The author concluded that this is due to lack of demand of fertilizer, process of diffusion of fertilizer practice is weak. Non availability of credit seems to restrict use of fertilizer.

Rao (1982) studied the fertilizer consumption and disparities in India for the period of 1970-71 to 1978-79. The study recorded an increase of fertilizer consumption of about 2.93 million tonnes over the year *e.i.* 134 per cent increased. During this period nitrogen, phosphorous and potassic fertilizer increase by 1.93, 0.64 and 0.37 million tonnes respectively. The regional disparities in nitrogen and phosphorous fertilizer consumption was reduced from 11.06 to 9.94 and 18.82 to 17.49 respectively. The disparities of potassic fertilizer was increased from 49.59 to 52.82.

Bhatia (1983) studied the pattern of fertilizer consumption in India for 16 states based on data collected from "comprehensive scheme for studying cost of cultivation of principal crops in India" for the year 1977-78. The study revealed that per hectare consumption of fertilizer is highest in Punjab (131 Kg/ha) followed by Tamil Nadu (108.71 kg ha^{-1}). The rate of consumption of fertilizer in case of jowar and bajra was generally very low. For the maize crop rate of consumption was highest in Punjab (40.29 kg ha^{-1}) and Rajasthan reported quite low consumption of 1.92 Kg/ha. For wheat crop, Punjab consume the highest rate (125.69 kg ha^{-1}) followed by Haryana (111.12 kg ha^{-1}). Maharashtra recorded the highest application in sugarcane (338.02 kg ha^{-1}) followed by Tamil Nadu (212.79 kg ha^{-1}). In case of cotton, highest rate of application of fertilizer was recorded in Andhra Pradesh (201.85 kg ha^{-1}) followed by Tamil Nadu (85.5 kg ha^{-1}). It was also revealed that in Orissa, paddy accounted for 93.49 per cent of the total fertilizer

consumption followed by Tamil Nadu (70.90 %) and Andhra Pradesh (68.10 %). Among the non foodgrain crops cotton and sugarcane were important fertilizer consumption point of view. In Andhra Pradesh, cotton and sugarcane accounted for 15.63 per cent and 8.5 per cent respectively of the total fertilizer consumption in the state. In Maharashtra, sugarcane accounted for 23.1 per cent whereas cotton accounted for 12.79 per cent of the total fertilizer consumption. It is also concluded that, paddy was the most important fertilizer consuming crop in the country which accounted for 34.72 per cent of the total fertilizer consumption followed by wheat (27.65%).

Singh (1983) using the coefficient of variation as a measure of inequalities in fertilizer use, examined the inter state variations in levels of fertilizer consumption during the period from 1961-62 to 1981-82. Although the consumption levels in all the states increased over the period, the degree of variation in levels of fertilizer use among the states had continued to remain high.

Leela (1985) studied the trend in the consumption of fertilizer in Andhra Pradesh. It was revealed that nitrogen consumption in the state declined from 92,200 tonnes in 1962-63 to 72600 tonnes in 1964-65, which further increase to 150300 tonnes in 1981-82. Total NPK consumption was 117100 tonnes in 1962-63 increase to 655,500 tonnes in 1981-82. Per hectare consumption of NPK was 3.01 kg ha^{-1} in 1960-61 which increase to 93.35 kg ha^{-1}. There is wide variation in the level of per hectare consumption of fertilizer among the district. The lowest level of fertilizer consumption was 0.46 kg ha^{-1} in Nalgonda district in 1960's and in 1980's it was 6.59 kg ha^{-1} in Adilabad district. The highest level of fertilizer consumption in 1960's was 11.74 kg ha^{-1} and 1980's was 120.15 kg ha^{-1} in Nizamabad district. There is reduction in the inter district variation in the level of per hectare consumption of fertilizer in Andhra Pradesh during 1960 to 1980.

Patel (1986) in his study growth pattern of fertilizer consumption in Gujarat examined district-wise growth as well as inter-district variation in fertilizer consumption, and assessed the factors influencing the inter-district variation in fertilizer consumption. The study found that the growth in fertilizer consumption was higher in 1970's as compared to that in 1960's. The study revealed that the extent of adoption of high value crops in the irrigated area was responsible for interstate variations in fertilizer consumption in Gujarat.

Singh *et al.* (1987) conducted a study on the pattern of fertilizer use in Punjab state. The data was collected from wheat and paddy growers (1971-72, 1981-82 and 1985-86).They found that the average yields of both wheat and paddy have shown a continuous and marked increase since the early seventies. The increase was from 34.73 qt ha^{-1} and 36.91 qt ha^{-1} during 1971-72 to 39.45 qt ha^{-1} and 38.11 qt ha^{-1} during 1985-86 for wheat and paddy respectively. The co-efficient of variation in yield showed a narrowing of yield differential on different farms. The coefficient of correlation between nitrogen fertilizer applied and the yield of wheat and paddy clearly showed that the application of nitrogen fertilizer had contributed significantly to increase the yield level.

Anonymous (1988) study the consumption of fertilizer in Tamil Nadu. The data for the study was obtained from comprehensive scheme for studying the cost of cultivation of Principal crops in Tamil Nadu for the year 1970-71- 1985.and fertilizer consumption at state level are collected from Fertilizer Association of India and Directorate of agriculture, Tamil Nadu. The study shows that Tamil Nadu consumed 2.96 lakh tonnes of NPK in 1970-71 which increased to 6.68 lakh tonnes in 1985-86. Sugarcane had maximum rate of fertilizer consumption (157.79:79:88) followed by paddy (105: 41:35). The study also revealed that irrigated crops consumed more fertilizer.

Thakur and Sinha (1988) examined the pattern, growth of fertilizer use in different regions of Bihar. The study revealed that among the different regions, use of plant nutrients (NPK) was comparatively higher in the southern regions followed by northern and Chotanagupur regions. Growth rate of total plant nutrients indicated that in all the three regions, it was not only positive but marginally higher in the north region followed by Chotanagpur and southern region.

Mohanam (1989) analyzed the growth rates of fertilizer consumption in Tamil Nadu. The study found that the rate of fertilizer consumption of Tamil Nadu is less than the all-India growth rate, and the growth rates of fertilizer consumption of the districts in Tamil Nadu almost cluster around the state level growth rate, there is inter-district variation. There is a difference in the growth rates of fertilizer consumption between the pre and post-green revolution period.

Srivastava and Patel (1990) examined the pesticide use in India. It was observed that among the five groups of pesticides, insecticides dominate in quantity and value terms.

In 1981-82, the share of insecticides was 89.9 per cent but it declined to 84.7 per cent in 1986-87. The share of herbicides and fungicides in terms of quantity has increased from 2.2 per cent and 6.1 per cent in 1981-82 to 3.8 per cent and 8.1 per cent in 1985-86 respectively. Pesticides in agriculture for 1984-85 was very high in Andhra Pradesh which accounts for 33.6 per cent of the pesticides consumption in the country. Karnataka, Gujarat, Punjab, and Maharashtra account for about 16.2 per cent, 15.2 per cent, 11.4 per cent and 5.1 per cent respectively. These five states together account for about 81.5 per cent of the consumption in the country.

Biswas and Tewatia (1991) studied the fertilizer use in different agro climatic regions of India. Fertilizer consumption has increased from 0.55 kg ha^{-1} in 1951 to 65.4 kg ha^{-1} in 1989-90. The crop productivity is maximum in zone 6 (trans-gangetic plains region) having highest irrigated area and fertilizer consumption. Productivity is lowest in zone 14 (west dryland) which suffer from scarcity of water and low use of fertilizer.

Kumar *et al.* (1991) studied fertilizer consumption pattern in upper Gangentic plain region. The total NPK consumption in the region during 1989-90 was 1349 thousand tonnes which constituted about 11.7 per cent of the total fertilizer consumption of the country.

Waghmore and Sorgekar (1991) urged the farmers to use chemical fertilizers as a part of the modern technology for agricultural production in India. The study examined the consumption pattern of fertilizers in Maharashtra in order to assess per hectare utilization and the consumption of nitrogen, phosphates, potash and all chemicals fertilizers together. Time series data for the period from 1972-73 to 1986-87 were used. The trends in fertilizer use in general were found to be positive in all most all districts in the state. The consumption of fertilizer per hectare was found to increase from 12.84 Kg in 1972-75 to 31.49 kg in 1984-87. The highest consumption level of 129.66 kg/ha was noticed in the district of Kolhapur.

Singh *et al.*(1992) studied the per hectare use of fertilizer in Haryana. It was observed that per hectare use of fertilizer on wheat crop has increased in all size groups in all the zones. It was 160.69 kg ha^{-1} in 1990-91 which increased to 190.17 kg ha^{-1} (increased by 18.35 %) in 1991-92. The fertilizer consumption per hectare of mustard increased from 81.73 to 110.00 kg ha^{-1} (35.72 per cent) in the same period.

Pradhan *et al*. (1993) attempted to study the trend and pattern of fertilizer consumption in Orissa in 1968-1992. The study found that the growth rate of total fertilizer consumption in Orissa was close to that of the all India level. The growth rate of per hectare fertilizer consumption of the state was 7.47 per cent, as against the growth rate of 8.67 per cent at the all India level. The total share in fertilizer consumption by leading five irrigated districts was reduced from 87.79 per cent in 1970-71 to 73.88 per cent in 1991-92.

Anonymous (1995) studied crop wise fertilizer use in Andhra Pradesh during 1990-91. The study revealed that small farmers with share of 18 per cent of the total cultivated area accounted for 23.5 per cent of the nutrient consumption, medium farmers with a share of 31.2 per cent of the cultivated area accounted for 32.4 per cent of nutrient consumption, while large farmers with a share of 50.8 per cent of the cultivated area accounted for 44.1 per cent of total nutrient consumption. The crops using the higher amounts of fertilizers were sugarcane, paddy and cotton.

Lin *et al.* (1995) studied pesticide and fertilizer use and trade in US agriculture. Pesticides used on major crops increased by more than two folds during the period between 1964 and 1982. Nitrogen, phosphate, and potash use for all purposes (agriculture and non agriculture) rose from 7.5 million pounds in 1960 to a record high of 23.7 million pounds in1981. Since the early 1950s, pesticide and fertilizer use in US agriculture has declined with crop acreage and amounted to 574 million pounds of pesticides and 20.7 mt of fertilizer in 1992.

Inamke *et al.* (1996) examined the fertilizer use pattern for sugarcane in respect of three recovery zones of sugarcane in Maharashtra at different points of time. They observed that among the three recovery zones, the use of N, P2O5 and K2O fertilizers was not as per the recommendation and it was very low in low recovery zone where the productivity was also very low (50 t ha^{-1}) as compared to other two zones.

Haffis *et al.* (1997) pointed out that fertilizer use deviated more widely in rice, groundnut, sesamum, black gram, sugarcane and cotton in different size of farms in Andhra Pradesh. Both excess- use and under-use of fertilizer nutrients were evident across different locations and crops.

Anonymous (1998) studied the consumption of fertilizer in India. The studied recorded that fertilizer use (N+P+K) increased from 1139.7 thousand tonnes in triennium

ending1968 to 16717.7 thousand tonnes in triennium ending 20004. The largest absolute increase occurred in N content. In the early phase of green revolution during 1965-1974, fertilizer use showed tremendous growth. From 1975 to 1990, when the green revolution technology matured, fertilizer use still grew at the higher rate but lower than the previous period. The growth has been slow since 1990s.

Rao *et al*. (1998) studied the fertilizer use pattern in Andhra Pradesh for the year 1992-93. The studied revealed that wide variations in fertilizer used were observed both within and across different agro-climatic zones of Andhra Pradesh. North Telangana and Krishna Godavari zone used high dose of fertilizer. It also revealed that regions with high fertilizer used for irrigation crops were not necessary applying the higher doses to dry land crops. There is no significant correlation between fertilizer used for irrigated and dryland crops. So, it was concluded that fertilizer used decisions are more governed by the factors external to the farmer profitability and risk associated with the crop, availability of fertilizer, accessibility to credit, rainfall etc.

Tripathi (1998) investigated the trend and pattern of consumption and production of agro-fertilizer in the country. The study revealed that India has made progress in consumption and production of fertilizer during the last 45 years. The contribution of fertilizer in food grains production was over 50 per cent in the country. The consumption had increased from 66 thousand tonnes in 1951-52 to 13.5 million tons in 1994-95.

Chandrasekaran and Krishnamoorthy (1999) studied the pattern of growth of fertilizer use in Tamil Nadu by using secondary data. The studied revealed that total fertilizer use and per hectare use had grown during the period between 1968 and 1992 by 297.08 per cent at state level. Among the districts, it ranges from 100.01 per cent in the Nilgiris district and 544.40 per cent in Madurai district. The compound growth rate of fertilizer consumption at the state was estimated at 7.18 per cent per annum. The per hectare fertilizer consumption had also increased from 28.45 kg ha^{-1} in 1968-71 to 122.43 kg ha^{-1} in 1989-92. The rate of growth of per hectare fertilizer use was 7.77 per cent at state level. It was also revealed the nutrient P and K had grown faster than N both at state and district level. And among P and K, the growth rates of K are substantially higher than that of P. The relative share of NPK among the district also change but ranking of districts on the basis of total fertilizer consumed, remained more or less same during the two point of

time. However in terms of fertilizer nutrients consumed per hectare, the ranking varied. The author concluded that there is need for continuing the fertilizer promotional measures such as the subsidized distribution, in view of the lower level of use of fertilizers predominantly rainfed agriculture.

Haffis et *al.* (1999) studied the variation of fertilizer use in different climatic zone in different crops in Andhra Pradesh. The study revealed that greater degree of inefficient use of fertilizer nutrients in the production of different crops across different agro-climatic zones of Andhra Pradesh.

Maloymudi and Giri (1999) conducted the study on variation in the pattern of fertilizer use between Aman paddy and potato and their economics in a latertic zone of West Bengal. Primary survey was conducted purposively in selected three village of Ghatal block in the district of Midnapur for the study. They found that farms used different types of fertilizer in different forms and combinations either as single nutrient fertilizer or a mixed nutrient fertilizer and branded, unbranded or in the combination of both. They concluded that the potato growers had inclination to use mixed fertilizers along with single nutrient fertilizer. Paddy growers preferred the use of single nutrient branded fertilizer in majority cases. There was a positive correlation (0.39) between percentage of nitrogen placed as top dressing and yield.

Singh *et al.* (1999) studied the fertilizer use, problems and potentials in rainfed areas in India. The study revealed that the impact of fertilizer use on productivity was much less significant in rainfed farming throughout the country. The average use of fertilizer remained quite low (25 kg ha^{-1}) in rainfed crops. A number of constraints limiting the wide spread use of fertilizer in dry lands was noticed. Uncertainty of rainfall was one of the primary risk factors influencing the farmer's decision in using this expensive input.

Velrasu and Singh (1999) examined the fertilizer use pattern and its impact on crop productivity from survey of 72 farmers. The study revealed that most of the farmers did not follow the recommended fertilizer dose in Tamil Nadu. Besides this, there was a wide disparity in fertilizer use among various categories of farmers and crops. Fertilizer use was high in irrigated areas as compared to dry land areas. The over utilization of N and under utilization of P and K was noticed. They emphasized the need for efforts to ensure balanced fertilizer use by the farmers to make agriculture sustainable.

Singh *et al.* (2000) studied constraints in fertilizer use in Arid Zone of Western Rajasthan. They found that among the fertilizer users, maximum farmers have applied more nitrogenous fertilizer as compared to phosphatic fertilizer and fertilizer applied was less than the recommended dose. The main constraints perceived by the farmers were lack of irrigation facilities, high cost of fertilizer and lack of knowledge on fertilizer use.

Vatta and Dhawan (2000) in their study highlighted the trends and changes in the fertilizer consumption and the factors affecting fertilizer use in Punjab. The study found that the fertilizer use has increased both in terms of total as well as per hectare in the state. However, increase in fertilizer use per hectare of cropped area was almost stagnated during the nineties. It necessitates a greater attention towards research and development of high-yielding varieties and new crops. The study further revealed that the consumption of fertilizer in the state was highly imbalanced. Proper and extensive efforts, effective pricing of fertilizers would help in achieving the objective of balanced fertilizer use.

Khunt *et al.* (2001) observed high fluctuation in fertilizer consumption with high growth rate in Gujarat state during the period from 1961-2000. They also noticed increasing consumption of K in *rabi* season and declining trend in *kharif* season.

Pratap *et al.* (2000) studied pesticide use in rainfed cotton: Frequency, intensity and determinants in Nanded district of Maharashtra. The studied found that average pesticide usage was estimated at 3.2 kg active ingredient per hectare of cotton area. Besides, farmers also use a number of physical and cultural methods directly or indirectly to limit the crop loss. Farmers vary in their attitude towards Insect pest risk and accordingly use pesticides. Risk averse farmers use pesticides excessively and indiscriminately. Findings suggest that improving farmers' existing stock of knowledge of pests and their management practices can help reduce pesticide use substantially.

Raut *et al.* (2002) studied the trend in fertilizer consumption and production in India. The studied revealed that in India fertilizer consumption increased from less than 50,000 tonnes in 19950 to 18.37 million tonnes in 1999-2000. There is a vast difference in consumption of fertilizer per hectare of cropped area in different region. The fertilizer consumption in 1999-2000 varies from 139, 131, 87.4, 162 (NPK) kg ha^{-1} crop area in North, South, East and West respectively. The studied shows that about 70-80 per cent fertilizer is used for growing rice and wheat. The lowest fertilizer use is in rainfed farming which is over nearly 2/3 of the cropped area in the country. There are wide difference in the

consumption ratio of three major nutrient N:P:K in different regions, crops and cropping system. The NPK ratio for India changed from 5.9:2.4:1 in 1991-92 to 6.9:2.7:1 in 1999-2000.

Rajendran (2003) studied the environment and health aspects of pesticide in Indian agriculture. The study recorded that in India, during the mid-sixties, when the new and high yielding (HYV) crop varieties, mainly cereals, were introduced among farmers, the synthetic inputs covering fertilizers (as nutrient) and pesticides (as insecticides) were recommended to increase production and productivity. The agricultural scientists, policy makers and extension officials had to work hard to educate and convince the farming community to use chemicals without carefully looking into their adverse effects.

Saraswat and Singh (2003) studied the strategy for fertilizer consumption in Himachal Pradesh. The study revealed that the annual compound growth rate in consumption of all fertilizers was 7.06 per cent per annum during the study period. The growth of fertilizer consumption in *kharif* and *rabi* season was 5.88 and 8.29 per cent per annum respectively. The highest annual growth was recorded in Kullu district (9.17%) and the lowest (3.0%) in Kinnaur district. The consumption of total fertilizer in *kharif* declined by 0.41 per cent in Kinnaur.

Mehmood and Shereen (2004) examined the fertilizer demand and drought in India. They observed that of the total fertilizer, 35.1 per cent was used for paddy, 19.3 per cent for wheat, 5.9 per cent for cotton, 5.5 per cent for sugarcane, 4.7 per cent for groundnut, 2.6 per cent for maize crop and the remaining consumption was accounted by other crops. On the whole, about 70 per cent of fertilizers was consumed in irrigated area. Another feature of fertilizer consumption in India was that the cereal crops consumed 60 to 65 per cent.

Singh (2004) in his study revealed that per hectare fertilizer consumption in India was less than that in other developed as well as a few developing countries, even though the consumption has increased by six-folds in the last three decades. He also reported that 55 per cent consumption of fertilizer was concentrated in 5 states.

Xavier (2004) conducted a study on yield response of crops to fertilizer use in Siragaga district of Tamil Nadu from a survey of 200 farmers. The study revealed that application of N was more than the recommended level in all categories of farmers while that of P fertilizers was less than the recommended. Regarding K, marginal farmers used 44.73 kg ha^{-1} while all other farmers used more than the recommended level of 50 kg ha^{-1}.

Bala *et al.,* (2005) studied the trend of fertilizer consumption in India for period of 25 years (1975-76 to 1999-2000). Fertilizer consumption grew at an average of 11.08 per cent over the period of 25 years.

Jeyanthi and Kombairaju (2005) worked out the pesticide use in four important vegetable crops, viz. chillies, cauliflower, brinjal and bhendi using farm level cross-sectional data. It was found that average pesticide usage has been estimated at 5.13, 2.77, 4.64 and 3.71 kg active ingredient per hectare on chillies, cauliflower, brinjal and bhendi crops, respectively. Again, on an average, cauliflower and brinjal are each given 15 applications, chillies is given 13 and bhendi is given 12 applications. For chillies, the number of spraying ranged from 11 to 17, with an average of 13. About 60 per cent of the farmers had an average of 13 or less sprayings, while the remaining gave 14-17 sprayings. For cauliflower, the number of spraying ranged from 11 to 22, with an average of 15. About 78 per cent of the farmers had on the average 15 or less sprayings, while the remaining applied 16 or more sprayings.

Devi (2007) examined Pesticide use in the rice in Kerala. The study recorded that India is the No. 1 manufacturer of basic pesticides in Asia and ranks 12th globally. Among the predominant classes of pesticides used in India are insecticides, which account for 75 per cent of total consumption, followed by fungicides (at 12 per cent) and herbicides (at 10 per cent). Furthermore, 54 percent of the total quantity of pesticides used in the country is used in cotton, with 17 per cent in rice and 13 per cent in vegetables and fruits.

Anonymous (2008) studied the growth of fertilizer consumption in Haryana for the year 1970-71 to 2003-04. The study showed that during this period total consumption of Nitrogen, phosphorous and potash grew by more than 8 per cent, 11.5 per cent and 6.10 per cent per annum, respectively. For wheat crop average fertilizer consumption was 150 kg ha^{-1} of N, 67 kg ha^{-1} of P_2O_5 and while that of paddy was 167 kg ha^{-1} of N and 50 kg ha^{-1} of P_2O_5.

Chand and Pandey (2008) examined the fertilizer growth in India. The study recorded that fertilizer use increased by more than 17 per cent during 1950-51 to 1966-67. Then the growth rate reduced during 1966-67 to 19991-92. It further reduced to 3.4 per

cent growth rate during 1991-92 to 2006-07. The per hectare consumption of fertilizer during 1950, 1991 and 2007 was 0.5 kg ha^{-1}, 70 kg ha^{-1} and 113 kg ha^{-1} respectively.

Qamar *et al*. (2008) studied the pesticide use by cotton growers. It was found that 94 per cent of cotton growers were involved in usage of pesticides to improve their cotton yield while 5 per cent farmers very occasionally used pesticides for their cotton crop and only approximately 1 per cent of farmers rarely used pesticides.

Prasad (2009) examined the efficient fertilizer use in India. The studied recorded that annual growth rate of fertilizer consumption was negative (–0.02%) during 1996–97 to 2003–04, as compared to 2.89 per cent during 1988–89 to 1996–97. And, the annual rate of growth in cereal production was only 0.02 per cent during 1996–97 to 2004–05 against 2.23 per cent during 1990–91 to 1996–97, and 3.15 per cent during 1980–81 to 1989–90. During 2004–05 to 2006–07, the rate of annual growth in fertilizer consumption was 6.2 per cent. With a consumption of 14.4 million tonnes N, 5.5 million tonnes P_2O_5, and 2.6 million tonnes of K_2O in 2007–08, India occupies the second position after China in N and P consumption. In K consumption, India occupies the fourth position. India also occupies the second position in fertilizer N production (10.9 million tonnes in 2007–08) and third position in phosphate fertilizer production.

Abhilash (2011) studied the pesticide use in India. The study recorded that among the various states, Uttar Pradesh is the largest consumer followed by Punjab, Haryana and Maharashtra. Regarding the pesticide share across agricultural crops, cotton account for 45% followed by rice (25%), chillies/vegetables/fruits (13-24%), plantations (7-8%), cereals/millets/oil seeds (6-7%), sugarcane (2-3%) and other (1-2%).Again, among the various pesticide formulations produced, dust formulations constitute about 85% of the total followed by water-soluble dispersible powder (12%) and dispersible powder (2%).

Endale (2011) examined the trend of fertilizer use in Ethiopian. Fertilizer use is concentrated on cereals followed by pulses and oil seeds respectively (CSA 1995/96-2007/08). In 2007-08 the national level amount of fertilizer applied in cereals, pulses and oil seeds were 3962, 160 and 136 thousands quintal, respectively (CSA 2008-09). Teff is the crop with the largest share in fertilizer use among the cereals (40%), followed by wheat and maize with respective shares of 29 per cent and 20 per cent in the period 1994/95-2005/06. In terms of application rate per hectare of cultivated land, wheat accounted for the

largest share (57 kg ha^{-1}), followed by teff and maize respectively. These statistics indicate that the national level intensity of fertilizer use is still lower than the recommended rate of 200 kg ha^{-1} (100 kg of DAP and 100 kg of Urea).

Vijay and Thaker (2011) examined the trend in fertilizer consumption in India in terms of aggregate consumption and intensity of used. Fertilizer consumption was around 78 thousand tonnes in 1965-66, which increased to 12.73 Mt in 1990's. It further increased to 26.5 Mt during 2009-10. The share of nitrogenous fertilizer was 78.5 per cent in 1950's which decline to 65.7 per cent and 62.9 per cent in 1980's and 2005 respectively. The share of phosphorous fertilizer the share was increased from 13.5 per cent in 1950 to 25.6 per cent in 2005. The share of Potash fertilizer increased from 8 per cent in 1950's which increase to 11.5 per cent in 2000's. The per hectare fertilizer consumption increased from less than 2 kg ha^{-1} in 1950's to 31.9 kg ha^{-1}in 19800-81 which further increased to 135 kg ha^{-1}.

Katyal and Reddy (2012) studied the fertilizer use in South Asia. The studied recorded that proportion of N,P and K was 9:3:1. It was observed that during the period 1971-1998, fertilizer consumption was multiplied fourfold. Intensity of fertilizer use ranges between 41 (Nepal) and between 141 kg NPK per hectare.

Mujeri *et al*. (2012) examined improving the effectiveness, efficiency and sustainability of fertilizer use in South Asia. Overall, the consumption of fertilizer in South Asia has shown a persistent upward trend. During 2002–2007, total consumption increased at an average annual rate of 5.7 per cent reaching more than 29 million metric ton of nutrients in 2007. The amount represents 16.5 per cent of the total global consumption in 2007. The region is not only one of the major consumers but also an important producer of fertilizer in the world. The use of Nitrogen is predominant in South Asia accounting for nearly 65 per cent followed by Phosphate (24 %) and Potash (11 %). In South Asia, fertilizer use has been forecasted to grow annually at a high rate of 2.8 per cent over the medium term with corresponding increases for N at 2.2 per cent, P_2O_5 at 3.5 per cent and K_2O at 4.2 per cent. The average application rate in South Asia was 86 kg ha^{-1}in 2006 compared with 118 kg ha^{-1} in Latin America and 179 kg ha^{-1}in developing countries in general.

Prasad (2012) studied the fertilizer and manure consumption in India. The study reported that in 2007-08, India is the second largest producer of fertilizer-nitrogen and the

third largest producer of phosphate fertilizers in the world after China. Potash is totally imported. As regards consumption, India is second only to China in nitrogen and phosphorus. However, the fertilizer consumption in India is quite skewed. The average fertilizer consumption of 120 kg ha^{-1} (in 2007–08). During 2007–08, fertilizer NPK consumption (kg ha^{-1}) was maximum in Andhra Pradesh (205) followed by Punjab (196), Tamil Nadu (184), Haryana (182) and Uttar Pradesh (154), but was less than 2 kg ha^{-1}in Arunachal Pradesh and Nagaland.

Abang *et al.* (2013) studied pesticide use by vegetable growers of the region of Cameroon. It was found that weekly spray of pesticides was the most common practice; 40 per cent of farmers sprayed insecticide, 28 per cent sprayed fungicides. However, 45 and 59 per cent could not identify the insect pests and diseases respectively they were attempting to control. Farmers applied 0.5-9 liters of pesticide per year, 10-49 kg, and 10 to 49 packets of chemicals depending on farm size. 90 per cent of farmers used a knapsack sprayer. About 25 per cent of farmers store chemicals at home. Seventy-five percent receive information about agricultural production from other farmers, and have never received any training on pesticide use practices and health effects. The absence of farmer training further increases the danger of pesticide misuse and cost of vegetable production.

Jadhav and Deshmukh (2014) studied the growth rate of fertilizer consumption. During period I (1990-2000) the nitrogenous fertilizer consumption increased significantly at linear rate 4.94 and at compound rate 4.98 per cent. Phosphatic fertilizer consumption increased significantly at the rate of 5.75 linearly and at compound 5.36 per cent respectively. Growth rate of potassic fertilizer were non significant during the I period in Maharashtra state. During the II period (2000-2010) the growth rate of nitrogenous fertilizer was non significant and the phosphatic fertilizer also non significant but potassic fertilizer was significant in the Maharashtra state. In the overall period the growth rate of nitrogenous fertilizer is non-significant but phosphatic and potassic fertilizers was significant in Maharashtra state.

Jayanthi *et al.* (2013) studied the growth and consumption pattern of fertilizer in India for a period of 30 years (1981-82 to 2009-10). The annual growth rates for consumption of N reached its maximum level at 26.84 during 1988-89; it came to the lowest level of negative percentage of 99.72 during 1986-87. The annual growth rate for P was its maximum level of 31.47 per cent during 1997-998. The annual growth rate for K

reaches its maximum level of 69.97 per cent during 1982-83. It came to the lowest level of a negative percentage of 35.04 during 1992-93. The exponential growth for nitrogen, potash and phosphorous was 4.41 per cent, 5.13 per cent and 4.08 per cent, respectively.

Shende and Bagde (2013) analyzed use of pesticide in paddy of Bhadara district. The farmer in the study were found to use pesticides frequently in paddy cultivation. More than 50 per cent farmers treated the crop by application of insecticide, three times during its production cycle. However, 23.33 per cent farmers applied insecticide four times. The maximum number of application of Insecticide was observed to be five times. It is observed that 31.67 per cent farmers were applied one spray of weedicide. The application of weedicides was not so common in the sample area. These farmer were applied weedicides might be due to unavailability of labour or high wage rate for weeding. The fungicides were mainly used to control fungal diseases. On paddy, blast was the common diseases observed in the study area. All most all formers were used fungicides, of which 61.67 per cent of them opted for two fungicide spray while remaining 20 and 18.33 per cent opted for single and even three fungicides spray respectively. On an average one hectare of paddy area received 1.72 a.i of technical grade pesticides in the study area. Insecticides were the most frequently used pesticides which accounted for bulk of the share (59.30 per cent) in total pesticides used and followed by Fungicides (29.65 per cent) and weedicides (11.05 per cent). On an average one hectare of paddy area received 1.72 a.i of technical grade pesticides in the study area. Insecticides were the most frequently used pesticides which accounted for bulk of the share (59.30 per cent) in total pesticides used and followed by Fungicides (29.65 per cent) and weedicides (11.05 per cent).

Singh (2013) studied growth rates in fertilizer consumption and foodgrains production of India. The studied shows that fertilizer consumption increased by more than 19 per cent in the pre-green revolution period (1950-51 to 1966-67) while food grains production increased by only 2.56 per cent. This significant increase in total fertilizer consumption increased per hectare fertilizer use from less than one kg in 1951-52 to about 7 kg in 1966-67. In the post-green revolution period, fertilizer use increased by 9.9 per cent per year during the first phase of green revolution (1967-68 to 1980-81) when spread of high yielding varieties was limited to mainly Punjab, Haryana, western part of Uttar Pradesh and some southern states. Per hectare fertilizer consumption increased from 9.4 kg

in 1967-68 to 31.9 kg in 1980-81. During the second phase of green revolution (1981-82 to 1990-91), when technology spread to other parts of the country, total fertilizer consumption increased an annual growth rate of 7.39 per cent. Per hectare fertilizer consumption increased more than doubled from 34.3 kg in 1981-82 to 69.8 kg in 1991-92.

Kaushik and Paharia (2014) studied the Pattern of fertilizer use on major crops grown in Hisar District of Haryana. The average quantity of fertilizer use per hectare of the cropped area in 2009-10 was found as 213.46 kg for the State as a whole. During the same period, it was 178.53 Kg in Hisar district, which comes out 83.63 per cent of the State average. In total consumption of NPK the proportions of N, P and K were respectively, 70.95, 24.57 and 4.47 per cent in Hisar district whereas for the State as a whole these were 76.98, 21.08 and 1.93 per cent respectively.

Rani (2014) studied the growth and consumption pattern of chemical fertilizers in Haryana during the period 1966-67 to 2011-12. The state consumed 13,347 tonnes of NPK during 1966-67 while the consumption was increased to 14, 28,048 tonnes during 2011-12. The consumption of N, P_2O_5 and K_2O was 12626, 574 and 147 tonnes respectively in 1966-6, which was increased to 1020892, 369624 and 37531 tonnes in 2011-12. The average consumption of NPK in Haryana was 579163.6, 175481.1 and 19158.2 tonnes respectively. The data reveals that during 1966-67 to 2011-12, the growth rate in consumption of NPK has shown an increasing trend. The growth rate of Nitrogen is 36.85 per cent, the rate of Phosphorus is 58.72 per cent which is highest and the rate of Potash is 48.57 per cent.

2.2 Factors influencing use of chemical fertilizers and pesticides

Sidhu and Carlos (1979) studied the fertilizer demand for Mexican wheat varieties in India for the year 1970-71. The results indicate that output price is a more powerful policy instrument than fertilizer price to influence fertilizer use.

Patil and Pandey (1982) conducted a study on nitrogenous fertilizers using time series data from 1955-56 to 1974-75. The study emphasized the need for remunerative and stable price of crops apart from irrigation and technological changes. In Karnataka irrigation was the only significant factor influencing the fertilizer use over the period.

Sarup and Pandey (1982) identified the socio-economic characteristics discriminating fertilizer users from non-users in Orissa. The discriminate functional analysis bought forth the innovative attitude of the farmer in terms of adoption of high - yielding variety seeds and plant protection measures and availability of short term credit during the crop season. The results suggested solving them institutional problems of the area to boost up the fertilizer use. Availability of improved seeds, and diffusion of technical know- how would induce the farmers to apply fertilizer.

Gupta (1983) examined the trends in fertilizer consumption by using multiple Regression analysis to capture the effect of different variables on consumption of nutrient N (kg) per hectare of cropped area in India (1970-79). Among the variables considered area under irrigation, weather, relative price of fertilizers and the share of cropped area exerted positive and significant influence on dependent variables, while the area under HYVs and the credit failed to exert significant influence.

Nagaraj (1983) studied the determinants of fertilizer use in Indian agriculture. The study shows that irrigation is uniformly a dominant influence- especially ground water. Spread of HYVs and fertilizer intensive crops are found to a positive effect on fertilizer consumption. Use of fertilizer and relative price are inversely related.

Flinn and Shakya (1985) studied the factors influencing the adoption and usage rate of fertilizer for wheat in Nepal. The study revealed that the factors related to fertilizer use in wheat were the area under cultivation, extent of irrigation, transport cost, and operators tenure status. They further revealed that fertilizer adoption was sensitive to the cost of fertilizer and procurement implying that farmers in the area were responsive to fertilizer price as reflected in procurement plus delivery cost.

Padma *et al.* (1985) examined the technical and economic factors influencing the adoption of modern varieties and the use of fertilizer on rice. The study found that adoption of modern varieties was highest where irrigation exists. However because half or more of Asia's rice land will remain rainfed in the foreseeable future, greater spread of modern varieties into these adverse environments would depend on new varieties being bred that are specifically adapted to these environments. Modern varieties adoption was also an important determinant of whether a farmer will use fertilizer and how much. Access to credit and in the case of fertilizers low transportation costs were significant determinants of adoption, as was frequency of extension contact. However, increasing extension visits had

less impact on adoption than changes in the price related variables. Neither the farm operators' years of schooling, nor his family size was a significant determinant of modern varieties or fertilizer adoption.

Subbarao (1985) argued that there were differences in the determinants of fertilizer off- take in low, medium and high productivity districts in the region. In the low productivity districts, fertilizer off-take was essentially demand determined, being explained almost entirely and directly by quantity of irrigation and soil rating index. In the medium and high productivity districts, fertilizer consumption was primarily influenced by supply side factors, viz., access to fertilizer retail out-lets, credit institutions, rural road net-work and related infrastructure. The study indicated that in both low and high productivity districts, the physical and institutional environment of the district played a dominant role in conditioning the extent of fertilizer use.

Desai (1986) analyzed the policies for growth in fertilizer consumption. He opined that because of the constraints in lowering real prices of fertilizers non-price policies would be more crucial in determining the fate of future growth in India's fertilizer consumption. Under the present price environment, there was great scope to accelerate growth in fertilizer consumption through non-price policies like improving the efficiency of fertilizer use, shifting the responses functions upwards through use of quality seeds and removing the deficiencies in fertilizer supply and distribution system.

Desai (1896) studied the factor affecting fertilizer growth in India. The author revealed that potential use of fertilizer in the country is determined by factors like soil quality, climatic environment, cropping pattern, genetic characteristics of crops. Beside this, generation of knowledge of about fertilizer response function, its spread among farmers and provision of credit to them. Then the flow of fertilizers from factories and ports to geographically dispersed location and the aggregate supply of fertilizer influence the use of fertilizer in India.

Parthasarathy and Rao (1986) studied determinants of fertilizer use in Andhra Pradesh for the year 1984-85. The fertilizer used was regressed with irrigation, HYVs, cropping Pattern, proportion of area under Rabi season to total area. The result shows that 10 per cent change in irrigation likely to increase use of NPK by 3 per cent. A 10 per cent change in cropping pattern towards high fertilizer using crops is likely to increase NPK used by 6 per cent.

Ramasamy *et al.* (1986) studied the determinant of fertilizer consumption in Tamil Nadu. The study observed that price of fertilizer standard deviation of rice price, amount of manure are negatively affect the fertilizer used. While well irrigation, education level of farmer are positive and significantly influence the use of fertilizer.

Thakur and Shiha (1988) examined determinants of fertilizer use in different regions of Bihar. The study revealed that the factors affecting fertilizer use in north as well as south were areas under high yielding varieties of irrigation and rainfall. In Chotanagpur region the area under high- yielding varieties and rainfall significantly affected fertilizer use. The study suggested an expansion of area under high-yielding varieties with assured irrigation facilities, for accelerating fertilizer use, to ensure better productivity and higher yields.

Raju (1989) studied the factor affecting consumption of fertilizer in Andhra Pradesh by using comprehensive scheme for the cost of cultivation schedule (1980-81). The author classified the factor in three groups- physical and technological factor, economic factor and institutional factor. Area under irrigation, HYV seed and cropping pattern increases fertilizer used. The studied revealed that irrigation and area under HYV are the important determinants of fertilizer use for family farmers whereas for capitalist farmers there are other factors which influence fertilizer use. The increase in fertilizer price by 10 per cent results in fall of its consumption by 2.3 per cent. There is significant dominant influence of net return on fertilizer used. This shows that availability of capital at the right time is essential for fertilizer used. It is also observed that fertilizer price relative to output price though significant, do not have strong influence on fertilizer used.

Mohanam (1990) studied the determinant of fertilizer use in Tamil Nadu. The study found that per cent of area under ground water irrigation, per cent of area under irrigation, index of cropping pattern, index of yield per hectare, per hectare short term credit for fertilizers and per hectare short term credit shows a positive correlation while relative price index shows negative correlation with fertilizer use. A result of step wise regression shows that only per cent area under ground water irrigation, per hectare fertilizer credit and per cent of area under irrigation are significant determinant of fertilizer use. Among these three variables, we found irrigation influences the fertilizer use largely.

Subramaniyan and Nirmala (1991) study the fertilizer demand in India. Demand for fertilizer was regressed by using static model. It was found that relative price and land intensity were negatively related with fertilizer demand, while per cent area under HYVs, per cent area under irrigated and weather had a positive relationship with fertilizer demand. The coefficient of relative price indicates that when relative price of fertilizer increases by 10 per cent, there is a 4.26 per cent decrease in the use of fertilizer. The coefficient for area under irrigation indicates that a 10 per cent increase in irrigated area lead to a 14.38 per cent increase in fertilizer use. For a 10 per cent increase in area under HYVs, the increase in fertilizer demand is less than one per cent.

Singh *et at.* (1992) studied the impact of increase in fertilizer price on consumption of fertilizer in Haryana for the year 1990-92. The studied shows that there is overall increase in fertilizer consumption per hectare for the crop wheat and mustard to the extent of 18.35 per cent and 35.75 per cent in spite of increase in price of fertilizer by 30 per cent.

Jha and Hojjati (1993) studied the variable which affect in fertilizer use on small house holder farms in Eastern province, Zambia. The result reported that for fertilizer use, the variables like age, liquidity, fertilizer supply, credit, and market access emerge as significant. None of the others (including personal and institutional factors) affect this decision. Current fertilizer use and adoption of hybrid maize decisions are independent of farm size. Farmers' liquidity, access to credit, and market infrastructure, as well as a functioning distribution system, are the major factors determining use or nonuse of fertilizer in any particular year. The predictive power of the equation explaining intensity of use was very low. Farmers in the Western Zone used lower levels of fertilizer. A higher level of education and access to oxen led to higher fertilization rates. The education result is important when the intensity of fertilizer application is considered, but not in the decision of whether to use fertilizer. A decision on how much fertilizer to use requires more knowledge.

Jena and Mitra (1994) studied the fertilizer use in groundnut cultivation in Orissa, which indicated that the importance of the use of compound fertilizer for better yield. Besides this, the yield rate could be raised to 170 kg ha^{-1} by sowing high yielding varieties seed, using proper irrigation and compound fertilizer in pre-rabi/ summer season then kharif season. By increasing chemical fertilizer by one kg per hectare, the yield of

groundnut would be increased by 2.5 kg ha^{-1}. Moreover, for increasing the yield level as well as production, the availability of compound fertilizer at block level and its proper distribution among groundnut growers have also much importance.

Dholakia and Majumdar (1995) studied the price elasticity of fertilizer demand in India. The result indicates that fertilizer demand in india is price inelastic. A ten percent increase in the relative price of fertilizer may also lead to a less than 2 per cent decrease in the short run and 3.5 percent decrease in the long run in the fertilizer use per hectare of cropopedarea. Thus, the fertilizer demand in India is price inelastic both in the short run and in the long run.

Sheoran and Nandal (1997) examined the factors affecting the consumption of nitrogenous fertilizer in the state of Haryana, which is one of the target contributors to the central pool of food grain. The study found that area under nitrogen responsive crop and irrigation were the most important determinants of nitrogen use. The study suggested a shift in cropping pattern towards nitrogen consuming fertilizers in the state. The improved farming methods and management practices, availability of Nitrogenous fertilizers on credit through government/ Cooperative outlets at subsidized rates and remunerative prices of crop outputs so as to ensure adequate net returns to the farmers should be given due importance in any policy decision, for accelerating the use of Nitrogenous fertilizers in the state .

Rao (1998) *et al.* studied the determination of fertilizer used in Andhra Pradesh for the year 1992-93. Fertilizer used was regressed on the factor like per cent cropped area irrigated, per cent cropped area under commercial crops, distanced to fertilizer dealers, proportion of fertilizer availing institutional credit. The result revealed that all the four variable influence the fertilizer used significantly. They together explained 69 per cent of variation in fertilizer used. Distanced to fertilizer dealer influence fertilizer used negatively and remaining factor influence positively.

Bal and Bal (1999) studied the fertilizer demand for wheat crop in Punjab. The study revealed that if the farmers were motivated to use the optimum does of fertilizer, the demand for nitrogen would be 3499.82 thousand quintals as against the estimated consumption of 1882.82 thousand quintals for the wheat crop during 1971-72. The

consumption of P_2O_5 for this crop was 528.31 thousand quintals against the demand of 1454.23 thousand quintals in the same period.

Wagle (1999) estimated fertilizer demand and private investment function in India using time series data from 1962-63 to 1988-89. They observed that exclusion of the water variable represent a serious deficiency in the specification of the fertilizer demand function. The chow test for structural stability turned out to be significant at 5 per cent level of confidence in respect of the static model. But it is not so in the dynamic model.

Kayarkanni (2000) in a study on the fertilizer use in three crops namely, rice, sugarcane and cotton by found that the relative price of fertilizers had a great influence on fertilizer use in all the three crops. It was found that fertilizer demand for the three crops was price- inelastic. It shows that the use of fertilizers is found to be higher in irrigated areas than the canal system.

Kayarkanni (2000) estimated the fertilizer demand function for Tamil Nadu. The analysis was based on the time series data from 1967-68 to 1992-93. The results of the static model indicated that relative price and land intensity were negatively related with fertilizer demand while per cent area under HYV, per cent area irrigated and weather had a positive relationship with fertilizer demand. The study indicated that 12 per cent increase in area under HYV would lead to increase in fertilizer demand by 1.13 per cent. The short-run price elasticity for fertilizer demand was -0.3527 and adjustment co-efficient was 0.0891. The short-run fertilizer demand decreased by 3.527 per cent in response to 10 per cent increase in relative price.

Bezbaruah and Roy (2002) conducted a study to identify the factors affecting the adoption and use of fertilizer by farmers in Barak Valley. They selected agricultural extension officer circle from each of the six agricultural sub-divisions in the region. They observed that the regression coefficients for operational holding, tenancy and low land were significant and expectedly positive. The result suggested that there was no significant variation in the application of fertilizer per hectare with farm size and multiple cropping tenant but the application of fertilizer per hectare by the farmers had been found to be significantly conditional upon availability of irrigation and access to extension service.

Jayanthi *et al.* (2003) studied the factor influencing fertilizer consumption in India. The author regressed consumption of fertilizer with production, import and subsidy of

fertilizer. From the studied it was revealed that production and subsidy was positively influence on fertilizer used whereas imports were insignificant.

Rahman (2003) studied factors determining use of pesticides using survey data from 21 villages in three agro-ecological regions of Bangladesh. The study found that pesticide cost accounts for about 7.7 per cent of the gross value of output in cotton, 3.6 per cent in vegetables, 2.5 per cent in potato, 1.8 per cent in modern rice, 1.6 per cent in spices and less than 1 per cent in other cereal and non-cereal crops. About 77 per cent of farmers (highest 94% in Comilla) used pesticides at least once (37% applied once and 31% applied twice, and the rest applied for 3–5 times) in a crop season. Cultivation of traditional and modern rice varieties, potatoes, spices, vegetables and cotton are the prime determinants of pesticide use. Farmers seem to treat pesticides as substitutes for fertilizers, indicated by the positive influence of fertilizer prices on pesticide use. Also, increases in pulse and jute prices increase pesticide use. Among the socio-economic variables, land ownership and agricultural credit are positively related to pesticide usage. Pesticide use is higher in underdeveloped regions. Sharp regional variations also exist in pesticide usage. Major policy thrusts for devising pesticide regulation and effective implementation, increasing farmers' awareness of the effects of pesticide use, and expansion of IPM practices are suggested to safeguard poor farmers in their pursuit of agricultural livelihoods.

Bala *et al.* (2005) studied the factor affecting fertilizer consumption in India. The study revealed that there is positive and significant relation between fertilizer use and subidy, area under high yielding varieties, gross irrigated area. Among the factors affecting fertilizer consumption, subsidy emerged to be the most important factors followed by area under HYV and gross irrigated area.

Chirwa (2005) debated the smallholder farmers in Malawi who have been relatively slow to adopt the new technology, despite decades of agricultural policies that promoted the adoption of fertilizer and hybrid seed technologies as ways of improving productivity in maize fanning. Alternative econometric techniques have been used in the empirical literature to analyze the factors associated with the decision by smallholder farmers to adopt new technologies. The modeling of decision was used as the latent variable and evaluated using logit regression analysis. Using bivariate probit analysis and controlling for technology acquisition through grants, it was found that fertilizer adoption was positively

associated with higher levels of education, larger plot sizes and higher non-farm incomes, but negatively associated with households headed by women and distance from input markets. The adoption of hybrid seeds was positively associated with market-based land tenure systems and fertile soils, but negatively associated with age of the farmer and distance from input markets.

Anomalous (2008) studied factor-affecting fertilizer used in Haryana. The study revealed that relative prices and percentage of irrigated area are the two most important factors affecting fertilizer consumption. Adequately and timely availability of irrigation is the most important factor which could promote fertilizer used. The study concluded that farmers are unwilling to increased fertilizer doses that could be due to the farmers are already using the required dose of fertilizer.

Anomalous (2008) studied the factors affecting fertilizer consumption in India. The study shows that area under irrigation significantly influences the fertilizer consumption. Again production of rice and wheat was influence by fertilizer consumption, area under high yielding varieties and irrigated area.

Chand and Pandey (2008) examined the impact of fertilizer price and other factor on food production. The study shows that one per cent increase in use of fertilizer increases foodgrain production by 0.20 per cent. One per cent increase in real price of fertilizer reduces fertilizer use by 0.16 per cent. And one per cent change in fertilizer price in real terms cause 0.12 per cent change in food grain production.

Okoroafor *et al.* (2010) examined demand for fertilizer in Nigeria. It was recorded that relative price coefficient (fertilizer to cassava price ratio) is consistent with a priori expected signs and statistically significant at the 5 per cent level. This result indicates that when the real price of fertilizers increases by 10 per cent, farmers in Nigeria decrease fertilizer use by 2.3 per cent in the short-run. In summary, demand for fertilizers depends on many salient factors and shows that irrigation and tractor in use exert a positive and statistical significant effect on the use of fertilizer. The use of these inputs also depends on their relative scarce values as coordinated by their prices The relationship between the harvest area of cassava and fertilizer demand, which was positive and significant at 10 per cent, indicates that a 10 per cent increase in harvest area of cassava leads to a 3.9 per cent

increase in fertilizer demand in the short–run. The lagged effect of fertilizer use and that of relative fertilizer price had positive but insignificant effect on fertilizer demand.

Quddus *et al.* (2008) study the demand of NPK. The demand function of NPK was regressed with ratio of fertilizer price index, farm income in year t-1, area under HYVs, water availability, area under principal crop and trend value. The study indicated that the demand for nitrogen and phosphorous are price elastic while the demand for potash is price elastic.

Yamano and Arai (2010) study the determinant of fertilizer price and application at the household level on major cereal crops in Kenya, Ethiopia and Uganda. The study revealed that the determinant of DAP price and application can be mostly explained by market forces and agro- ecological factors, suggesting that market based policies would be effective for Kenya. In Ethiopia, on the other hand, the estimation results indicate that policy related factors determine the fertilizer price and application. Although the subsidy program in Ethiopia may contribute to poverty alleviation, technical returns from such programs could be low. Uganda should learn from the experience from these two neighboring countries.

Vijay and Hrima (2011) studied the factor affecting demand for chemical fertilizer in India. The author analyzed the data for the year 1976-77 to 2009-10. The study reported that price of fertilizer was negatively related while area under HYV, irrigation, cropping intensity, price output and credit has positive relationship with fertilizer demand. The studied shows that non-price factor is more important determinant of fertilizer used. Among the non-price factors irrigation was the important factor followed by cropping pattern. The price of fertilizer was the 3rd important determinant of fertilizer use in the country.

Beshir *et al.* (2012) assessed the determinants of the probability of adoption and intensity of use of inorganic fertilizer in two districts of south Wollozone, in Ethiopia. The study employed cross section data to analyze the effect of farmers' demographic, socioeconomic and institutional setting, market access and physical attributes on the probability and intensity of use of inorganic fertilizer. A double hurdle model was employed using data collected from randomly selected 252 farmers between July 2009 and

November 2009. Secondary data were also used to complement the primary data. The study depicted low utilization of inorganic fertilizer which was 29.6 per cent and 19 per cent of total cultivated crop land in Ethiopia and South Wollo, respectively. The econometric results of the study provided empirical evidence of a positive impact of extension and credit services, age, farmland size, education, livestock, off/non-farm income and gender in enhancing the adoption of inorganic fertilizer. Physical characteristics like distance from farmers' home to markets, roads, credit and input supply played a critical role in the adoption of inorganic fertilizers as proximity to information, sources of input and credit supply and markets save time and reduce transportation costs. Therefore, the results of the study suggest that the probability of adoption and intensity of use of inorganic fertilizers should be enhanced to meet the priority needs of smallholder farmers and to alleviate the food shortage problem in the country in general and in the study area in particular.

Jaga and Patel (2012) studied the factor affecting demand of chemical fertilizer in India . Simple linear regression model of fertilizer demand was estimated by using ordinary least square method. The study revealed that price of fertilizer was negatively related with fertilizer demand while area under high yielding varieties, irrigation, cropping intensity, price of output and credit has a positive relationship with fertilizer demand. Increase in area under irrigation and cropping intensity will accelerate fertilizer consumption in the country. Increase in price of output has positive affect on fertilizer usedbut was less powerful than input price. The author suggest that in order to increase fertilizer consumption , policy maker should prioritize non price factor such as better irrigation facilities, high yielding varieties etc over pricing policies between output price and input pricing policy, there is need to keep fertilizer prices at affordable level as they are more powerful in influencing fertilizer demand.

Jasbir (2013) studied the factor affecting demand for chemical fertilizer in India. The study revealed that non-price factor is more important in influencing demand for fertilizer. Affordable fertilizer is more powerful than high agricultural commodity prices in influencing fertilizer consumption. The author suggest to give due importance by government to non-price factor such as better seed, irrigation, credit etc to increase fertilizer use in the country. Therefore, investment in irrigation, Agricultural Research and Development, extension service and infrastructure are indispensable for India. The result

also suggest that fertilizer subsidy policy to be more appropriate means to achieve the extensive use of fertilize compared to support price policy.

2.3 Impact of chemical fertilizers and pesticides on yield/ crop production

Singh and Pandey (1981) examined the pattern of fertilizer use on different categories of farms in different agro climatic regions of Haryana. The relationship between fertilizer use and crop yield variability, along with estimated fertilizer use efficiency by fitting production function for major crops in Haryana state were studied. The study concluded that the crop yields were highly responsive to fertilizer application in the assured and semi-irrigated regions. The increase in agricultural output in the state during the last decades may be attributed to increased application of fertilizers. With the increase in the crop yield instability, the fertilizer use showed a declining tendency and the creation of assured irrigation facilities and infrastructures complementary to irrigation works, help in increasing and stabilizing fertilizer application and consequently boosting agricultural production.

Parikh and Mosley (1983) examined fertilizer response of wheat farms in Haryana for 1970-71. The study revealed that large majority of farmers use fertilizer less than the recommended doses. Application of nitrogen fertilizer per acre has a significant role to play in explaining variation in yield per acre for HYV. The base yield of HYV with fertilizer is much higher than local varieties.

Chhotan *et al.* (1984) attempted to estimate the agricultural production under the normative use of nitrogenous fertilizer for each state, as well as for the country as a whole. The findings of the study revealed that there exists a large gap between the potential and the actual food grains production. The untapped production reservoir existing in different crops could be harvested through the use of optimal level of fertilizer along with other complementary inputs like irrigation, seed of high yielding varieties and credit.

Gupta *et al.* (1986) attempted to analyze the extent of manures and fertilizer used and their relation to the productivity on small farms. Cobb-Douglas production function was fitted to assess the efficiency, of manures and fertilizer for two major crops, viz., bajra and wheat. The production function revealed that the efficient use of manures and fertilizer, and possibilities for the re-adjustment of the resources further increases efficiency.

Bhatnagar *et al.* (1986) analyzed the scope and extent of fertilizer application to mustard. The study revealed that the application of even small doses of fertilizers to mustard crops are beneficial and assure remunerative returns.

Ramasamy *et al.* (1986) highlighted that fertilizer has been one of the important factors contributing to the improvement of crop yields in India for the past one and half decades. With the advent of the high yielding varieties in the mid-1960 the role of fertilizer has become more crucial.

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

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

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

Singh and Sirohi (1988) in their study attempted to estimate the agricultural production under the normative use of nitrogenous fertilizers for each state, as well as for the country as a whole. The findings of the study revealed that there exists a large gap between the potential and the actual food grains production. The untapped production reservoir existing in different crops could be harvested through the use of optimal level of fertilizers along with other complementary inputs like irrigation water, seeds of high yielding varieties, credit and pesticides etc.

Reddy (1989) studied the share of fertilizer in the total cost of cultivation of groundnut under rain fed and irrigated conditions and analyzed the efficiency of use of this scarce input. The study indicated that, overall, efficiency of use of fertilizers on sample farms is quite low and fertilizers need to be judiciously combined with other complementary inputs, such as credit, improved seed, improved implements, irrigation, insecticides and technical knowhow at a right time and at reasonable prices. The groundnut growers also need to be enlightened on the proper time of application and dosage of fertilizers as well as efficient methods of fertilizer application.

Deepak and Bhat (1990) analyzed the economics of fertilization in maize and wheat in Himachal Pradesh for the year 1984-85. The study shows that though the total net returns increased with increasing level of NPK but net returns per rupee of investment on NPK fertilizer exhibited inverse relationship. The net profit per rupee of investment at a dose of 50 per cent NPK in maize and wheat turn out to be Rs. 3.55 and Rs. 3.79 respectively. The optimum dose of NPK for wheat was 191.5% while for maize was 194.78 per cent.

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

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

Ram and Nandal (1994) attempted a study on fertilizer use pattern in Haryana which revealed that the level of fertilizer used per hectare of cropped area in Haryana was low in less irrigated regions, Kharif season and rain-fed crops of small farms. The study revealed that efforts have to be carried out for crops to receive an assured irrigation facility and also for efficient and balanced use of fertilizer.

Sengar and Pant (1996) in their study on fertilizer scenario in India had observed that there was a variation in both quantity and percentage use of fertilizer in southern, Eastern and Western part of the country. Fertilizers such as Ammonium Sulphate, Calcium Ammonium Nitrate, Urea, Potassium Sulphate etc., were common nutrients for better plant growth. The study indicated that the application of improved seeds, weedicides and insecticide along with fertilizers would certainly increase the food grain production and would result in real success of green revolution in the country.

Haffis and Reddy (1997) analyzed the actual fertilizer use patterns, extent of their deviations from recommended doses and economics of crops at different locations of Andhra Pradesh. This will in turn help the planners and policy makers as also fertilizer industry to identify factors responsible for these disparities in fertilizer use patterns and reasons, therefore to adopt corrective measures for increasing production and productivity of crops at a desired level. The study indicated that there were wide deviations in fertilizer use from recommended doses in almost all the crops and location. While N was applied excessively, P and K were under - used in most of the places even where fertilizers use was considerably high in case of irrigated crops.

Nkonya *et al*. (1997) studied the factors affecting the adoption of improved maize seed and fertilizer in Northern Tanzania from a survey conducted on 246 farmers. The study showed that influence of fertilizer application on the improved maize seed was

significant but small in magnitude whereas the effect of improved seed on the adoption of fertilizer was much greater.

Mohanty (1998) has attempted to explore the productivity and potentiality of paddy in Sambalpur district of Orissa. The study revealed that rice yield increases significantly with increasing level of Nitrogen up to 8 kg of Nitrogen per hectare (43.56 qt ha^{-1}). The application of N:P:K as per soil test gives highest yield rate to grain (48.83 qt ha^{-1}) response of 100 per cent Nitrogen also gives 28.01 per cent increase in yield over the control. But when it is associated with full dose of phosphorus the yield is increased by 30.55 per cent over control.

Singh *et al.* (1999) studied impact of fertilizer use on productivity and found that fertilizer use on productivity was much less significant in rain fed farming throughout the country. The average use of fertilizer remained quite low (25 kg ha^{-1}) in rain fed crops. A number of constraints limiting the wide spread use of fertilizer in dry lands was noticed. Uncertainty of rainfall was one of the primary risk factors influencing the farmer's decision in using this expensive input.

Birthal *et al*. (2000) studied the pesticide use in cotton in Nanded district of Maharashtra. The study recorded that average pesticide usage is estimated at 3.2 kg active ingredient per hectare of cotton area. Besides, the farmers also use a number of physical and cultural methods directly or indirectly to limit crop loss.

Abedullah *et al.* (2007) studied the efficiency of rice production in Punjab (Pakistan). The results of stochastic production function indicated that coefficient of pesticide is non significant probably due to heavy pest infestation while fertilizer is found to have negative impact on rice production mainly because of improper combination of N, P, and K nutrients. The results of inefficiency model suggest that investment on tractor (mechanization) could significantly contribute to improve farmer's technical efficiency, implying that the role of agricultural credit supply institutes (such as banks) needs to be redefined. Rice farmers are 9 percent technically inefficient, implying that little potential exists that can be explored through improvement in resource use efficiency.

Anomalous (2008) studied the factor affecting yield crop. In case of wheat consumption of nitrogen and phosphorous appears to be significant determinants of yield. The value of marginal product (VMP) of fertilizer use is much higher than the marginal

factor cost of fertilizer (MFC). In case of paddy, Nitrogen and phosphorous do no show significant effect on paddy yield.

Das and Sahu (2009) observed that the growing demand for food production to meet the hunger of ever increasing population call for increasing requirement of fertilizers day by day. In India especially in West Bengal, use of fertilizers seems to be very different for each agro-climatic zone, each district, block even village of the same block. The study was conducted in order to assess farmers' response to fertilizer use at the micro level. As 90% of the farmers belong to small and marginal category it can be conducted that in both small and marginal farmers there is indeed a knowledge gap about the use of appropriate combination of fertilizer.

Savita *et al.* (2013) studied Cost and returns of plant protection in paddy under different nitrogen scenario in Tungabhadra project command. It was found that excessive use of nitrogenous fertilizers has resulted in higher plant protection chemicals and has further resulted in increase in pest incidence, but also high cost structure in the production process. The study revealed that the extent of application of insecticides increased from 5413 ml g^{-1} a.i ha^{-1} to 7338 ml g^{-1} a.i ha^{-1}, fungicides application from 805 mlg^{-1} a.i ha^{-1} to 1283ml g^{-1} a.i ha^{-1} and weedicides from 4853 ml g^{-1} a.i ha^{-1} to 7625 ml g^{-1} a.i ha^{-1} from nitrogen level 1 (upto 50% RD of nitrogen) to nitrogen level 3(>100% RD of nitrogen), respectively. Thus, the total cost incurred towards plant protection chemicals ranged from Rs. 15886 ha^{-1} to Rs. 24442 ha^{-1} from nitrogen level 1 to 3, respectively in paddy cultivation.

Shende and Bagde (2013) analyzed the economic consequences of pesticides use in paddy cultivation. The studied found that the estimated parameters of seeds and pesticides were positively significant at one per cent of probability level for selected farmers indicating that every one per cent increase in seed would result in increase of gross return by 0.3489 per cent and for every one per cent increase in pesticides would result in an increase of gross income by 0.0287 per cent. The coefficients of fertilizers and manures and labour were negative for farmers and non significant. The ratio of marginal value product and marginal factor cost was positive and more than unity for seeds for the farmers indicating that the resource was under utilized and there was scope for maximizing returns by increasing the use of seeds. The ratio of marginal value product and marginal factor cost were negative and below unity for fertilizers and manures where as positive but below

unity for pesticides indicating that these resources were over used i.e. decrease in the use of these inputs would enhance the returns.

2.4 Projection for chemical fertilizers and pesticides.

Vijay and Hrima (2011) analysed the future demand for fertilizer consumption in India for the year 2015-16 and 2020-21. The total demand for fertilizer (NPK) is projected to increase to about 35 million tonnes by 2015-16 and 41.6 million tonnes by 2020-21. The demand for nitrogen, phosphorous and potash is projected around 23,11.5 and 7.1 million tonnes respectively for 2020-21.

Jasbir (2013) projected fertilizer demand for India. By 2020 the fertilizer demand in the country will increase to about 41.6 million tonnes. The projected fertilizer demand in eastern and southern region is expected to grow at a faster rate compare to north and west .

Jayanthi et al (2013) predicted the future consumption of fertilizer in India for the year 2011-12 to 2020-21. From the study it was predicted that by the year 2020-21, the fertilizer consumption for India would be increase by 456.73 lakh metric tonnes. The concluded that the increasing trend might be due to the transport subsidy for moving fertilizers into the inferior markets, ready available for seed high yielding varieties, availability of water and power on priority basis to agriculture, intensive fertilizer promoter campaign, availability of credit etc.

Chapter III

MATERIALS AND METHODS

This chapter deals with the methodology followed in the present study. It includes database sources and analytical tools employed in analyzing the objectives of the study. Both the conventional and suitable analytical techniques were employed to arrive at results and valid conclusions. An attempt has been made in this chapter to describe the study area, the sampling design, nature of data collection, concepts used in the study and various analytical tools, being employed in achieving the objectives of the present study.

The contents of this chapter are

3.1 DESCRIPTION OF THE STUDY AREA

An assessment of any development activity can be made with a detailed understanding of the physical and natural characteristics and socio-economic status of the region. Hence, an attempt has been made to describe the physical, natural and socio-economic features of the study area.

The state of Andhra Pradesh (fig. 3.1) is situated in a tropical region between the latitudes 13º to 20º North and the longitudes 77º to 85º East and is bounded by the Bay of Bengal in East with a coastal line of 960 km. The other bounders to the State are Orissa, Madhya Pradesh and Maharashtra in North, Karnataka in West and Tamil Nadu in South. The state has an area of 2.75 lakh hectares forming 8.4 per cent of the total geographical area of the country. Agriculture is the main occupation of the people and 70 per cent of the people are depending on agriculture and allied activities. The state consists of 23 districts and has been divided into three regions, viz., Coastal Andhra, which comprises of 9 districts, Rayalaseema, which consists of 4 districts and Telangana, which covers 10 districts.

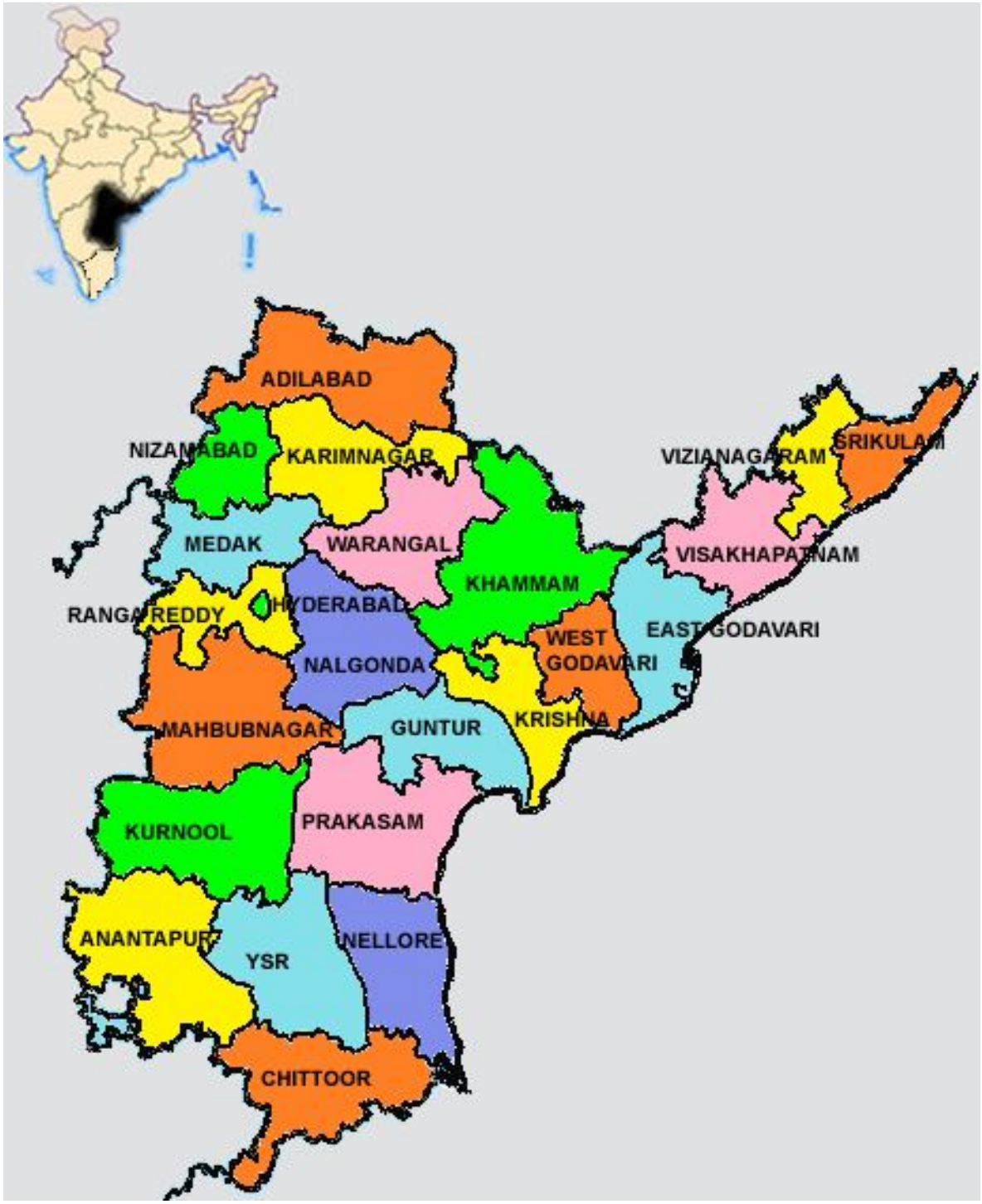

Figure 3.1: Map of Andhra Pradesh

3.1.1 General information of Andhra Pradesh

The general information of Andhra Pradesh was depicted in table 3.1. The demographic aspects influence economic development of any region. With a population of 846.66 lakh enumerated in the 2011 census constituting about 7 per cent of India's population, Andhra Pradesh is the fifth most populous state in India in 2011 Census. Out of the total population, the male population is 425.10 lakh and the female population is 421.56 lakh representing 50.21 and 49.79 per cent respectively. As per 1981 census, the population of the state was 535.5 lakhs, which increase to 846.66 lakhs as per 2011 census. In 1981, 76.68 per cent of the population are living in the rural areas while in 2011 census 66.51 per cent are in rural area. The literacy rate in 1981census was 29.9 per cent out of which 39.30 per cent male and 20.40 per cent female. In 2011 census, the literacy rate was 67.66 per cent of which 75.56 per cent are male literacy rate and 59.74 per cent are female. The total workers in 1981 was 245.06 lakh which increase to 348.94 lakh in 2011. The agricultural workers in 1981 comprises of 64.20 per cent and 35.80 per cent of non agricultural workers. However, about 62.16 per cent and 37.83 percent are other agricultural workers, and non agricultural workers respectively in 2011 census. The average annual rainfall in 1981 was 227 cm and in 2011 was 113 cm.

Number of farmers in all categories increased over the years. In both the years, majority of the farmers belonged to marginal land holding followed by small, semi medium, medium and large holding. In 1981, marginal farmer comprises of 67.63 per cent of the total farmers which decreased to 61.59 per cent in 2011 census. On Contrary, percentage of farmers in the remaining categories increased in the later year.

3.1.2 Cropping pattern

Andhra Pradesh cultivate both food and non-food crops. Paddy, maize, jowar, bajra, blackgram, greengram, redgram, cotton, chillies, groundnut etc. are the main crops grown in the state. Cropping pattern is given in Table no. 3.2

The cropping intensity of the state in TE (1981-84) was 116.03 per cent, which increase to 126.43 per cent in TE (2008-11). Gross cropped area during TE (1981-84) was 130.70 lakh hectare which increase to 136.33 lakh hectare. In both the years, percent area in paddy was more. It was 29.65 per cent, which increased to 30.75. Next to paddy, jowar occupied 2nd highest area (16.09 %) followed by groundnut (11.75 %) in TE (1981-84).

Table: 3.1 General information of Andhra Pradesh

Sl. No.	Particulars	1981-82	2010-11
1	Geographical area (lakh ha)	2.74	2.75
2	Population (lakh)		
	Total	535.5	846.66
	Male	271.09	425.1
	Female	264.41	421.56
	Rural	410.62	563.12
	Urban	124.88	283.54
3	Literacy (%)	29.9	67.66
	Male	39.3	75.56
	Female	20.4	59.74
4	Rainfall (cm)	227	113
5	Workers (lakh)	245.06	348.94
	Agriculture	157.33	216.92
	Non agriculture	87.73	132.02
6	Land holding (numbers)		
	Marginal	629000 (67.63)	7417461 (61.59)
	Small	176000 (18.92)	2639110 (21.91)
	Semi medium	95000 (10.22)	1444083 (11.99)
	Medium	27000 (2.90)	419956 (3.49)
	Large	3000 (0.32)	123508 (1.03)

Source: Districts at a glance, AP-1985 & 2012, Directorate of Economics And Statistics, Government of Andhra Pradesh, Hyderabad

Note: Numbers in brackets indicate per cent to total

Table : 3.2 Cropping pattern of Andhra Pradesh.

		Absolute area (lakh hectare)		% area to gross cropped area	
Sl. No.	Crop	TE (1981-84)	TE (2008-11)	TE (1981-84)	TE (2008-11)
1	Rice	38.75	41.93	29.65	30.75
2	Maize	3.35	7.93	2.56	5.81
3	Bengal gram	0.57	6.13	0.44	4.49
4	Red gram	2.51	5.15	1.92	3.77
5	Green gram	5.88	3.35	4.5	2.45
6	Jowar	21.02	3.06	16.09	2.24
7	Bajra	5.1	0.57	3.9	0.41
8	Ragi	2.52	0.46	1.93	0.33
9	Groundnut	15.4	15.63	11.78	11.46
10	Cotton	4.64	15.5	3.55	11.36
11	Total Oilseeds	20.16	24.05	15.43	17.64
12	Total Pulses	14.62	19.45	11.19	14.26
13	Total Foodgrains	92.22	73.79	70.56	54.12
14	Total Cereals and Millets	76.09	54.34	58.23	39.85
15	Gross cropped area	130.7	136.33		
16	Net cropped area	112.65	107.77		
17	Cropping intensity (%)	116.03	126.43		

Source: Season and Crop Report, AP- 1982-83 and 2011-12, Directorate of Economics And Statistics, Government of Andhra Pradesh, Hyderabad

While in TE (2008-11), after paddy 2nd highest area was occupied by groundnut (11.46 %) and 3rd was cotton (11.36 %). Overall, percent area under food grains was 70.56 per cent in TE (1981-84) while in TE (2008-11) was 54.12 %.

The percent area under oilseeds increased, while per cent area under pulses got reduced over years.

3.1.3 Land utilization pattern of Andhra Pradesh

The Geographical area distribution under different uses is an important indicator of the effective use of land for different purposes. The land use pattern of the study area for the year 1981-82 and 2010-11 is presented in Table no. 3.3. The table showed that the Geographical area is spread over 274.4 lakhs hectares. Net area sown in 1981-82, was 113.25 lakh hectare, which decrease to 112.88 lakh hectare. Forest cover in 1981-82 was 61.61 lakh hectare and 62.29 lakh hectare in 2010-11.

Table : 3.3 Land utilization pattern of Andhra Pradesh. (lakh ha)

Sl. No.	Particulars	1981-82	2010-11
1	Total Geographical area	274.4	275.04
2	Forest (lakh hectare)	61.61	62.29
3	Barren and un culturable land	23.01	20.26
4	Land puts to non- agricultural uses	21.68	27.7
5	Culturable waste	8.89	6.25
6	Permanent pasture and other grazing land	9.48	5.54
7	Land under miscellaneous tree crops and groves not included in net area sown	2.69	2.9
8	Current fallows	20.65	22.28
9	Other fallows land	13.19	14.9
10	Net area sown	113.25	112.88
11	Area sown more than once	17.22	33.25
12	Total cropped area	130.47	145.12

Source: Districts at a glance, AP-1985 & 2012, Directorate of Economics And Statistics, Government of Andhra Pradesh, Hyderabad.

Barren and uncultivated land was 23.01-lakh hectare in 1981-82, which reduce to 20.26 lakh hectare in 2010-11. Land utilizations for non-agricultural use was 21.68 in 181-82 which increased to 27.7 lakh hectare. The area under culturable waste was 8.89 lakh hectare while in 2010-11 it was reduce to 6.25 lakh hectare. The area under Permanent pasture and other grazing land was 9.48 lakh hectare in 1981 while in 2010-11 was 5.54 lakh hectare. The area under current fallow was 20.65 lakh hectare and 22.28 lakh hectare in 1981-81 and 2010-11 respectively. Area sown more than once was 17.22 lakh hectare in 1981-82 which increase to 33.25 lakh hectare in 2010-11. Total cropped area was 130.47 and 145.12 lakh hectare in 1981-82 and 2010-11 respectively.

3.1.4 Production and productivity of major crops in Andhra Pradesh

The table no 3.4 shows the production and productivity of the main crops grown in Andhra Pradesh. Over the years, productivity of the all the crops increased except for green gram. The production of rice during TE (1981-84) was 81.10 lakh tones compared to 131.66 Lakh tones in TE (2008-11)

Table: 3.4 Production and Productivity of major crops in Andhra Pradesh

Sl. No.		1981-84 (TE average)		2008-11 (TE average)	
		Production (lakh tones)	Productivity (kg ha^{-1})	Production (lakh tones)	Productivity (kg ha^{-1})
1	Rice	81.10	2092.90	131.66	3139.99
2	Maize	6.33	1887.47	36.22	4569.32
3	Bengalgram	0.24	420.07	8.08	1319.07
4	Redgram	0.60	237.31	2.23	433.71
5	Greengram	2.47	419.33	1.22	363.20
6	Jowar	13.26	630.96	3.94	1286.82
7	Bajra	3.55	695.82	0.72	1255.62
8	Ragi	2.61	1035.46	0.52	1132.95
9	Groundnut	14.29	927.82	41.66	2664.85
10	Cotton	7.69	1655.44	35.64	2302.90

Source: Season and Crop Report, AP- 1982-83 and 2011-12, Directorate of Economics And Statistics, Government of Andhra Pradesh, Hyderabad

The productivity of maize was 1887.47 kg ha^{-1} which increased to 4569.32 kg ha^{-1} in TE(2008-11). The productivity of Bengal gram, jowar, bajra, groundnut was increased by 3, 2, 2 and 3 times respectively. The production was reduced in green gram, jowar, bajra and ragi over the years.

3.2 NATURE AND SOURCES OF DATA

In the present study secondary data were used for evaluating the specific objectives of the study. The secondary data on consumption of pesticide and chemical fertilizer (NPK), season wise consumption, gross cropped area, net cropped area, consumption of fertilizer materials production and area of various crops, irrigated area, area under HYVs, were collected from the various issues of FAI and Directorate of Economics and Statistics, Andhra Pradesh. The secondary data covered the period of 30 years from 1981 to 2010. The cross-section data relating to the crop output and use of various inputs in Andhra Pradesh were drawn from the centrally sponsored project "Comprehensive scheme to study the cost of cultivation of principal crops in Andhra Pradesh'', being managed by the Department of Agricultural Economics, ANGRAU, Hyderabad. The data relating to general information about the respondents, land holding, irrigation source, cropping pattern, fertilizer use were obtained from the sample respondents of Comprehensive scheme to study the cost of cultivation of principal crops in Andhra Pradesh. Data pertaining to the pattern of fertilizer consumption, name of fertilizer, quantity of fertilizer applied, prices of fertilizer, quantity of FYM applied, time of application, method of application, cost of transportation, area under crops were also elicited from sample farmers.

3.3 SAMPLING DESIGN OF THE COMPREHENSIVE SCHEME

Under this scheme the Andhra Pradesh state is divided into three agro-climatic homogeneous zones based on crops, soil types, irrigation and rainfall, etc. The sample size covered under the scheme in state is 600 farm holdings distributed among 60 tehsils. From each zone the sample farmers were selected using three stages stratified sampling technique, with tehsil as stage one, a village or cluster of villages at stage second and operational holdings within the cluster as the third and final stage of the sample. From each cluster, a sample of 10 operational holdings, two each from the five size classes viz. category I (<1 ha), category II (1-2 ha), category III (2-4 ha), category IV (4-6 ha) and category V (>6 ha) were selected. Cost accounting method has been adopted for collection

of household data, which is in very detailed form covering all the inputs and outputs of all the crops grown as well as other agriculture related activities on the selected holding.

Table 3.1: Size limits of sample farm holdings with category of size group

Size group	Size limit of holdings (in ha)	Number of sample farmers (2010-11)
Category I	< 1	120
Category II	1-2	120
Category III	2-4	120
Category IV	4-6	120
Category V	Above 6	120
Total		600

3.4 ANALYTICAL TOOLS EMPLOYED

Keeping in view the specific objectives of the study, the data collected were subjected to following statistical analysis.

3.4.1Tabular analysis

3.4.2 Growth rate analysis.

3.4.3 Measurement of district disparities

3.4.4 Production function analysis

3.4.5 Regression analysis

3.4.6 Future projections

3.4.1 Tabular analysis

Triennium averages for various aspect of fertilizer and pesticide consumption were worked out to even out annual fluctuations. The technique of tabular presentation was followed for presenting the land holding, cropping pattern, crop wise and season wise consumption of chemical fertilizer, to draw meaningful inferences. Various dimensions were compared and contrasted with the help of frequency, average and percentage.

3.4.2 Growth rate analysis

In order to analyze the growth in production and various aspects of consumption of fertilizers and pesticides, the compound growth rate analysis was carried. The compound growth function was specified as follows:

$Y = AB^{T}e^{U}$

Log (Y) = Log (A) + t Log (B)

CGR= (Antilog (B)-1) X 100

Where,

Y = consumption

A = Intercept

t = Year

B = Regression coefficient

CGR= compound growth rates in terms of percentage.

Annual growth rate (AGR) = $\frac{\text{current year consumption} - \text{previous year consumption}}{previos\ year\ consumption} X\ 100$

3.4.3 Measurement of districts disparities

In order to study the trends in the inter- district variations in per hectare consumption of fertilizers and pesticide, the coefficient of variation has been estimated. The coefficient of variation is given as:

$$C.V = \frac{S.D}{Mean} \times 100$$

Where S.D= standard deviation.

3.4.4 Production function

Production function analysis was carried out to estimate the response of fertilizers and pesticide on major crops grown on the sample farmers. Keeping in view the nature of data collected and objectives of the study, the linear and Cobb-Douglas forms of production function has been fitted to estimate the relationship between per hectare output of crops i.e. paddy, cotton, maize, groundnut, chilli, and pulses and quantities of nitrogen, phosphorus, potash, value of pesticide and other inputs applied in producing these crops.

For selecting a particular equation as the best fit two empirical criteria were used in this study. One criterion was the magnitude of the coefficient of determination, R^2,

assuming errors to be normally and independently distributed, with R^2 indicating the proportion of variance in the dependent variable accounted for by a particular type of equation, the larger value was taken to indicate the form which was most appropriate for estimates. Other related statistics used as empirical criteria was t test (the null hypothesis of regression coefficient at zero level). The constant in both the equations was computed and t test was used to indicated terms. While selecting a particular equation as the best fit both R^2 value and t-test was considered. An equation with a high value of R^2 and relatively more number of significant constant terms was ultimately selected as the best fit. So both functions are used. The following form of linear and Cobb-Douglas equation was considered for estimating the response of fertilizers in different crops.

Linear equation

$$Y = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7X_7 + a_8X_8 + a_9X_9 + ui$$

Cobb-Douglas equation

$$Y = b_0 X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} X_7^{b7} X_8^{b9} X_9^{b9} Ui$$

Where,

Y= Yield (output) (qt ha^{-1})

X1= Area under specified crop (ha)

X2= Seed (kg ha^{-1})

X3= Human Labour (hr ha^{-1})

X4= Animal Labour (hr ha^{-1})

X5= NPK (kg ha^{-1})

X6= Tractor hour (hr ha^{-1})

X7= Value of Pesticide (` /ha)

Ui = error term

And a_0 , b_0 are the constants and a_1 ,a_2, a_3, a_4, a_5, a_6, a_7, b_1, b_2 ,b_3, b_4, b_5, b_6, b_7, are the elasticity coefficients of model.

Elasticity of production

Elasticity of production (EP) is the determination of response of output to changes in the variable input. The elasticity of various inputs was determined by formula given below.

$$\text{Elasticity of Production } Xi = a_i \frac{\overline{X}}{\overline{Y}}$$

Where,

Y = geometric mean of crop productivity

Xi = geometric mean of ith resource

ai = production elasticity of ith resource X

In the Cobb-Douglas production function, regression coefficients are still the elasticities and used to measure the rate of return to scale.

Criteria for return to scale is

ΣEP =1: constant return to scale

ΣEP <1: decreasing return to scale

ΣEP >1: increasing return to scale

3.4.5 Determinant analysis

i) Multiple Regression model

a) Fertilizer determinant:

The determinants of fertilizer use were examined using multiple regression model. The identification of explanatory variables was based on the empirical evidences made by the early writers (Mohanam, 1989, Parthasarathy and China Rao, 1986 and Sharma and Thaker, 2011). Both the time series data and cross section data are consider.

For time series data, to determine the various factors influencing the fertilizer use in Andhra Pradesh variables viz: percentage of gross irrigated area, cropping intensity, price of fertilizer, percentage of area under HYV crops and output price for 30 years (1981-82 to 2010-11) were considered. To study the simultaneous impact of above mention factor on fertilizer consumption a multiple linear analysis was used.

Macro level analysis

$Y_1 = a_0 + a_1 IRR + a_2 CI + a_3 HYV + a_4 P_o + a_5 P_f + Ui$

Where,

Y_1 = Consumption of fertilizer (kg ha^{-1})

IRRI = Percent of gross area under irrigation

CI = Cropping intensity

HYV= percent area under HYV crops

P_o = deflated output price

P_f = deflated N/P/K/ NPK price in nutrient term

Ui = error term

And a_0 is the constants and a_1 ,a_2, a_3, a_4, a_5 are the elasticity coefficients of model.

Micro level analysis

a)fertilizer use

In cross section data variable consider are farm size, cropping intensity, proportion of area irrigated, quantity of FYM, value of pesticides, relative price of output to fertilizer price, irrigation charges of the sample farmers are considered. In his both Cobb Douglas and linear regression model are use and final model was decided by the R2 value and number of significant of variable factor in the model. The mathematical form are as follows:

$Y_2= a_0+ a_1 Z_1+a_2 Z_2+ a_3 Z_3+ a_4Z_4+a_5Z_5 + a_6Z_6+ a_7X_7+ a_8X_8+a_9X_9$ Ui…… multiple linear regression

$Y_2= a_0 Z_1^{a1} X_2^{a2} Z_3^{a3} Z_4^{a4} Z_5^{a5} Z_6^{a6} Z_7^{a7} Z_8^{a8} Z_9^{a9}$ ……Cobb Douglas

Where

Y= consumption of fertilizer on particular category per hectare

Z1= Farm size (ha)

Z2= Cropping intensity (%)

Z3= Proportion of area irrigated (%)

Z4= FYM (qty/ha)

Z5=Proportion of area under intensive fertilizer consumption cropped

Z6= Wages (Rs hr^{-1})

Z7= Relative price (output price/ fertilizer price)

Z8= Value of irrigation charges (Rs ha^{-1})

Z9 =Value of pesticide (kg ha^{-1})

Ui = error term

b) Determinants of Pesticides used

For pesticide determinant only cross section data are considered due to insufficient data for time series data. The variables consider for determining the use of pesticide on the particular crop are area under particular crop, value of seed, NPK and value of the output. To study the simultaneous impact of above mention factor on pesticide consumption a multiple linear regression and Cobb Douglas model was used. The model are as follows

$Y3 = a_0+ a_1B_1+a_2B_2+ a_3B_3+ a_4B_4+$ Ui…….. linear multiple regression

$Y3= a_0 B_1^{a1} B_2^{a2} B_3^{a3} B_4^{a4} Ui$…….. Cobb Douglas regression

Where ,

Y3= Expenditure on pesticide (Rs. ha^{-1})

B1= Area under particular crop (ha)

B2= Value of seed (Rs ha^{-1})

B3= NPK (kg ha^{-1})

B4= Price of output (Rs qt^{-1})

Ui = error term

3.4.6 Future prediction

To find out the future prediction of fertilizer consumption, the Exponential Trend analysis, cubic trend analysis, Compound annual growth rate was used. And among these most appropriate was selected which have highest adjusted R^2 .

3.5. CONCEPTS USED IN THE STUDY

1. Fertilizer

Fertilizers are artificially produced inorganic substances of concentrated manure, which supply plant nutrients like nitrogen, phosphorus, potash, sulphur and others. This includes urea, di-ammonium phosphate, ammonium chloride, calcium ammonium nitrate, complex fertilizers, mixed fertilizers, super phosphate and micronutrients. The three major fertilizers are nitrogenous (N), Phosphatic (P) and Potasic (K) fertilizers.

2.Fertilizer Consumption

The application or usage of NPK fertilizers, in cultivation of land, in order to increase crop productivity is termed as fertilizer consumption.

3.Plant protection chemicals

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

4.Cropping intensity

$$\text{Cropping intensity} = \frac{\text{Gross cropped area}}{\text{Net sown area}} \times 100$$

5.Gross cropped area (GCA)

The total cropped area including area sown more than once

6.Net sown area (NSA)

It implies the actual area under cultivation

7.Gross area irrigated (GAI)

Total area irrigated in cultivation of crops including area under cultivation irrigated more than once.

8.Net area irrigated (NAI)

It represents the actual area under cultivation that has been irrigated.

9.Human labour

The human labour is measured in terms of man days for different farm operations of crop cultivation. This variable was developed by adding up the family labour, hired labour employed for various operations of the particular crops grown on farm during the year. Labour hours for women labour and child labour were converted to man hour equivalents by multiplying with standard conversion factors of 0.67 and 0.50, respectively.

10.Bullock labour

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

11.Machine labour

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

12.Seed cost

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

13. Intensive fertilizer used crop

These are the crops that consumed high quantity of fertilizer per hectare. The crops considered in the present study was paddy, maize, chilli and sugarcane.

Chapter IV

RESULTS AND DISCUSSION

In accordance with the pre-determined objectives of the study, this chapter deals with the presentation and discussion of results obtained from the analysis of the data pertaining to the study, are presented in this chapter under the following headings:

4.1 Consumption pattern of Fertilizers and Pesticides

4.1.1 Consumption of fertilizers in Andhra Pradesh and among the districts.

4.1.2 Consumption of pesticides in Andhra Pradesh and among the districts.

4.1.3 Consumption of fertilizers and pesticides among sample farmers

4.2 Impact of fertilizers and pesticide on productivity

4.3 Factors affecting fertilizers and pesticides consumption

4.4 Projection of fertilizers and pesticides consumption

4.1 Fertilizers and Pesticides consumption

In India, during green revolution period stands recognized for introduction and adoption of new HYVs and hybrids, the fertilizers and pesticides in large quantities. The utilization of chemical fertilizers and pesticides has been an important element of crop production. Sixteen-plant food nutrients are said to be essential for proper crop development. Each is equally important for plant growth, yet required in different quantities. Based on quantity required these were grouped into three categories namely primary (macro) nutrients, secondary nutrients, and micronutrients. Primary (macro) nutrients are nitrogen (N), phosphorus (P), and potassium (K). They are most frequently in larger quantities by crops in the form of fertilizer. Some chemical fertilizers that supply nitrogen are Urea and Ammonium sulphate; phosphorous are Diammonium phosphate and single super phosphate and potash are Muriate of potash and Muriate of sulphate. The nitrogen is said to be responsible for growth, phosphorous for root growth and resistance to pests and diseases. The secondary nutrients include calcium, magnesium, and sulphur. For most crops these three are needed in lesser amounts than the primary nutrients. The

micronutrients namely boron, chlorine, copper, iron, manganese, molybdenum, and zinc are used in small amounts, but they are as important as the major nutrients for profitable crop production. However, major focus of the Indian fertilizer sector policy has been on primary (macro) nutrients. The present study has focused on consumption pattern of major fertilizer containing namely Nitrogen, phosphorous and potash.

The incidence of pests and diseases has increased with intensive use of chemical fertilization as required by high yielding varieties and hybrids. The high yielding varieties which grow into sturdy plants attract the pest and diseases. Therefore, it has become customary to use pesticides to control them. During green revolution period, the application of fertilizers and pesticides has picked up as they are provided at subsidized prices. Thus, along with fertilizer, pesticides also become an integral component of crop production. The predominant classes of pesticides used in India (during 2000-01) were insecticides, accounting for 61 per cent of total consumption, followed by fungicides (19 %) and herbicides (17 %). In India, most pesticide use is on cotton (45%), followed by rice (22%) (Krishna *et al*, 2005). Therefore along with fertilizer consumption the study analysed pesticides consumption also.

With the gradual closing of the land frontier, future increase in agricultural output has to depend on increasing the productivity of land only. Continued application of fertilizers and pesticide has reached to an irreversible stage that resulted in its excessive and indiscriminate use. Nevertheless, the scientific crop production insisted on optimum input use. However, there have been wide variations in the use of fertilizers and pesticides across districts and in the state over the years. So it is important to the know the trends of pesticide and chemical fertilizer consumption over time in Andhra Pradesh. As there are differences in the pattern and growth of fertilizers and pesticides consumption among the districts and over the years in the Andhra Pradesh. It was essential to examine the consumption at district level also to draw valid conclusions. For carrying out Fertilizers and pesticides consumption analysis of the Andhra Pradesh state and at district level both primary data from the cost of cultivation scheme and secondary data are basically considered to have a clear-cut comprehensive idea about consumption pattern, growth, variation of the fertilizers and pesticides consumption.

4.1.1 Consumption of fertilizers in Andhra Pradesh and among the districts.

In this section of results and discussion, time series analysis of fertilizer consumption at the state level and district level was discussed to draw and bring out the important conclusions. The three major fertilizers nutrients- nitrogen, phosphorus and potash have been considered to study the consumption of fertilizer in Andhra Pradesh.

4.1.1.1 Consumption trends of different fertilizers (N, P and K) in Andhra Pradesh

Fertilizer consumption trends expressed in terms of aggregate quantities reflect the pattern of fertilizer consumption over time. In order to analyze the trends and fluctuations in the consumption of N, P, and K, the annual average growth rate was calculated using the consumption data and was presented in table 4.1 and figure 4.1.

From the table 4.1and figure 4.1 it was observed that over the last three decades i.e. 1981-82 to 2010-11, consumption of N, P, K and total NPK in Andhra Pradesh shows an overall increasing trend except in few years which showed negative annual growth rates. Overall NPK consumption was 655 thousand tonnes during 1981-82, which increased to 1619 thousand tonnes in 1990-91, reached to a level of 2174 thousand tonnes during 2001 and it was 3496 thousand tonnes during 2010-11. Overall, NPK consumption was increased five times during 1981-82 to 2010-11. The annual growth rate was highest in the year, 1988-89 (40.20 per cent), which might be due to overall good monsoon condition prevailed in the country. The findings also coincided with the studies of Senger *et al.* (1996) and Jayathi *et al.* (2013) in all India level. The total consumption of NPK showed a negative growth rate during 1985-86 (-9.4%). Further, in 1992-93, total also it was negative growth rate by -4.31 per cent. The decline in the consumption may be attributed to change in fertilizer pricing policy measures taken by the government of India under its macroeconomic policy causing increased fertilizer prices. The consumption scenario changed unlikely in 1992-93 followed the new fertilizer pricing policy stemming from decontrol of P and K, fertilizers in 1992, the results also coincided with the findings of Tripathi (1998) in all India level. The decline in use of fertilizer was highest (36.85 %) in case of potassic and about 9.73 per cent in phosphatic fertilizer. Due to severe drought in 2001-02 and 2002-03, fertilizer consumption declined from 1957 thousand tonnes to

Table 4.1 Trends in consumption of fertilizer nutrients (N, P and K) in Andhra Pradesh: 1981-82 to 2010-11. (000' tonnes)

Year	N	AGR	P	AGR	K	AGR	NPK	AGR
1981-82	456.25		150.4		48.78		655.54	
1982-83	502.76	10.19	158.88	5.64	64.77	32.78	726.41	10.81
1983-84	612.55	21.84	222.65	40.14	73.42	13.36	908.62	25.08
1984-85	644.96	5.29	254.35	14.24	80.98	10.29	980.29	7.89
1985-86	568.89	-11.79	242.79	-4.54	76.44	-5.61	888.12	-9.4
1986-87	583.15	2.51	241.45	-0.55	76.91	0.62	901.52	1.51
1987-88	619.79	6.28	270.28	11.94	76.67	-0.31	966.74	7.23
1988-89	903.61	45.79	345.69	27.9	106.03	38.3	1355.33	40.2
1989-90	1018.79	12.75	401.68	16.2	111.95	5.58	1532.42	13.07
1990-91	1068.13	4.84	424.14	5.59	127.48	13.87	1619.75	5.7
1991-92	997.89	-6.58	454.96	7.27	129.46	1.55	1582.31	-2.31
1992-93	1021.66	2.38	410.7	-9.73	81.75	-36.85	1514.1	-4.31
1993-94	1085.75	6.27	369.5	-10.03	88.07	7.73	1543.32	1.93
1994-95	1138.09	4.82	385.82	4.42	120.27	36.56	1644.18	6.53
1995-96	1187.39	4.33	420.79	9.06	142.98	18.88	1751.16	6.51
1996-97	1199.58	1.03	436.38	3.71	132.81	-7.11	1768.78	1.01
1997-98	1075.26	-10.36	491.56	12.64	130.21	-1.96	1697.02	-4.06
1998-99	1284.26	19.44	560.46	14.02	163.19	25.33	2007.91	18.32
1999-00	1314.57	2.36	602.96	7.58	201.11	23.23	2118.64	5.51
2000-01	1361.79	3.59	603.46	0.08	209.32	4.08	2174.57	2.64
2001-02	1182.72	-13.15	547.84	-9.22	226.52	8.22	1957.08	-10
2002-03	1035.71	-12.43	433.92	-20.79	203.05	-10.36	1672.68	-14.53
2003-04	1138.83	9.96	474.1	9.26	240.08	18.24	1853.01	10.78
2004-05	1156.53	1.55	538.98	13.69	292.36	21.78	1987.87	7.28
2005-06	1522.09	31.61	690.09	28.04	340.36	16.42	2552.54	28.41
2006-07	1466.08	-3.68	635.83	-7.86	332.06	-2.44	2433.97	-4.65
2007-08	1560.37	6.43	695.02	9.31	412.19	24.13	2667.58	9.6
2008-09	1720.84	10.28	852.21	22.62	497.83	20.78	3070.88	15.12
2009-10	1704.58	-0.95	872.51	2.38	479.5	-3.68	3056.59	-0.47
2010-11	1966.63	15.37	1031.98	18.28	498.18	3.9	3496.79	14.4
CGR	4.09		5.18		7.59		15.12	
C.V	34.19		43.97		69.67		39.86	

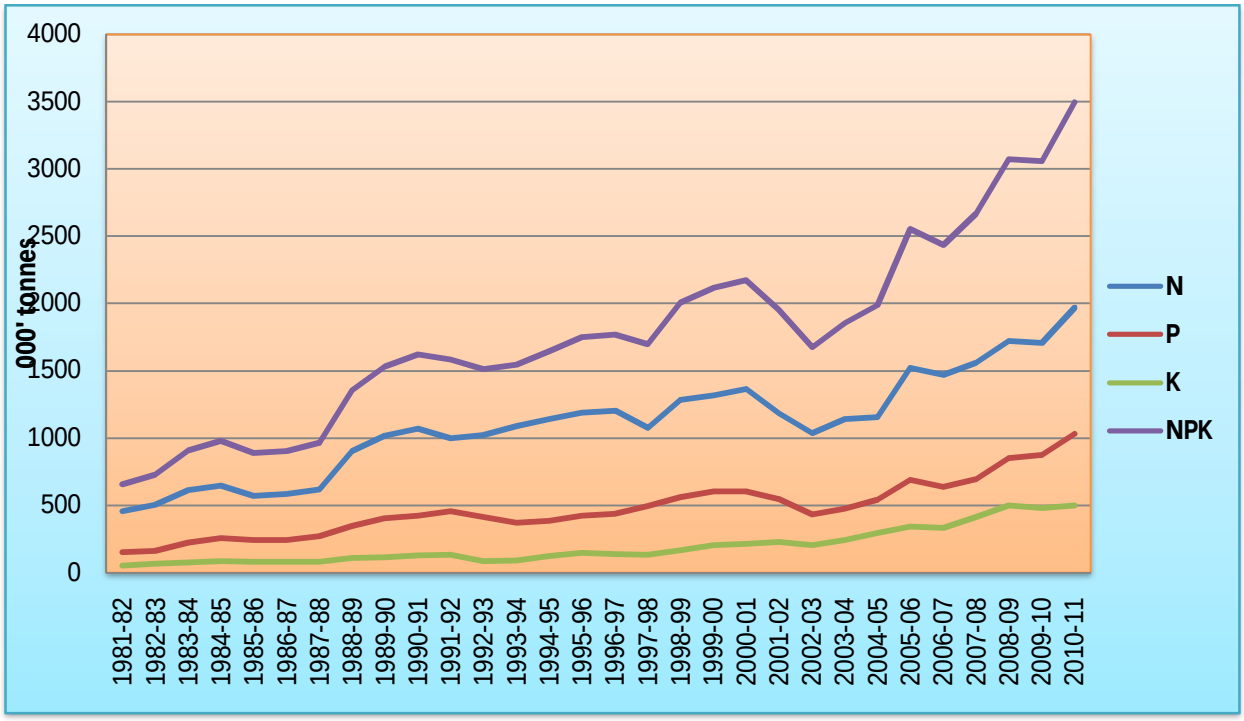

Figure 4.1 Trends in consumption of plant nutrients (N, P and K) in Andhra Pradesh :1981 82 to 2010-11.

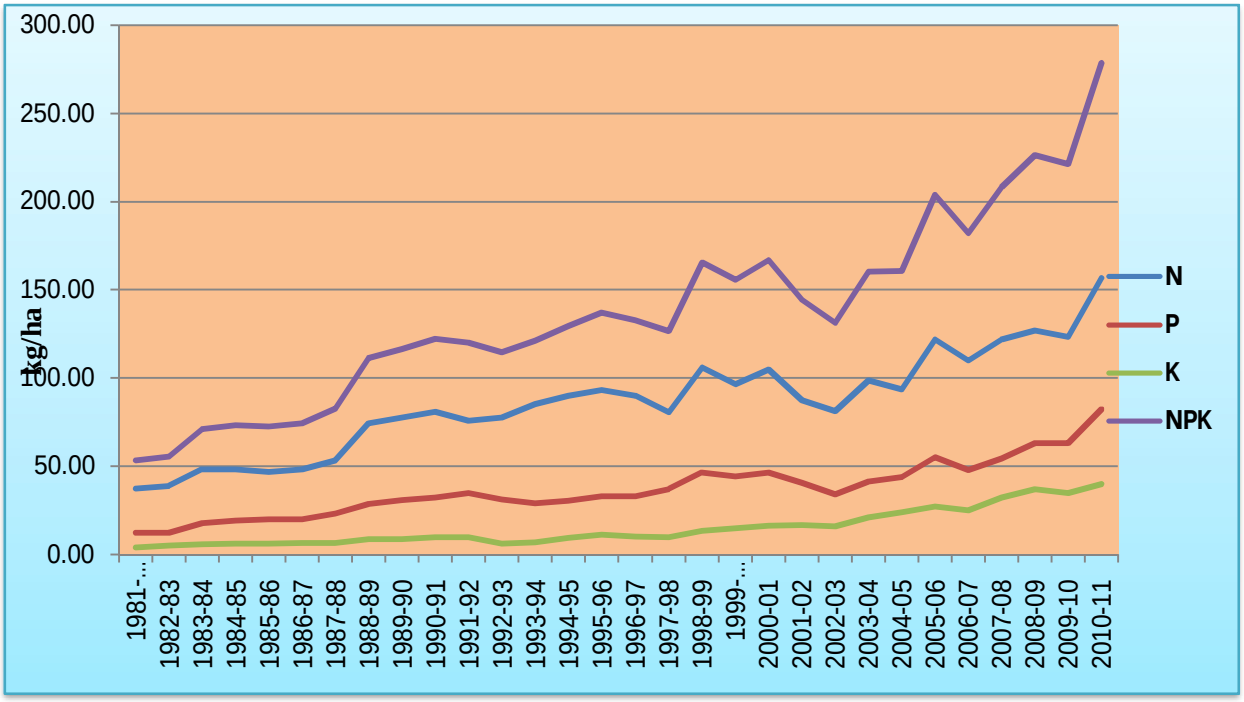

Figure 4.2 Trends in per hectare consumption of plant nutrients (N, P and K) in Andhra Pradesh: 1981-82 to 2010-11.

1672 thousand tonnes. Again in 2006-07 and 2009-10, there is overall decline in NPK consumption by -4.65 per cent and -0.47 per cent annual growth rate respectively.

From the table 4.1 it was also observed that the annual growth rates worked out for consumption of nitrogen had shown a fluctuating trend from 1981-82 to 2010-11. The annual growth rate for consumption of N was at maximum by 45.79 during 1988-89 and was the lowest with negative growth percentage of 13.15 during 2001-02. Nitrogen consumption was around 456 thousand tons in 1981-82 and it picked up very fast during the late-1980s. In 1984-85, nitrogen consumption increased to 644 thousand tonnes.

But during 1985-86, fertilizer consumption of nitrogen was reduced to 568 thousand tonnes, that is registering an annual growth rate of -11.79 per cent. However, nitrogen consumption has again increased to 583 thousand tonnes in 1986-87 and the trend continued to increased through the years till 1990-91 reaching 1068 thousand tonnes. In 1991-92, the consumption of nitrogen has reduced showing growth rate of -6.58 per cent (997 thousand tonnes). In 1990s, nitrogen consumption fluctuated between 1068 thousand tonnes and 1314 thousand tonnes. In 1997-98, the consumption was decreased to 1057 thousand tonnes showing an annual growth rate of -10.36 per cent. In 2000's although nitrogen consumption had shown an increasing trend, a remarkable negative annual growth rate was observed during 2001-02 (-13.5 %) and 2002-03 (-12.43 %). Similarly, during 2006-07 and 2009-10, slight decrease in annual growth rates of -3.68 and -0.95 per cent respectively was registered. In these three decades, nitrogen fertilizer consumption increased by four times.

The phosphorous consumption in absolute term also showed a positive growth rate except in few years which has negative annual growth rates. The annual growth rate for phosphorous was as high as 40.14 per cent during 1983-84. During the year 2002-03 it was lowest and recorded negative percentage of 20.79. The absolute phosphorous in Andhra Pradesh during 1981-82 was 150 thousand tonnes which increased to 424 thousand tonnes during 1990-91. In 2000-01 and 2010-11 phosphorous consumption was 603 thousand tonnes and 1031 thousand tonnes respectively. Overall, phosphorous consumption was found to be increased by six times during the last three decades.

The consumption of potash was less compared to nitrogen and phosphorous during the study periods. But there was increase in the potassic fertilizer consumption in Andhra Pradesh during the last three decades. It also followed a fluctuating trend in consumption.

Table 4.2 Trends in per hectare consumption of fertilizer nutrients (N, P and K) in Andhra Pradesh: 1981-82 to 2010-11. (kg ha^{-1})

	N	AGR	P	AGR	K	AGR	NPK	AGR
1981-1982	37.15		12.25		3.97		53.38	
1982-83	38.53	3.72	12.18	-0.57	4.96	24.98	55.67	4.3
1983-84	47.97	24.5	17.44	43.2	5.75	15.83	71.16	27.82
1984-85	48.16	0.39	18.99	8.91	6.05	5.15	73.19	2.86
1985-86	46.58	-3.27	19.88	4.68	6.26	3.51	72.72	-0.64
1986-87	48.19	3.46	19.95	0.37	6.36	1.56	74.5	2.45
1987-88	53.01	9.99	23.12	15.85	6.56	3.17	82.68	10.98
1988-89	74.35	40.27	28.45	23.05	8.73	33.05	111.52	34.88
1989-90	77.47	4.19	30.54	7.38	8.51	-2.43	116.53	4.48
1990-91	80.57	4	31.99	4.74	9.62	12.96	122.17	4.85
1991-92	75.64	-6.12	34.49	7.8	9.81	2.05	119.94	-1.83
1992-93	77.27	2.15	31.06	-9.93	6.18	-36.99	114.51	-4.52
1993-94	85.13	10.17	28.97	-6.73	6.91	11.69	121.01	5.67
1994-95	89.7	5.37	30.41	4.96	9.48	37.27	129.59	7.09
1995-96	92.89	3.56	32.92	8.25	11.19	18	136.99	5.71
1996-97	89.9	-3.21	32.71	-0.65	9.95	-11.01	132.56	-3.23
1997-98	80.18	-10.81	36.66	12.08	9.71	-2.45	126.55	-4.54
1998-99	105.83	31.99	46.19	26	13.45	38.5	165.47	30.75
1999-2000	96.48	-8.83	44.26	-4.18	14.76	9.76	155.5	-6.02
2000-01	104.57	8.38	46.34	4.71	16.07	8.89	166.98	7.38
2001-02	87.33	-16.49	40.45	-12.7	16.73	4.06	144.51	-13.46
2002-03	81.19	-7.03	34.02	-15.91	15.92	-4.83	131.13	-9.26
2003-04	98.53	21.35	41.02	20.58	20.77	30.49	160.31	22.26
2004-05	93.52	-5.08	43.58	6.26	23.64	13.82	160.75	0.27
2005-06	121.59	30.01	55.13	26.48	27.19	15	203.9	26.85
2006-07	109.72	-9.76	47.58	-13.68	24.85	-8.6	182.16	-10.66
2007-08	121.8	11.01	54.25	14.01	32.18	29.48	208.23	14.31
2008-09	126.84	4.14	62.81	15.78	36.69	14.04	226.35	8.7
2009-10	123.25	-2.83	63.09	0.43	34.67	-5.51	221.01	-2.36
2010-11	156.59	27.05	82.17	30.25	39.67	14.41	278.42	25.98
CGR	3.98		5.06		7.46		4.62	
CV	33.83		43.64		69.58		39.52	

The annual growth rate for potash was highest by 38.30 per cent during 1988-89. It came to the lowest level of a negative percentage of 36.85 during 1992-93. In 1981-82, potassic fertilizer consumption in Andhra Pradesh was 48 thousand tonnes which increased to 127 thousand tonnes during 1990-91. Further in 2000-01, potassic consumption increased to 209 thousand tonnes while in 2010-11 it was 498 thousand tonnes. So within three-decades potassic fertilizer consumption increased by 10 times.

The exponential growth rate was maximum for potash, showing 7.59 per cent and minimum for nitrogen 4.09 per cent. It was 5.18 per cent for phosphorous and were significant. The consumption of potash in Andhra Pradesh had shown highest growth rate against nitrogen and phosphorous. The co-efficient of variation for NPK fertilizers was 39.86 per cent from 1981-82 to 2010-11. The highest co-efficient of variation was observed in case of potash (70 %) followed by phosphorous (44%) and nitrogen (35 %). This was due to variation in consumption of potassic fertilizer. It might also be due to less consumption of potash in 1980's and 1990's as famers give less importance to potash and high priority to nitrogenous fertilizer. But in later years, the consumption of potash and also phosphorous fertilizers was increased due to spread of importance of consumption of balance fertilizer doses.

Looking at the total fertilizer consumption in absolute terms might not give clear idea. Therefore, along with the examination of trend in absolute terms it is also appropriate to examine trend in fertilizer consumption per hectare of cropped area over time. From table 4.2 and figure 4.2, it was evident that per hectare consumption of N, P, K and total NPK per annum was increasing with some fluctuation in few years. The total NPK per hectare consumption was 53.38 kg ha^{-1} during 1981-82 and was less than 100 kg ha^{-1} up to 1980's. It crossed above 100 kg ha^{-1} during 1988-89 and showed an increasing trend thereafter. During 2005-06, NPK per hectare consumption crossed 200 kg ha^{-1}. In 2010-11 this was 278.42 kg ha^{-1}. The highest growth rate was observed during 1988-89 (34.88 %) and highest negative growth rate was observed in 2001-02 (-13.46 %), due to bad monsoon (Sharma and Hrima, 2011).

Similarly, from the table 4.2, also it was observed that consumption of per hectare N, P and K was showing increasing trend. The nitrogen per hectare consumption was 37.15 kg ha^{-1} during 1981-82 which increased to 80.57 kg ha^{-1} during 1990-91. The per hectare consumption of nitrogen crossed 100 kg ha^{-1} during 1998-99 and it showed a negative

growth rate but after 2005-06, nitrogen per hectare consumption was above 120 kg ha^{-1}. The highest annual growth rate of per hectare nitrogen consumption was observed in 1998-89 (40.27 %) and lowest negative annual growth rate was observed in 2001-02 (-16.49 %). The soil fertility status degraded year after year and because nitrogenous fertilizers are volatile and loss through leaching and evaporation will be more, therefore the above increasing trend was observed. During the post green revolution and later, farmers were found to have an impression that nitrogen is more useful compared to phosphorous and potash, as they could visualize the crop growth to become luxuriant after application of urea, a nitrogenous fertilizer.

The per hectare consumption of phosphorous was less than 90 kg ha^{-1} in the study years. It was 12 kg ha^{-1} during 1981-82, which gradually increased to 32.99 kg ha^{-1} (1995-96). This was further increased to 46 kg ha^{-1} during 2000-01 and was 82 kg ha^{-1} during 2010-11. The highest annual growth rate in negative terms was observed in 1988-89 and lowest annual negative growth rate was observed in 2002-03. The fertilizer policy on phosphorous subsidy, imports and fertilizer price might have influenced the consumption of phosphorous. Phosphorous was also important for the root growth, seed development and oil content etc. but was neglected by farmers due to high unit price. More over as domestic demand cannot be met with domestic production there was a dependence on import. Due to these facts, application of phosphorous fertilizer has become second priority to the farmers.

In case of potash fertilizer, per hectare consumption showed an increasing trend over the study period. The per hectare consumption was less than 10 kg ha^{-1} till 1997-98 except in 1995-96 (11 kg ha^{-1}). Then it crossed 11 kg ha^{-1} from 1998-99 and from 2003-04 its consumption become more than 20 kg ha^{-1}. During 2010-11, per hectare potassic fertilizer was 39 kg ha^{-1}. Over the last three decade per hectare consumption of potassic fertilizer increased by 11 times in Andhra Pradesh. From the foregoing analysis it can be concluded that after globalization(1997-98) the application of potassic fertilizer was picked up. Potash was the third priority in the order of fertilizer consumption even though it is important for nutrient intake and for disease resistance in crop plants.

The exponential growth rate of unit consumption was maximum for potash, showing 7.46 per cent and minimum for nitrogen 3.98 per cent. It was 5.06 per cent of growth for phosphorous. All the parameters showed significant growth rate. The co-efficient of variation for NPK fertilizers was 39.52 per cent from 1981-82 to 2010-11. The

highest co-efficient of variation was observed in potash (70 %) followed by phosphorous (44%) and nitrogen (33 %). This was due to less consumption of potassic fertilizer in 1980's and 1990's as famers give less importance to this fertilizer and consumed more of nitrogenous fertilizer. But in later years, the consumption of potash and also phosphorous fertilizer was increased due to the spread of scientific crop management.

From the above discussion it was concluded that, over the last three decades, N, P, K and NPK per hectare consumption observed an increasing trend with some fluctuation in some years. The absolute NPK consumption was increase by four times while per hectare consumption was increased by five times. During the year, 1988-89, absolute as well as per hectare consumption shows a maximum annual growth rate. This might be due to favorable monsoon and easy availability of fertilizer in the state. The per hectare nitrogen consumption was more compared to phosphorous and potassic fertilizer in all the study years. The ratio of per hectare consumption of N:P:K was 12:4:1 and 4:2:1 during 1981-82 and 2010-11 respectively . The balance recommended dose for N, P and K is 4:2:1 (Chand and Pandey, 2008). So, in early 1980's deviation from recommended dose was more but in recent years it come in line with recommended doses. This confirmed that farmers adopted use of balance dose of fertilizer. The foregoing discussions revealed that absolute quality and per hectare analysis fall in line with one another. The variation overtime was more of potash and also the exponential growth rate was more for potash. The variations in growth and priority of the farmers might be due to several factors.

4.1.1.2 District wise consumption of NPK in Andhra Pradesh

It is not sufficient just note the overall trend in N, P and K consumption as it gives a macro level view. To have a better idea it is better to probe at least up to the district level data in order to study variation in NPK consumption across the districts. The district wise average consumption of NPK and that for the state as a whole is furnished in Table 4.3. It is evident from the table that between the two-triennium periods studied namely TE (1981-84) and TE (2008-11) all the districts witnessed an increase in the consumption of NPK. For convenience in understanding different approach was adopted by taking TE averages at two points of time.

Table 4.3 District wise consumption of NPK in Andhra Pradesh. (000' tonnes)

Sl. No.	District	TE (1981-84)	TE (2008-11)	% change	Ranking as per consumption during	
					TE (1981-84)	TE(2008-11)
1	Srikakulam	15.30 (2.00)	53.87 (1.68)	252.11	18	20
2	Vizianagaram	11.72 (1.54)	48.33 (1.51)	312.32	20	21
3	Visakhapatnam	7.38 (0.97)	33.61 (1.05)	355.30	22	22
4	East Godavari	52.25 (6.84)	174.18 (5.43)	233.40	5	7
5	West Godavari	73.96 (9.69)	261.75 (8.16)	253.92	2	2
6	Krishna	59.86 (7.84)	221.68 (6.91)	270.35	4	4
7	Guntur	105.06 (13.76)	309.08 (9.63)	194.20	1	1
8	Prakasam	35.70 (4.68)	148.76 (4.64)	316.72	9	11
9	Nellore	34.35 (4.50)	152.46 (4.75)	343.79	10	9
10	Kurnool	47.77 (6.26)	226.25 (7.05)	373.67	6	3
11	Anantapur	14.94 (1.96)	115.32 (3.59)	671.88	19	14
12	Kadapa	19.97 (2.62)	93.64 (2.92)	368.96	14	18
13	Chittoor	18.75 (2.46)	70.51 (2.20)	276.06	15	19
14	Ranga Reddy	18.54 (2.43)	114.23 (3.56)	516.19	16	15
15	Nizamabad	64.44 (8.44)	149.13 (4.65)	131.44	3	10
16	Medak	16.84 (2.21)	102.32 (3.19)	507.72	17	17
17	Mahboobnagar	25.62 (3.36)	121.55 (3.79)	374.46	12	13
18	Nalgonda	26.84 (3.52)	213.78 (6.66)	696.51	11	5
19	Warangal	43.09 (5.64)	161.72 (5.04)	275.29	7	8
20	Khammam	24.58 (3.22)	130.26 (4.06)	429.98	13	12
21	Karimnagar	37.19 (4.87)	201.67 (6.29)	442.27	8	6
22	Adilabad	9.40 (1.23)	104.00 (3.24)	1005.88	21	16
23	Andhra Pradesh	763.52 (100.00)	3208.08 (100.00)	320.17		

Note: figure in parantheses indicate per cent to respective total

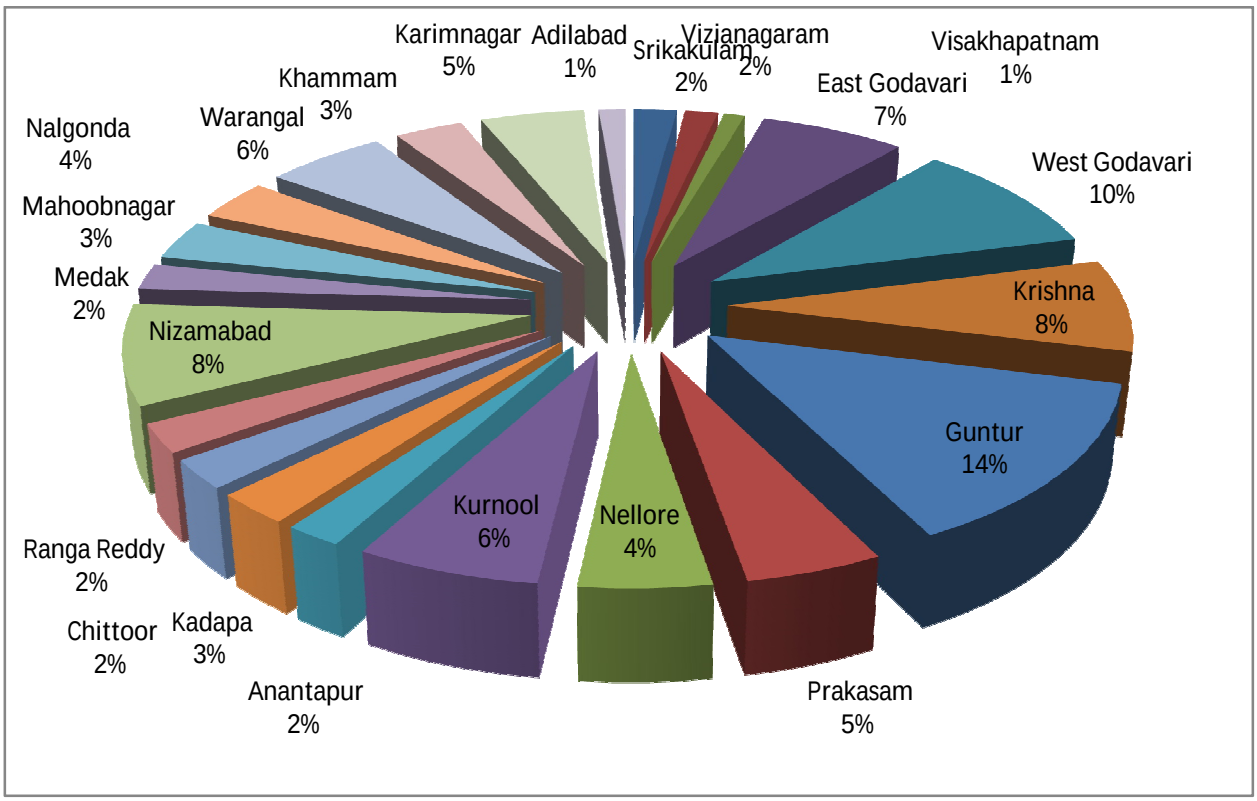

Figure 4. 3 NPK share among the districts in TE (1981-84)

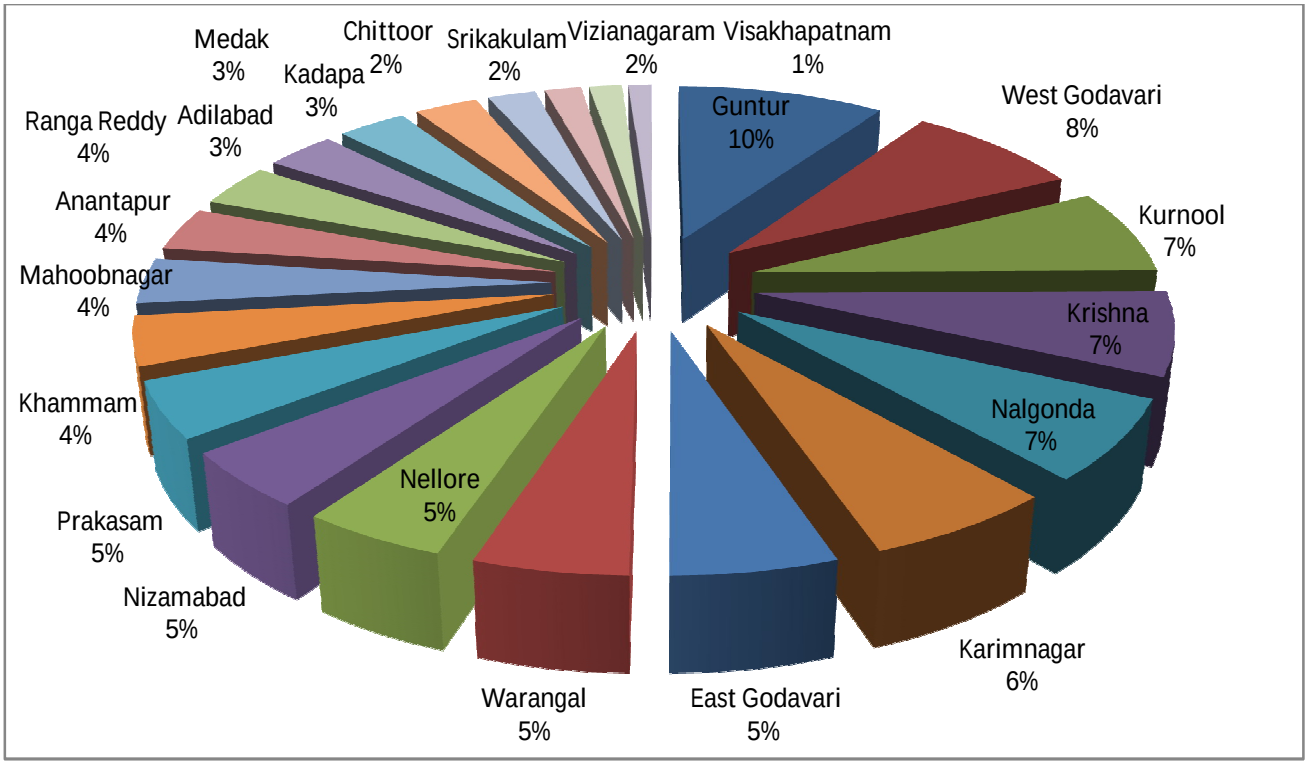

Figure 4.4 NPK share among the districts in TE (2008-11)

The highest percentage increase in the average consumption of NPK was noticed in Adilabad (1005.88 %) followed by Nalgonda, Anantapur and Ranga Reddy with the value of 696.51 per cent, 671.88 per cent and 516.19 per cent, respectively over the two triennium period. While, lowest percentage increase in the average consumption of NPK was observed in Nizamabad with the value of 131.44 per cent and state as a whole recorded an increase in the average consumption of NPK of 320.17 per cent.

Overall, average consumption of NPK during the TE (1981-84) was 763.52 thousand tonnes, which increased to 3208.08 thousand tonnes in TE (2008-11). During the TE (1981-84), among the districts, highest NPK consumption was observed in Guntur (105.06 thousand tonnes) followed by West Godavari (73.96 thousand tonnes), Nizamabad (64.44 thousand tonnes) and Krishna (59.86 thousand tonnes). However, lowest NPK consumption was recorded in Visakhapatnam (7.38 thousand tonnes) followed by Adilabad (9.40 thousand tonnes) and Vizianagaram (11.72 thousand tonnes). Guntur district is known for black cotton soils and cotton was predominant among the other districts like Godavari, Nizamabad and Krishna, the farmers adopted green revolution technology quickly and more irrigation facilities are there. Therefore reflected in high consumption of NPK during the first TE period considered.

In TE 2008-11, among the district, highest NPK consumption was observed in Guntur (309.08 thousand tonnes) followed by West Godavari (261.75 thousand tonnes), Kurnool (226.25 thousand tonnes) and Krishna (221.68 thousand tonnes). And lowest NPK consumption was recorded in Visakhapatnam (33.61 thousand tonnes) followed by Vizianagaram (48.33 thousand tonnes) and Srikakulam (53.87 thousand tonnes). The highest consumption to the total was maintained among the same districts except in Nizamabad. The highest increase in NPK consumption in the respective districts, might be attributed to changes in cropping pattern and use of fertilizer intensive varieties (sugarcane, maize).

Again from the table 4.3 and fig. 4.3 and 4.4 it can reported that during the TE (1981-84), Guntur (13.76 %) share the highest consumption of NPK followed by West Godavari (9.69 %). While lowest share in NPK consumption was recorded in Visakhapatnam (0.97 %) followed by Adilabad (1.23 %). During the TE (2008-11) also, among the districts, Guntur share the highest consumption of NPK followed by West

Table 4.4: District wise TE average consumption of Nitrogen in Andhra Pradesh. (000'tonnes)

Sl. No.	District	TE (1981-84)	TE(2008-11)	% change
1	Srikakulam	13.61	32.65	139.84
2	Vizianagaram	9.27	28.41	206.39
3	Visakhapatnam	6.34	22.45	254.24
4	East Godavari	39.57	101.09	155.47
5	West Godavari	49.15	141.26	187.41
6	Krishna	40.83	124.26	204.3
7	Guntur	68.28	166.77	144.23
8	Prakasam	22.29	77.52	247.75
9	Nellore	22.48	90.44	302.38
10	Kurnool	27.62	108.75	293.79
11	Anantapur	9.24	52.65	469.89
12	Kadapa	13.80	41.11	197.99
13	Chittoor	12.99	42.63	228.16
14	Ranga Reddy	12.30	62.53	408.34
15	Nizamabad	48.66	92.23	89.55
16	Medak	11.06	58.46	428.38
17	Mahboobnagar	16.73	64.28	284.24
18	Nalgonda	18.21	121.68	568.13
19	Warangal	30.42	100.42	230.09
20	Khammam	16.73	75.09	348.88
21	Karimnagar	22.19	131.00	490.43
22	Adilabad	7.80	61.66	690.13
	Total	519.57	1797.35	245.93

Adilabad district registered the highest increased in the share of NPK consumption (62.00%) followed by Nalgonda (47.00%).

Godavari (8.16%). And lowest share in NPK consumption was recorded in Visakhapatnam (1.05 %) followed by Vizianagaram (1.51 %). Over the year, the share of NPK fertilizer was considerably declined in Nizamabad (-82.00%) followed by Guntur (-43.00%). While it can be concluded that Guntur and West Godavari districts consumed highest share of NPK consumed by the state. Visakhapatnam remained as lowest consumer of NPK in absolute terms. This might be influenced by quick adoption of chemical fertilization by the farmers of these districts and irrigation facilities and the crops like paddy, sugarcane cultivated in larger areas.

4.1.1.3 District wise consumption of Nitrogen in Andhra Pradesh

The particulars of nitrogen consumption was furnished district wise in table 4.4. At the state level, the average consumption of nitrogenous fertilizer grew by 245.93 per cent between the two-triennium periods. The highest increase in the consumption of nitrogen fertilizer was observed in Adilabad (690.13%) followed by Nalgonda (568.13%), Karimnagar (490.43%) and Anantapur (469.89 %) whereas Nizamabad district witnessed a lowest increase (89.55%) in the consumption of nitrogen fertilizer followed by Srikakulam (139.84 %) and Guntur (144.23 %), during the study period.

In the TE (1981-84), average total nitrogen consumption was 519.57 thousand tonnes, which increased to 1797.35 thousand tonnes in TE (2008-11). In the TE (1981-84), among the districts, highest nitrogen consumption was observed in Guntur (68.28 thousand tonnes) followed by West Godavari (49.15 thousand tonnes), Nizamabad (48.66 thousand tonnes) and Krishna (40.83 thousand tonnes). While lowest nitrogen consumption was recorded in Visakhapatnam (6.34 thousand tonnes) followed by Adilabad (7.80 thousand tonnes), Anantapur (9.24 thousand tonnes) and Vizianagaram (9.27 thousand tonnes).

In TE 2008-11, among the districts, highest nitrogen consumption was observed in Guntur (166.77 thousand tonnes) followed by West Godavari (141.26 thousand tonnes), Karimnagar (131.00 thousand tonnes) and Krishna (124.26 thousand tonnes). However, lowest nitrogen consumption was recorded in Visakhapatnam (22.45 thousand tonnes) followed by Vizianagaram (28.41 thousand tonnes), Srikakulam (32.65 thousand tonnes) and Kadapa (41.11 thousand tonnes).

Table 4.5 District wise TE average consumption of Phosphorus fertilizer in Andhra Pradesh (000'tonnes)

Sl no.	District	TE (1981-84)	TE (2008-11)	% change
1	Srikakulam	1.62	12.18	652.79
2	Vizianagaram	2.33	10.96	370.93
3	Visakhapatnam	0.96	6.77	605.25
4	East Godavari	8.85	43.21	388.45
5	West Godavari	18.24	68.09	273.3
6	Krishna	13.93	61.15	339.13
7	Guntur	27.34	100.39	267.23
8	Prakasam	9.20	55.38	502.03
9	Nellore	7.84	42.08	436.99
10	Kurnool	13.27	83.50	529.1
11	Anantapur	3.87	38.27	889.87
12	Kadapa	4.67	33.39	615.35
13	Chittoor	3.91	17.39	344.79
14	Ranga Reddy	4.34	32.05	638.76
15	Nizamabad	12.79	37.68	194.7
16	Medak	3.91	28.57	630.66
17	Mahboobnagar	6.72	41.13	511.98
18	Nalgonda	7.11	66.05	829
19	Warangal	10.44	35.74	242.36
20	Khammam	5.78	34.57	498.27
21	Karimnagar	8.63	43.41	402.89
22	Adilabad	1.59	26.96	1592.93
23	Andhra Pradesh	177.31	918.90	418.24

4.1.1.4 District wise consumption of phosphorous in Andhra Pradesh

The district wise consumption of phosphate fertilizer is illustrated in Table 4.5. The table revealed that all of the districts showed an increase in the consumption of phosphatic fertilizer between the two periods. The average consumption of phosphorus fertilizer at the state level increased by 418.24 per cent. Among the districts, the highest increase in the consumption of phosphorus was noticed in Adilabad (1592.93 %) followed by Anantapur (889.87 %), Nalgonda (829.00 %) and Srikakulam (652.79 %) districts. Lowest increase in the average consumption of phosphate fertilizer was observed in Nizamabad (194.70%) followed by Warangal (242.36 %) district.

In the TE (1981-84), average total phosphate consumption was 177.31 thousand tonnes, which increased to 918.90 thousand tonnes in TE (2008-11). In the TE (1981-84), among the districts, highest phosphate consumption was observed in Guntur (27.34 thousand tonnes) followed by West Godavari (18.24 thousand tonnes), Krishna (13.93 thousand tonnes) and Kurnool (13.27 thousand tonnnes). And lowest phosphate consumption was recorded in Visakhapatnam (0.96 thousand tonnes) followed by Adilabad (1.59 thousand tonnes, Srikakulam (1.62 thousand tonnes) and Vizianagaram (2.33 thousand tonnes).

In TE 2008-11, among the districts, highest phosphate consumption was observed in Guntur (100.39 thousand tonnes) followed by Kurnool (83.50 thousand tonnes), West Godavari (68.09 thousand tonnes) and Nalgonda (66.05 thousand tonnes). While, lowest phosphate consumption was recorded in Visakhapatnam (6.77 thousand tonnes) followed by Vizianagaram (10.96 thousand tonnes), Srikakulam (12.18 thousand tonnes) and Chittor (17.39 thousand tonnes).

It can be concluded that Guntur were registering highest while Visakhapatnam were lowest share in phosphorous use in both TE periods considered.

4.1.1.5 District wise consumption of Potash in Andhra Pradesh

The district wise and state consumption of potash fertilizer is illustrated in Table 4.6. The state recorded an increase in the average consumption of potash fertilizer by 689.15 per cent between the two-triennium periods. All the districts recorded an increase in the consumption of potash fertilizer over the years. The highest percentage increase in the

Table 4.6: District wise TE average consumption of Potash fertilizer in Andhra Pradesh. (000'tonnes)

Sl. No.	District	TE (1981-84)	TE (2008-11)	% change
1	Srikakulam	0.07	9.05	12945.67
2	Vizianagaram	0.12	8.96	7282.42
3	Visakhapatnam	0.09	4.39	5068.63
4	East Godavari	3.83	29.88	680.51
5	West Godavari	6.57	52.40	697.78
6	Krishna	5.10	36.27	611.64
7	Guntur	9.44	41.92	344.21
8	Prakasam	4.21	15.86	277.05
9	Nellore	3.98	19.95	401.67
10	Kurnool	6.88	34.00	394.47
11	Anantapur	1.84	24.41	1229.15
12	Kadapa	1.50	19.14	1173.08
13	Chittoor	1.85	10.49	467.32
14	Ranga Reddy	1.90	19.64	935.15
15	Nizamabad	2.99	19.22	542.03
16	Medak	0.64	15.29	2307.4
17	Mahboobnagar	2.17	16.14	644.21
18	Nalgonda	1.52	26.05	1616.43
19	Warangal	2.23	25.56	1046.05
20	Khammam	2.10	20.59	880.66
21	Karimnagar	3.15	27.26	764.27
22	Adilabad	0.17	15.38	8720.65
23	Andhra Pradesh	62.33	491.84	689.15

average consumption of potash fertilizer was noticed in Srikakulam (12945.67%) followed by Adilabad (8720.65%), Vizianagaram (5068.63%) and Visakhapatnam (5068.63%) districts. Lowest percentage increase in the average consumption of Potash fertilizer was observed in Prakasam (277.05 %) followed by Guntur (344.20 %) districts.

In the TE (1981-84), average total potash consumption was 62.33 thousand tonnes, which increased to 491.84 thousand tonnes in TE (2008-11). In the TE (1981-84), among the districts, highest potash consumption was observed in Guntur (9.44 thousand tonnes) followed by Kurnool (6.88 thousand tonnes), West Godavari (6.57 thousand tonnes) and Krishna (5.10 thousand tonnes). Lowest Potash consumption was recorded in Srikakulam (0.07 thousand tonnes) followed by Visakhapatnam (0.09 thousand tonnes), Vizianagaram (0.12 thousand tonnes) and Adilabad (0.17 thousand tonnes).

In TE 2008-11, among the district, highest Potash consumption was observed in West Godavari (52.40 thousand tonnes) followed by Guntur (41.92 thousand tonnes), Krishna (36.27 thousand tonnes) and Kurnool (34.00 thousand tonnes). And lowest potash consumption was recorded in Visakhapatnam (4.40 thousand tonnes) followed by Vizianagaram (8.96 thousand tonnes), Srikakulam (9.05 thousand tonnes) and Chittor (10.49 thousand tonnes).

Just like nitrogen and phosphorous, Guntur average consumption of potash was highest, which meant the adoption of use of chemical fertilizers was high by Guntur progressive farmers. The highest consumption of potash was found in West Godavari, Guntur and Krishna districts also in both the periods.

4.1.1.6 District wise per hectare consumption of NPK in Andhra Pradesh

The details of per hectare consumption of NPK are presented in Table 4.7. It is evident from the table that the state registered 303.70 per cent increase in the per hectare consumption of NPK between the two-triennium periods.

Almost all the districts recorded increase in the per hectare NPK consumption over the years. The highest percentage increase in the average per hectare consumption of NPK was noticed in Adilabad (938.69 %) followed by Ranga Reddy (856.67 %), Nalgonda (797.43 %) and Anantapur (598.78 %). While the lowest increase in per hectare consumption of NPK was observed in Nizamabad (89.43 %) followed by Guntur (173.42 %), East Godavari (214.92%) and Srikakulam (218.07 %) districts.

Table 4.7: District wise per hectare consumption of NPK in Andhra Pradesh

Sl. No.	District	TE (1981-84)	TE (2008-11)	% change
1	Srikakulam	39.92	126.98	218.07
2	Vizianagaram	34.19	123.01	259.77
3	Visakhapatnam	20.54	95.71	366.06
4	East Godavari	84.34	255.32	202.73
5	West Godavari	120.97	380.94	214.92
6	Krishna	80.85	299.48	270.43
7	Guntur	135.92	371.62	173.42
8	Prakasam	53.18	220.64	314.91
9	Nellore	89.31	350.60	292.58
10	Kurnool	47.75	224.59	370.30
11	Anantapur	15.58	108.86	598.78
12	Kadapa	48.76	185.96	281.39
13	Chittoor	36.29	166.61	359.10
14	Ranga Reddy	49.51	473.63	856.67
15	Nizamabad	166.17	314.78	89.43
16	Medak	31.54	178.03	464.50
17	Mahboobnagar	25.51	136.58	435.41
18	Nalgonda	34.66	311.01	797.43
19	Warangal	70.00	252.40	260.57
20	Khammam	51.80	254.41	391.11
21	Karimnagar	68.45	283.78	314.58
22	Adilabad	15.10	156.86	938.69
	Total	58.32	235.46	303.70

In TE 1981-84, average per hectare consumption of NPK was 58.32 kg ha^{-1}, which increased to 235.46 kg ha^{-1} in the TE 2008-11. In TE 1981-84, highest per hectare consumption of NPK was recorded in Nizamabad (166.17 kg ha^{-1}) while Adilabad (15.10 kg ha^{-1}) recorded the lowest per hectare consumption of NPK. Among the districts, Nizamabad, Guntur, West Godavari, Nellore, East Godavari, Krishna, Warangal and Karimnagar recorded higher values than state average, whereas districts like Prakasam, Khammam, Ranga Reddy, Kadapa, Kurnool, Srikakulam Chittoor, Nalgonda, Vizianagaram, Medak, Mahoobnagar, Visakhapatnam, Anantapur and Adilabad fell below the state average.

In TE 2008-11, highest per hectare consumption of NPK was observed in Ranga Reddy (473.63 kg ha^{-1}) while Vishakhapatnam (95.71 kg ha^{-1}) recorded the lowest per hectare consumption of NPK. In TE 2008-11, Ranga Reddy, West Godavari, Guntur, Nellore, Nizamabad, Nalgonda, Krishna, Karimnagar, East Godavari, Khammamand Warangal showed the above state average whereas district like Kurnool, Prakasam, Kadapa, Medak Chittoor, Adilabad, Mahoobnagar, Srikakulam, Vizianagaram, Anantapur and Visakhapatnam consumed less than state average.

In the district analysis the absolute NPK and per hectare NPK consumption did not show similar pattern, Nizamabad shown highest consumption followed by Guntur in the first TE. This might be due to sugarcane crop grown in Nizamabad.

During the second triennium Ranga Reddy district had a highest share in per unit NPK consumption. This might be due to cropping pattern with fertilizer intensive crops such as turmeric and maize.

4.1.1.7 District wise per hectare consumption of Nitrogen in Andhra Pradesh

The details of per hectare consumption of nitrogen are presented in Table 4.8. It is evident from the table that the state registered 232.23 per cent increase in the per hectare consumption of nitrogen between the two-triennium periods.

All the districts recorded increase in the per hectare nitrogen consumption over the years. The highest percentage increase in the average per hectare consumption of nitrogen was noticed in Ranga Reddy (693.89 %) followed by Nalgonda (648.98 %), Adilabad (643.06 %) and Anantapur (416.75 %). While the lowest increase in per hectare consumption of nitrogen was observed in Nizamabad (54.91 %) followed by Srikakulam (116.51 %), Guntur (126.81%) and East Godavari (132.38 %) districts.

Table 4.8: District wise per hectare consumption of Nitrogen in Andhra Pradesh.

Sl. No.	District	TE (1981-84)	TE (2008-11)	% change
1	Srikakulam	35.52	76.91	116.51
2	Vizianagaram	27.16	72.30	166.24
3	Visakhapatnam	17.59	63.84	262.99
4	East Godavari	63.91	148.52	132.38
5	West Godavari	80.40	205.62	155.75
6	Krishna	55.13	167.84	204.44
7	Guntur	88.37	200.44	126.81
8	Prakasam	33.15	115.14	247.39
9	Nellore	58.39	207.96	256.19
10	Kurnool	27.61	107.95	290.97
11	Anantapur	9.61	49.68	416.75
12	Cuddapah	33.66	81.60	142.44
13	Chittoor	24.98	100.76	303.35
14	Hyderabad/ Ranga Reddy	32.90	261.15	693.89
15	Nizamabad	125.50	194.41	54.91
16	Medak	20.72	101.89	391.81
17	Mahboobnagar	16.65	72.06	332.79
18	Nalgonda	23.55	176.36	648.98
19	Warangal	49.43	156.32	216.23
20	Khammam	35.23	146.54	315.94
21	Karimnagar	40.89	184.82	352.00
22	Adilabad	12.53	93.08	643.06
23	Andhra Pradesh	39.70	131.89	232.23

In TE 1981-84, average per hectare consumption of nitrogen was 39.70 kg ha^{-1}, which increased to 131.89 kg ha^{-1} in the TE 2008-11. In TE 1981-84, highest per hectare consumption of Nitrogen was observed in Nizamabad (166.17 kg ha^{-1}), followed by Guntur (88.37 kg ha^{-1}), West Godavari (80.40 kg ha^{-1}) and East Godavari (63.91 kg ha^{-1}) while lowest per hectare consumption of Nitrogen was recorded in Anantapur (9.61 kg ha^{-1}) followed by Adilabad (12.53 kg ha^{-1}) district.

In TE 2008-11, highest per hectare consumption of Nitrogen was observed in Ranga Reddy (216.15 kg ha^{-1}) indicated the indiscriminate use of nitrogen, as the fertilizer consumption per unit area is important than the overall consumption. Vishakhapatnam (95.71 kg ha^{-1}) recorded the lowest per hectare consumption of Nitrogen. In TE 2008-11, Ranga Reddy, Nellore, West Godavari, Guntur, Nizamabad, Karimnagar, Nalgonda, Krishna, Warangal, East Godavari, Khammam showed the above state average whereas districts like Prakasam, Kurnool, Medak, Chittoor, Adilabad, Cuddapah, Srikakulam, Vizianagaram, Mahbubnagar, Visakhapatnam, Anantapur showed the below state average.

4.1.1.8 District wise per hectare consumption of Phosphorous in Andhra Pradesh

The details of per hectare consumption of phosphorous are presented in Table 4.9. It is evident from the table that the state registered 398.11 per cent increase in the per hectare consumption of phosphorous between the two-triennium periods.

All the districts recorded increase in the per hectare phosphorous consumption over the years. The highest percentage increase in the average per hectare consumption of phosphorous was noticed in Adilabad (1489.50%) followed by Ranga Reddy (1045.17%), Nalgonda (952.15%) and Anantapur (792.53%). Lowest increase in per hectare consumption of Phosphorous was observed in Nizamabad (141.27%) followed by Warangal (229.40 %), West Godavari (232.21%) and Guntur (241.40 %) districts, as these districts particularly West Godavari and Guntur are highest consuming district even at the time of first triennium considered.

In TE 1981-84, average per hectare consumption of phosphorous was 13.53 kg ha^{-1}, which increased to 67.40 kg ha^{-1} in the TE 2008-11. In TE 1981-84, highest per hectare consumption of Phosphorous was observed in Guntur (35.36 kg ha^{-1}) followed by Nizamabad (32.96 kg ha^{-1}), West Godavari (29.83 kg ha^{-1}) and Nellore (20.32 kg ha^{-1}) while lowest per hectare consumption of phosphorous was recorded in Adilabad (2.56 kg

Table 4.9 District wise per hectare consumption of Phosphorous in Andhra Pradesh

Sl. No.	District	TE (1981-84)	TE (2010-11)	% change
1	Srikakulam	4.22	28.75	581.66
2	Vizianagaram	6.68	27.94	318.19
3	Visakhapatnam	2.71	19.49	619.58
4	East Godavari	14.24	62.95	341.98
5	West Godavari	29.83	99.09	232.21
6	Krishna	18.85	82.65	338.38
7	Guntur	35.36	120.72	241.40
8	Prakasam	13.69	81.95	498.44
9	Nellore	20.32	96.68	375.79
10	Kurnool	13.28	82.86	524.05
11	Anantapur	4.04	36.04	792.53
12	Cuddapah	11.42	66.25	480.23
13	Chittoor	7.67	41.03	434.82
14	Hyderabad/ Ranga Reddy	11.55	132.28	1045.17
15	Nizamabad	32.96	79.53	141.27
16	Medak	7.33	49.44	574.76
17	Mahboobnagar	6.69	46.26	591.04
18	Nalgonda	9.15	96.28	952.15
19	Warangal	16.93	55.76	229.40
20	Khammam	12.20	67.52	453.55
21	Karimnagar	15.84	60.69	283.26
22	Adilabad	2.56	40.74	1489.50
23	Andhra Pradesh	13.53	67.40	398.11

Table 4.10 District wise per hectare consumption of Potash in Andhra Pradesh.

Sl. No.	District	TE(1981-84)	TE (2008-11)	% change
1	Srikakulam	0.18	21.32	11708.34
2	Vizianagaram	0.35	22.77	6349.34
3	Visakhapatnam	0.24	12.38	5068.53
4	East Godavari	6.18	43.86	609.17
5	West Godavari	10.74	76.23	609.88
6	Krishna	6.86	48.99	614.00
7	Guntur	12.19	50.47	314.09
8	Prakasam	6.34	23.55	271.52
9	Nellore	10.42	45.95	340.93
10	Kurnool	6.86	33.77	392.02
11	Anantapur	1.93	23.14	1101.11
12	Cuddapah	3.68	38.11	935.18
13	Chittoor	3.64	24.83	582.14
14	Hyderabad/ Ranga Reddy	5.06	80.20	1484.42
15	Nizamabad	7.71	40.84	429.41
16	Medak	1.19	26.69	2142.30
17	Mahbubnagar	2.17	18.27	743.13
18	Nalgonda	1.96	38.37	1859.68
19	Warangal	3.64	40.33	1007.42
20	Khammam	4.44	40.35	809.44
21	Karimnagar	5.80	38.27	559.63
22	Adilabad	0.28	23.04	8140.84
23	Andhra Pradesh	4.76	36.17	659.12

ha^{-1}) followed by Visakhapatnam (2.71 kg ha^{-1}), Anantapur (4.04 kg ha^{-1}) and Srikakulam (4.22 kg ha^{-1}).

In TE 2008-11, highest per hectare consumption of phosphorous was observed in Ranga Reddy (132.28 kg ha^{-1}) while Vishakhapatnam (19.49 kg ha^{-1}) recorded the lowest per hectare consumption of phosphorous. Ranga Reddy, Guntur, West Godavari, Nellore, Nalgonda, Kurnool, Krishna, Prakasam, Nizamabad, Khammam showed above the state average whereas district like Cuddapah, East Godavari, Karimnagar,Warangal, Medak, Mahbubnagar, Chittoor, Adilabad, Anantapur, Srikakulam, Vizianagaram, Visakhapatnam showed below the state average.

There was a five time increase in the consumption of phosphorous per unit, when the state's data for TE I and TE II is considered. It was also found that the districts consumed more phosphorous per unit during TE I were not the same in TE II period. In the TE I Guntur was highest average consumer, while in TEII it was Ranga Reddy. This might be accounted to change in cropping pattern.

4.1.1.9 District wise per hectare consumption of Potash in Andhra Pradesh

The district wise and state consumption of potash fertilizer is illustrated in Table 4.10. The state recorded an increase in the average consumption of potash fertilizer by 659.12 per cent between the two-triennium periods. All the districts recorded increase in the consumption of potash fertilizer over the previous years. The highest percentage increase in the average consumption of potash fertilizer was noticed in Srikakulam (11708.34%) followed by Adilabad (8140.84%), Vizianagaram (6349.34%) and Visakhapatnam (5068.53%) districts. While the lowest increase in the average consumption of Potash fertilizer was observed in Prakasam (271.52 %) followed by Guntur (314.09 %) districts.

In the TE (1981-84), average per hectare consumption of potash was 4.76 kg ha^{-1}, which increase to 36.17 kg ha^{-1}in TE (2008-11). In the TE (1981-84), among the districts, highest potash consumption was observed in Guntur (12.19 kg ha^{-1}) followed by West Godavari (10.74 kg ha^{-1}), Nellore (10.42 kg ha^{-1}) and Nizamabad (7.71 kg ha^{-1}). While four districts consumed less than 1 kg ha^{-1} of potash. And lowest Potash consumption was recorded in Srikakulam (0.18 kg ha^{-1}) followed by Visakhapatnam (0.24 kg ha^{-1}), Adilabad (0.28 kg ha^{-1}) and Vizianagaram (0.35 kg ha^{-1})

Table 4.11.variation in fertilizer consumption per hectare of gross cultivated area among districts –year wise.

Year	Nitrogen	Phosphorous	Potash	NPK
1981-82	57.36	66.23	81.11	55.96
1982-83	73.37	73.76	71.23	69.83
1983-84	77.62	76.82	90.32	76.64
1984-85	76.01	70.45	103.60	75.28
1985-86	81.05	79.72	104.32	80.43
1986-87	76.85	69.06	92.51	69.64
1987-88	76.26	69.33	89.66	72.69
1988-89	63.26	63.13	83.69	62.24
1989-90	57.46	57.99	85.79	57.67
1990-91	55.16	51.47	76.89	53.54
1991-92	52.57	49.57	66.23	50.78
1992-93	49.92	45.00	59.65	47.72
1993-94	47.53	54.59	68.31	47.82
1994-95	47.46	54.15	58.02	48.02
1995-96	51.25	50.43	67.61	49.83
1996-97	51.52	52.04	61.93	49.57
1997-98	51.05	50.69	60.26	48.19
1998-99	46.20	55.50	69.98	48.64
1999-2000	51.77	50.66	65.40	47.85
2000-01	46.45	65.49	79.24	50.69
2001-02	45.64	57.21	96.11	49.92
2002-03	50.96	50.82	85.43	50.99
2003-04	53.28	52.76	84.59	53.03
2004-05	51.11	52.96	103.44	56.07
2005-06	51.05	58.10	97.60	56.30
2006-07	48.99	54.90	145.23	59.51
2007-08	50.97	63.66	78.82	56.61
2008-09	46.04	45.71	41.42	43.24
2009-10	47.94	52.04	53.75	48.21
2010-11	39.35	41.58	48.38	38.35

In TE 2008-11, among the districts, highest potash consumption was observed in Ranga Reddy (80.20 kg ha^{-1}) followed by West Godavari (76.23 kg ha^{-1}), Guntur (50.47 kg ha^{-1}) and Krishna (48.99 kg ha^{-1}). Lowest potash consumption was recorded in Visakhapatnam (12.38 kg ha^{-1}) followed by Mahbubnagar (18.27 kg ha^{-1}), Srikakulam (21.32 kg ha^{-1}) and Vizianagaram (22.77 kg ha^{-1}).

Except in Ranga Reddy district the comparison of potash per hectare remained in the same order during the two periods considered. The application of potash did not pick up as fast as nitrogen as many farmers were unaware of the benefits of application of potash, also the availability and cost also might have influenced this.

4.1.1.10 Variation in fertilizer consumption overtime

The trend in the coefficient of variation in per hectare fertilizer use among districts was illustrated in table 4.11. The table showed that inter district variation in the per hectare consumption of fertilizer was reduced over the years which is due to the easy availability of fertilizer and more adaptability among all categories of the farmers. The coefficient of variation of total NPK per hectare was fluctuating over the year. It was 55.96 per cent in 1981-82, which increased to 57.67 per cent in 1989-90. However, it reduced to 47.85 per cent and 38.35 per cent in 1999-2000 and 2010-11 respectively. It was also observed that among the three fertilizers, consumption of nitrogen per hectare has less variation among the districts. This shows that nitrogen fertilizer is mostly use by farmer. Highest variation was observed in potash consumption among the districts. This may be due to non availability of potash fertilizer, as entire potash fertilizer is imported in India.

The coefficient of variation in the consumption of nitrogen per hectare was 57.36 per cent in 1981-82, which reduced to 51.77 per cent and 39.35 per cent respectively in 1999-2000 and 2010-11.

Similarly, the coefficient of variation of consumption of phosphorous per hectare was 66.23 per cent in 1981-82, which reduced to 50.66 per cent in 1999-00. Then it was further reduced to 41.58 per cent in 2010-11.

The coefficient of variation for the consumption of potash per hectare ranges from 145.23 per cent in the year 2006-07 to 48.38 per cent in 2010-11 among the districts in the study period. It was also observed that in all the study year the coefficient of variation in consumption of potash was high among the districts compare to nitrogen and phosphorous.

Table 4.12 Growth in per hectare consumption of Nitrogen fertilizer in Andhra Pradesh.

Sl. No	District	1981-91	1991-01	2001-11	1981-2010
1	Srikakulam	5.41**	1.85^{NS}	1.58*	2.45***
2	Vizianagaram	7.53^{NS}	-1.01*	7.17***	3.16***
3	Visakhapatnam	15.74*	1.70*	2.97*	4.03***
4	East Godavari	9.76**	2.50***	3.63***	2.76***
5	West Godavari	12.10***	-8.18^{NS}	3.45***	1.88**
6	Krishna	11.62***	1.50 ^{NS}	3.25***	2.98***
7	Guntur	5.48*	1.00 ^{NS}	7.48***	2.38***
8	Prakasam	9.88***	5.62 ^{NS}	4.82**	4.62***
9	Nellore	11.66***	1.09 ^{NS}	5.86***	3.26***
10	Kurnool	3.19^{NS}	4.80***	6.36***	5.70***
11	Anantapur	12.49*	4.16 ^{NS}	7.99***	6.26***
12	Cuddapah	9.26**	0.16 ^{NS}	3.60**	2.77***
13	Chittoor	7.85**	3.29***	6.71***	4.62***
14	Hyderabad/ Ranga Reddy	9.64*	4.09 ^{NS}	5.78**	9.20***
15	Nizamabad	1.20^{NS}	1.81 ^{NS}	1.72 ^{NS}	2.14***
16	Medak	10.75***	6.91**	7.47***	4.97***
17	Mahbubnagar	9.51***	1.47 ^{NS}	7.59***	4.66***
18	Nalgonda	9.62***	4.67 ^{NS}	7.73***	7.37***
19	Warangal	12.71**	2.12**	3.63**	4.71***
20	Khammam	10.34***	3.56***	5.33***	5.08***
21	Karimnagar	9.32^{NS}	5.45***	0.69 ^{NS}	6.96***
22	Adilabad	8.80*	10.21***	12.27***	7.89***
23	Andhra Pradesh	9.17***	2.87***	5.28***	3.93***

*** denotes significant at 1% level
** denotes significant at 5% level
*denotes significant at 10% level
NS denotes Non significant

This might be due to potash was uncommon and farmer give less importance for the use of potash. But the variation was reduced over the year.

The variation might also be accounted to improper fertilizer distribution, availability and high price, which suggests intervention at the government level. The uneven distribution and sub optimal use of fertilizer will degraded the soil quality by getting accumulated at one place and becoming deficient in other areas.

4.1.1.11 Growth in per hectare consumption of Nitrogen fertilizer in Andhra Pradesh.

The district wise growth in per hectare consumption of nitrogen fertilizer in Andhra Pradesh is presented in Table 4.12. The growth for periods considered for analysis were namely 1st decade (1981-90), 2nd decade (1991-2000) and 3rd decade (1991-10) revealed that during the period under study, the growth in per hectare consumption of nitrogen fertilizer in the state recorded a significant positive growth rate of 3.93 per cent per annum. Among the three decades, 1st decade (1981-990) has highest growth of 9.17 per cent followed by 3rd decade (2001-10) with a growth rate of 5.28 per cent while least is the 2nd decade (1991-2000) with 2.87 per cent.

Over the three decades (1981-2010), all the districts shown positive growth in per hectare consumption of nitrogen fertilizer. Among the districts, highest growth in consumption of nitrogen fertilizer was recorded in Ranga Reddy district (9.20%) followed by Adilabad (7.89 %). While lowest growth was recorded in East Godavari (1.88 %) followed by Nizamabad (2.14%). The results are in compliance with the earlier findings.

The table further revealed that during the 1st decade (1981-91), all the districts recorded significant positive growth rate in the per hectare consumption of nitrogen fertilizer. The growth rate range from 1.22 per cent to 15.74 per cent. The highest positive growth rate was noticed in Visakhapatnam (15.74%) followed by Warangal, Anantapur and West Godavari, whereas Nizamabad (1.20%) district recorded the lowest growth rate.

The growth in per hectare consumption of nitrogen fertilizer during the 2nd decade (1991-2001) shows a positive trend while two district shows negative growth rate and most of the districts witnessed a non significant growth rate. The highest growth rate was registered in Adilabad (10.21%) district followed by Medak (6.91%), Prakasam (5.62%) and Karimnagar (5.45%). A negative and non-significant growth was noticed in West Godavari (-8.18%) and significant and negative growth rate was observed in Vizianagaram (-1.01%) districts. This might be attributed that the utilization of nitrogen was in its peak

Table 4.13 Growth in per hectare consumption of Phosphorous fertilizer in Andhra Pradesh.

Sl. No.	District	1981-91	1991-01	2001-11	1981-2011
1	Srikakulam	17.90***	7.05***	3.91**	5.33***
2	Vizianagaram	10.68**	1.61^{NS}	10.87***	4.32***
3	Visakhapatnam	12.92**	2.72^{NS}	12.10***	5.58***
4	East Godavari	9.96**	5.69***	4.48**	5.18***
5	West Godavari	10.53^{NS}	5.91***	3.13***	4.59***
6	Krishna	14.90***	3.10^{NS}	4.32***	4.27***
7	Guntur	5.38^{NS}	2.54^{NS}	10.45***	3.44***
8	Prakasam	5.59*	8.92*	9.72***	7.01***
9	Nellore	9.27*	5.12^{NS}	7.64***	4.78***
10	Kurnool	8.40***	3.40^{NS}	8.40***	6.75***
11	Anantapur	18.26***	5.28^{NS}	8.46***	7.39***
12	Cuddapah	13.60***	1.59^{NS}	6.94**	4.93***
13	Chittoor	12.72***	2.46^{NS}	7.20***	4.51***
14	Hyderabad/ Ranga Reddy	17.41***	6.80^{NS}	5.57*	10.15***
15	Nizamabad	4.68^{NS}	1.58^{NS}	7.75***	2.70***
16	Medak	8.10**	4.56^{NS}	13.70***	5.23***
17	Mahbubnagar	17.04***	0.60^{NS}	9.41***	5.35***
17	Nalgonda	13.37***	5.83***	10.69***	8.03***
19	Warangal	15.57**	1.01^{NS}	5.11***	3.85***
20	Khammam	17.25***	7.20***	6.15***	5.63***
21	Karimnagar	15.68***	5.67***	1.17^{NS}	5.01***
22	Adilabad	18.47***	8.48*	15.49***	8.90***
23	Andhra Pradesh	11.51***	4.66***	7.35***	5.00***

*** denotes significant at 1% level
** denotes significant at 5% level
*denotes significant at 10% level
NS denotes Non significant.

during the 2nd decade considered for analysis.

During the 3st decade (2001-11), almost the districts recorded significant positive growth rate while two districts viz Karimnagar and Nizamabad showed a non-significant growth in the per hectare consumption of nitrogen fertilizer. The highest positive growth rate was noticed in Adilabad (12.27%) followed by Anantapur and Nalgonda, whereas Karimnagar (0.69%) district recorded the lowest growth rate.

4.1.1.12 District wise growth in consumption of phosphorous in Andhra Pradesh- per hectare

The district wise growth rate in the per hectare consumption of phosphorus fertilizer is presented in Table 4.13. A positive and significant growth of 5.00 per cent per annum in the per hectare consumption of phosphorus fertilizer in the state was noticed during the study period. All the districts, showed a positive growth rate. The highest growth rate was found in Ranga Reddy (10.15%) followed by Adilabad (8.90%) and Nalgonda (8.03%) districts. The lowest growth rate was observed in Nizamabad (2.70%) district.

The growth rate in the consumption of phosphorus fertilizer was positive and significant (11.51%) in the state during the 1st decade (1981-91). The highest positive growth rate was noticed in Adilabad district (18.47) followed by Anantapur (18.26%), Srikakulam (17.90%) and Ranga Reddy (17.41%) districts. Nizamabad district showed the lowest non significant growth rate of 4.68 per cent per annum followed by Guntur (5.38%) district.

Further, the table revealed that during the 2nd decade (1991-2001) period, the state witnessed a positive and significant growth rate of 4.66 per cent per annum. Most of the districts in Andhra Pradesh recorded positive and non significant growth rates while only six districts shows positive and significant growth rate. The highest growth in the consumption of phosphorus was observed in Prakasam followed by Adilabad, Khamam and Srikakulam districts.

During the 3st decade (2001-11), the state witnessed a positive and significant growth rate of 7.35 per cent per annum. In this period all the districts recorded significant positive growth except Karimnagar, which shows non-significant growth rate. The highest positive growth was noticed in Adilabad (15.49%) followed by Medak and Visakhapatnam whereas Karimnagar (1.17%) district by recording the lowest growth rate.

Table 4.14 Growth in per hectare consumption of Potash fertilizer in Andhra Pradesh.

Sl. No.	District	1981-91	1991-01	2001-11	1981-2011
1	Srikakulam	31.24***	12.87***	12.62***	17.50***
2	Vizianagaram	21.86 NS	10.72**	22.23***	18.93***
3	Visakhapatnam	32.18*	3.00 NS	1.69 NS	13.24***
4	East Godavari	9.32***	7.29**	2.40 NS	7.95***
5	West Godavari	15.26***	6.14**	8.19***	6.72***
6	Krishna	12.88***	9.14 NS	-0.43 NS	7.95***
7	Guntur	5.64 NS	7.44*	12.92***	4.28***
8	Prakasam	2.54 NS	11.58**	11.34***	5.63***
9	Nellore	9.75**	7.49*	11.76***	4.01***
10	Kurnool	0.67 NS	5.49*	10.82***	6.45***
11	Anantapur	16.37**	8.06*	10.14***	9.26***
12	Cuddapah	10.66***	5.19*	17.42***	7.37***
13	Chittoor	9.29 NS	7.00**	7.38***	6.34***
14	Hyderabad/ Ranga Reddy	6.77 NS	16.11***	2.72 NS	15.58***
15	Nizamabad	2.14 NS	10.40**	19.72***	6.25***
16	Medak	4.02 NS	10.38**	30.44***	10.38***
17	Mahbubnagar	10.32**	2.01 NS	18.82***	5.98***
18	Nalgonda	13.02**	7.36*	17.04***	10.11***
19	Warangal	9.37**	8.12***	14.99***	9.11***
20	Khammam	9.75*	10.87***	16.63***	9.01***
21	Karimnagar	7.12 NS	7.50**	10.99***	7.42***
22	Adilabad	8.36**	18.89*	26.79***	16.53***
23	Andhra Pradesh	8.81***	8.40***	9.69***	7.41***

*** denotes significant at 1% level
** denotes significant at 5% level
*denotes significant at 10% level
NS denotes Non significant.

During the three decades, all the districts recorded positive and significant growth in phosphorous consumption where the growth ranged from 2.7 for Nizamabad to 10.15 for ranga Reddy district. This confirmed that there is a difference per hectare consumption in phosphorous consumption across the period considered and across the districts considered.

4.1.1.13 District wise growth of consumption of potash in Andhra Pradesh- per hectare.

The district wise growth in the per hectare consumption of potash fertilizer is furnished in Table 4.14. It could be noted that during the study period all the districts recorded a positive growth rate. State recorded a positive and significant growth rate of 7.41 per cent per annum. Vizianagaram recorded the highest positive growth rate of 18.93 per cent per annum followed by Srikakulam (17.50%), Adilabad (16.53%) and Ranga Reddy (15.58%) districts. While lowest per hectare growth rate was noticed in Nellore (4.01 %) followed by Guntur (4.28 %).

The growth rate of potash consumption in the state was highest in the 3rd decade (2001-10) followed by 2nd decade (1991-2001) and 1st decade (1981-1991). This confirmed that there was increase in the importance given for the consumption of potash in the recent years. Further, the table illustrated that there was a significant and positive growth in most of the districts and state recorded a positive and significant growth rate of 3.40 per cent per annum during the 1st decade (1981-2001). The highest positive growth rate was recorded by Visakhapatnam district (32.18%) followed by Srikakulam (31.24%), Vizianagaram (21.86 %) and Anantapur (17.41%) districts. Kurnool district showed the lowest non significant growth rate of 0.67 per cent per annum next to this was Nizamabad (2.14%) district.

The state during the 2nd decade (1991-2001) recorded a positive growth rate of 8.40 per cent. All the districts except Visakhapatnam and Mahbubnagar registered a positive growth rate during this period. A high positive significant growth rate was noticed in Adilabad (18.89%), Ranga Reddy (16.11%), and Srikakulam (12.87 %) districts.

During the 3st decade (2001-11), the state witnessed a positive and significant growth rate of 9.69 per cent per annum. All the districts recorded positive growth rate except Krishna district which showed negative growth rate (-0.43%). The highest positive growth rate was noticed in Medak (30.44%) followed by Adilabad (26.79%) and Vizianagaram (22.23%).

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Table 4.15 Growth in per hectare consumption of NPK fertilizer in Andhra Pradesh.

Sl. No.	District	1981-91	1991-01	2001-11	1981-2011
1	Srikakulam	7.51***	3.43***	3.43***	3.59***
2	Vizianagaram	8.28**	0.00 ^{NS}	9.83***	4.05***
3	Visakhapatnam	15.71***	1.75*	4.18**	4.68***
4	East Godavari	9.72**	3.67***	3.57***	3.86***
5	West Godavari	12.19***	1.93***	4.14***	3.25***
6	Krishna	12.53***	2.88*	2.82***	3.91***
7	Guntur	5.40*	1.86	9.02***	2.88***
8	Prakasam	8.04***	6.91*	7.08***	5.40***
9	Nellore	10.77***	2.46^{NS}	6.98***	3.69***
10	Kurnool	4.47*	4.40***	7.69***	6.14***
11	Anantapur	14.57**	4.96 ^{NS}	8.57***	7.07***
12	Cuddapah	10.49***	0.93 ^{NS}	6.73***	3.98***
13	Chittoor	8.98***	3.40***	6.93***	4.77***
14	Hyderabad/ Ranga Reddy	11.42**	6.19*	5.17*	10.34***
15	Nizamabad	2.05	2.13**	4.43***	2.57***
16	Medak	8.01***	6.41***	10.92***	5.22***
17	Mahbubnagar	11.85***	1.27 ^{NS}	9.29***	4.99***
18	Nalgonda	10.82***	5.16**	9.45***	7.79***
19	Warangal	13.26**	2.16***	5.23***	4.87***
20	Khammam	12.02***	4.92***	6.78***	5.51***
21	Karimnagar	9.45	5.56***	1.75	5.92***
22	Adilabad	10.85***	9.77***	14.47***	8.57***
23	Andhra Pradesh	9.59***	3.75***	6.44***	4.57***

***denotes significant at 1% level
** denotes significant at 5% level
*denotes significant at 10% level
NS denotes Non significant

It can be said that those districts which recorded negative growth in 3rd decade considered might be due to the fact that the consumption of potassic fertilizer in that district has reached to a peak

4.1.1.14 District wise growth in consumption of NPK in Andhra Pradesh- per hectare

Table 4.15 shows the district wise growth in the per hectare consumption of NPK in Andhra Pradesh. It could be noticed from the table that over the study period, the consumption of NPK fertilizer in the state showed a significant positive growth rate of 4.57 per cent per annum. A positive and significant growth rate at one per cent level was observed in all the districts. Ranga Reddy district recorded the highest growth rate of 10.34 per cent in per hectare consumption of NPK followed by Adilabad (8.57%) and Nalgonda (7.79%) districts during the study period. The results coincide with N, P and K consumption pattern already presented.

The growth rate in the 1st decade was more than the remaining decades. In the 1st decade (1981-91), the consumption of NPK in the state showed a significant positive growth of 9.59 per cent per annum. The highest positive and significant growth rate was recorded in Visakhapatnam (15.71%) followed by Anantapur (14.57%), Warangal (13.26%) and Krishna (12.53%) districts. The lowest growth rate was recorded in Nizamabad (1.66%).

In the 2nd decade (1991-2001) at the state level, the consumption of NPK fertilizer accelerated with a growth rate of 3.75 per cent per annum and was statistically significant. Almost all the districts in the state recorded a significant positive growth rate while three districts showed non-significant positive growth rate.

It can be observed that during the 3rd decade (2001-11) state observed significant and positive growth rate of per hectare consumption of NPK (6.44%). The entire districts shows significant and positive growth rate except Karimnagar which showed non-significant growth rate.

The overall growth in NPK consumption was high during the 1st decade, recorded very low growth in the 2nd period and later picked up during the 3rd decade for the state indicating more growth in per hectare chemical fertilizer in the pre globalised and post green revolution period. The foregoing discussion also confirmed that the consumption of

Table 4.16 Growth in absolute consumption of NPK fertilizer in Andhra Pradesh.

Sl. No.	District	1981-91	1991-01	2001-11	1981-11
1	Srikakulam	7.63***	2.05*	5.01***	4.06***
2	Vizianagaram	10.56*	0.88^{NS}	9.31***	4.67***
3	Visakhapatnam	18.17***	1.51^{NS}	3.53**	4.67***
4	East Godavari	12.02***	4.69***	3.31**	4.54***
5	West Godavari	13.48***	3.06***	5.33***	3.72***
6	Krishna	12.68***	2.38^{NS}	4.80***	3.73***
7	Guntur	6.85**	1.96*	10.03***	3.01***
8	Prakasam	7.86**	5.62*	9.72***	5.24***
9	Nellore	10.42**	1.35^{NS}	10.21***	4.04***
10	Kurnool	4.04^{NS}	3.90**	9.02***	6.28***
11	Anantapur	15.64**	5.79^{NS}	8.81***	7.86***
12	Cuddapah	10.66***	0.60^{NS}	8.80***	4.71***
13	Chittoor	8.72***	2.45**	6.98***	3.84***
14	Hyderabad/ Ranga Reddy	9.18^{NS}	6.25**	2.85^{NS}	8.91***
15	Nizamabad	1.21^{NS}	4.74***	10.03***	3.21***
16	Medak	6.37***	8.98***	12.05***	5.86***
17	Mahbubnagar	11.10***	2.51^{NS}	10.26***	4.71***
18	Nalgonda	9.76***	5.61***	13.14***	7.13***
19	Warangal	12.39*	5.02***	7.07***	5.28***
20	Khammam	12.24***	4.47***	9.82***	5.61***
21	Karimnagar	10.40^{NS}	7.09***	7.38***	6.89***
22	Adilabad	10.02**	9.18***	16.99***	8.44***
23	Andhra Pradesh	9.74***	4.10***	8.07***	4.75***

*** denotes significant at 1% level
** denotes significant at 5% level
*denotes significant at 10% level
NS denotes Non significant.

NPK was at its peak during the second decade and registered slow growth thereafter, but during the third decade the NPK consumption increased which indicated the importance of export oriented crops in the post globalization period.

4.1.1.15 District wise growth in consumption of NPK in Andhra Pradesh- Absolute

The district wise growth in consumption of NPK fertilizer in Andhra Pradesh is presented in Table 4.16. The table revealed that during the study period, the growth in consumption of NPK fertilizer in the state recorded a significant positive growth rate of 4.75 per cent per annum. Among the three decades, 1st decade (1981-991) has highest growth rate of 9.17 per cent followed by 3rd decade (2001-11) with a growth rate of 5.28 per cent and least was recorded in the 2nd decade (1991-2001) with 2.87 per cent. The analysis of growth rates per unit and in absolute figures for NPK followed the similar trend.

Over the three decades (1981-2011), all the districts shown positive growth of consumption of NPK fertilizer. Among the districts, highest growth of consumption of NPK fertilizer was recorded in Ranga Reddy district (8.91%) followed by Adilabad (8.44 %). The lowest growth in consumption of nitrogen fertilizer was recorded in Guntur (3.01 %) followed by Nizamabad (3.21%).

The table further revealed that during the 1st decade (1981-91), all the districts recorded significant positive growth rate in the consumption of NPK fertilizer. The growth rate ranged from as low as 1.21 per cent to 18.17 per cent. The state shows a positive and significant growth rate of 9.74 per cent. During the 1st decade farmers after getting convinced with the bumper yields, many districts as many as thirteen districts consumed more NPK, which was evident by their respective growth rates being more than ten.

The growth in consumption of NPK fertilizer during the 2nd decade (1991-2001) shows a positive trend and most of the districts witnessed a non significant growth rate. The highest growth rate was registered in Adilabad (9.18%) district followed by Medak (8.98%), Karimnagar (7.09%) and Ranga Reddy (6.25%). Lowest growth rate was observed in Caddapah (0.60 %) followed by Vizianagaram (0.88 %).

During the 3st decade (2001-11), all the districts recorded significant positive growth rate of NPK fertilizer consumption. The sate recorded a growth rate of 8.07% of NPK fertilizer consumption. The highest growth rate was noticed in Adilabad (16.99%) followed by Nalgonda and Medak, whereas Ranga Reddy district recorded the lowest

Table 4.17 District wise consumption of NPK during *kharif* season. (000'tonnes)

Sl. No.	district	1981-84	2008-11	% changes
1	Srikakulam	7.41	42.07	468.06
2	Vizianagaram	5.27	33.44	534.81
3	Visakhapatnam	3.88	21.48	454.25
4	East Godavari	19.81	80.76	307.71
5	West Godavari	28.42	103.91	265.60
6	Krishna	29.69	108.20	264.47
7	Guntur	50.53	142.79	182.60
8	Prakasam	7.11	49.29	593.26
9	Nellore	10.86	39.39	262.73
10	Kurnool	16.71	126.49	657.08
11	Anantapur	5.53	66.74	1106.99
12	Kadapa	6.34	46.26	630.05
13	Chittoor	6.22	29.33	371.39
14	Ranga Reddy	8.98	68.95	667.68
15	Nizamabad	41.19	81.61	98.10
16	Medak	8.74	62.74	618.25
17	Mahoobnagar	10.37	73.52	609.22
18	Nalgonda	9.27	105.57	1039.26
19	Warangal	20.00	98.01	390.01
20	Khammam	10.70	71.24	566.12
21	Karimnagar	18.51	116.75	530.61
22	Adilabad	3.60	83.25	2209.61
23	Andhra Pradesh	329.11	1651.78	401.89

Table 4.18 District wise consumption of NPK during *Rabi* season. (000'tonnes)

Sl. No.	District	TE (1981-84)	TE(2008-11)	% changes
1	Srikakulam	7.89	11.80	49.46
2	Vizianagaram	6.45	14.89	130.74
3	Visakhapatnam	3.51	12.12	245.89
4	East Godavari	32.44	93.43	188.02
5	West Godavari	45.54	157.85	246.62
6	Krishna	30.17	113.48	276.13
7	Guntur	54.53	166.30	204.95
8	Prakasam	28.59	99.47	247.95
9	Nellore	23.49	113.07	381.26
10	Kurnool	31.06	99.76	221.2
11	Anantapur	9.41	48.58	416.23
12	Cuddapah	13.63	47.38	247.58
13	Chittoor	12.53	41.18	228.72
14	Hyderabad/ Ranga Reddy	9.56	45.28	373.8
15	Nizamabad	23.24	67.52	190.53
16	Medak	8.10	39.57	388.52
17	Mahbubnagar	15.25	48.03	214.92
18	Nalgonda	17.57	108.21	515.77
19	Warangal	23.09	63.71	175.91
20	Khammam	13.88	59.01	325.09
21	Karimnagar	18.68	84.92	354.71
22	Adilabad	5.80	20.75	257.77
23	Andhra Pradesh	434.41	1556.30	258.26

growth rate (2.85%). The growth rates calculated for per hectare consumption of NPK and in absolute terms perfectly comply with each other.

4.1.1.16 District wise consumption of NPK during *kharif* season.

The district wise average consumption of NPK in kharif season is tabulated in Table 4.17. All the districts of Andhra Pradesh noticed an increase in the consumption of NPK during kharif season. The highest increase in the average consumption of NPK was noticed in Adilabad (2209.61 %) followed by, Anantapur, Nalgonda and Ranga Reddy with the value of 1106.99 per cent, 1039.26 per cent and 667.68 per cent, respectively. While lowest increase in the average consumption of NPK was observed in Nizamabad with the value of 98.10 per cent and state as a whole recorded an increase in the average consumption of 401.89 per cent.

In the TE (1981-84), average total NPK consumption in kharif season was 329113.7 tonnes, which increased to 1651782 tonnes in TE (2008-11). In the TE (1981-84), among the districts, highest NPK consumption (kharif) was observed in Guntur (50525.67 tonnes) followed by Nizamabad (41194.67 tonnes), Krishna (29686.33 tonnes) and West Godavari (28420.67 tonnes). Lowest NPK consumption was recorded in Adilabad (3604.67tonnes) followed by visakhapatnam (3876 tonnes) and Vizianagaram (5267 tonnes).

In TE 2008-11, among the districts, highest NPK consumption (kharif) was observed in Guntur (142786.30 tonnes) followed by Kurnool (126493.3 tonnes), Karimnagar (116746.70 tonnes) and Krishna (108198.70 tonnes). Lowest NPK consumption (kharif) was recorded in Visakhapatnam (33606.00 tonnes) followed by Chittoor (29326.67 tonnes).

4.1.1.17 District wise consumption of NPK during *Rabi* season

The consumption of NPK fertilizer during rabi season in Andhra Pradesh is presented in Table 4.18. The state recorded 258.26 per cent increase in the consumption of NPK during rabi season between the two-triennium periods. All the districts of Andhra Pradesh witnessed an increase in the consumption of NPK during rabi season. The highest increase in the consumption of NPK was noticed in Nalgonda (515.77%) followed by Anantapur (416.23%), Medak (388.52%) and Nellore (381.26%) district. The lowest

Table 4.19 Season wise average consumption of NPK fertilizer in Andhra Pradesh

Sl. No.	District	Kharif TE(1981-84)	Rabi TE (1981-84)	% difference	kharif TE(2008-11)	Rabi TE(2008-11)	% difference
1	Srikakulam	7.41	7.89	6.56	11.80	42.07	256.69
2	Vizianagaram	5.27	6.45	22.53	14.89	33.44	124.53
3	Visakhapatnam	3.88	3.51	-9.57	12.12	21.48	77.20
4	East Godavari	19.81	32.44	63.77	93.43	80.76	-13.56
5	West Godavari	28.42	45.54	60.23	157.85	103.91	-34.17
6	Krishna	29.69	30.17	1.63	113.48	108.20	-4.65
7	Guntur	50.53	54.53	7.93	166.30	142.79	-14.14
8	Prakasam	7.11	28.59	302.10	99.47	49.29	-50.45
9	Nellore	10.86	23.49	116.33	113.07	39.39	-65.16
10	Kurnool	16.71	31.06	85.88	99.76	126.49	26.80
11	Anantapur	5.53	9.41	70.20	48.58	66.74	37.38
12	Cuddapah	6.34	13.63	115.10	47.38	46.26	-2.35
13	Chittoor	6.22	12.53	101.38	41.18	29.33	-28.79
14	Hyderabad/ Ranga Reddy	8.98	9.56	6.39	45.28	68.95	52.29
15	Nizamabad	41.19	23.24	-43.58	67.52	81.61	20.86
16	Medak	8.74	8.10	-7.27	39.57	62.74	58.55
17	Mahbubnagar	10.37	15.25	47.15	48.03	73.52	53.05
18	Nalgonda	9.27	17.57	89.64	108.21	105.57	-2.44
19	Warangal	20.00	23.09	15.44	63.71	98.01	53.84
20	Khammam	10.70	13.88	29.79	59.01	71.24	20.73
21	Karimnagar	18.51	18.68	0.88	84.92	116.75	37.47
22	Adilabad	3.60	5.80	60.90	20.75	83.25	301.21
23	Andhra Pradesh	329.11	434.41	31.99	1556.30	1651.78	6.14

Table 4.20 Relative share of N,P and K in total consumption of N+P+K

	Share of NPK in total (%)			Ratio of N,P and K		
	N	P	K	N	P	K
TE 1981-84	69.60	22.94	7.44	9.35 (8.33)	3.08 (2.84)	1
TE 1991-94	63.07	28.75	8.18	7.71 (10.43)	3.51 (4.14)	1
TE 2001-04	60.43	27.99	11.57	5.22 (5.01)	2.41 (2.17)	1
TE 2008-11	56.24	29.51	14.25	3.95 (3.65)	2.07 (1.86)	1

Figure in parentheses represents ratio of per hectare consumption of NPK

increase in the consumption of NPK was recorded in Srikakulam (49.46 %) followed by Vizianagaram (130.74%).

In the TE (1981-84), average total NPK consumption (rabi) was 434410.00 tonnes, which increase to 1556302.33 tonnes in TE (2008-11). In the TE (1981-84), among the districts, highest NPK consumption was observed in Guntur (54532.67 tonnes) followed by West Godavari (45538.33 tonnes), East Godavari (32438.33 tonnes) and Kurnool (31057.33 tonnes). Lowest NPK consumption was recorded in Adilabad (3604.67tonnes) followed by Visakhapatnam (3505.00 tonnes) and Adilabad (5800.00 tonnes).

In TE 2008-11, among the district, highest NPK consumption (rabi) was observed in Guntur (166297.33 tonnes) followed by West Godavari (157845.00 tonnes), Krishna (113477.33 tonnes) and Nellore (113066.67 tonnes). Lowest NPK consumption was recorded in Srikakulam (11795.67 tonnes) followed Visakhapatnam (12123.33 tonnes)

4.1.1.18 Season wise average consumption of NPK fertilizer in Andhra Pradesh

The district wise average composition of NPK in 2 season viz. kharif and rabi is tabulated in Table 4.19 during the two triennium ending. The per cent difference in NPK used in two seasons was 31.99 per cent during TE (1981-84) which decreased to 6.14 per cent during TE (1981-84).

During the TE (1981-84), almost all the district consumed more NPK in rabi season than kharif season. Among the districts, the highest difference between two seasons in NPK consumption was observed in Prakasam (302.10%) followed by Nellore (116.33%), Caddapah (115.10%) and Chittoor (101.38%). While the three districts viz. Medak, Visakhapatnam and Nizamabad consumed NPK more in Kharif season.

It was also observed that during the TE (2008-11), most of the districts (9 districts) consumed more NPK during kharif season. The highest difference between two seasons in NPK consumption was recorded in Adilabad (301.21 %) followed by Srikakulam (256.69 %). There might be as they applied more fertilizer in rabi and generally rabi yields are observed to be high.

Table 4.21: Average consumption of different fertilizers in Andhra Pradesh ('000 tonnes)

Sl. No.	Fertilizer	TE (1995-98)	TE (2008-11)	Change (%)	Growth rate (1995-2011)
1	Urea	1805.90	2777.33	53.79	1.96*
2	A/S	173.86	113.33	-34.81	-4.32*
3	CAN	91.06	23.47	-74.23	-9.46 ^{NS}
4	SSP	248.19	203.77	-17.90	-2.298*
5	MOP	128.67	601.27	367.31	12.21*
6	SOP	6.70	4.87	-27.33	2.40*
7	DAP	464.19	915.93	97.32	4.19*
8	10:26:26	4.37	284.70	6419.85	38.53*
9	14:35:14	45.00	274.47	509.88	13.65*
10	15:15:15	20.85	34.97	67.68	6.79*
11	16:20:00	58.39	44.17	-24.35	-4.83*
12	20:20:00	387.02	960.27	148.12	5.99^{NS}
13	28:28:00	128.95	150.40	16.64	3.80*

* indicates 1 per cent significant level

4.1.1.19 Relative share of N,P and K in total consumption of N+P+K

Table 4.20 shows the relative share and ratio of N, P and K in total consumption of NPK at different period of time. The share of consumption of nitrogen is highest in all the four different period of time followed by phosphorous and potash. Over the year percentage share of nitrogen was decreased while phosphorous and potash increased. This shows the 3.95:2.07:1 during TE (2001-04) and TE (2008-11) respectively. Thereby, share of potash and phosphorous in per hectare consumption increases due to the increase in the importance of balance fertilizer consumption.

4.1.1.20 Consumption of different fertilizer material in Andhra Pradesh

The changes in consumption of fertilizers are presented in Table 4.21. There was an increase in the consumption of fertilizer materials in Andhra Pradesh over the period except in the few fertilizer material. The average urea consumption in TE (1995-98) was 1805 thousand tonnes which increased to 2777 thousand tonnes in TE (2008-11). In case of ammonium sulphate the average consumption was 173 thousand tonnes but decrease to 113 thousand tonnes in TE (2008-09). CAN consumption was drastically reduced by 74.23 per cent. SPP consumption was reduced slightly (-17.90 %) over the year. The consumption of MOP was 128.67 thousand tonnes in TE (1995-98) which increase to 601.27 thousand tonnes in TE (2008-11). The consumption of SOP also reduced over the year. The consumption of DAP was increased by 97.32 per cent over the year. The highest change in the consumption was noticed in 10:26:26 (6419.85%) followed by 14:35:14 (509.88%), MOP (367.31%) and 20:20:20 (148.12%). There was decrease in the consumption of CAN (74.23 %), A/S (-34.81 %), SOP (-27.33 %), 16:20:00 (-24.35 %) and SSP (17.90 %).

The particulars of growth rates in the consumption of fertilizer materials in Andhra Pradesh are also presented in Table 4.27. During the study period most of the fertilizer materials recorded a positive growth rate except A/S, CAN, SSP and 15:15:15. Among the materials, 10:26:26 registered the highest growth rate of 38.53 per cent per annum followed by 14:35:14 (13.65 %) and 15:15:15 (6.79 %).

Table 4.22: Trends in consumption of pesticide in Andhra Pradesh: 1989-90 to 2009-10.

Sl. No.	Year	Absolute consumption (MT technical grades)		Per hectare consumption (a.i kg ha-1)	
			Average annual growth rate		Average annual growth rate
1	1989-90	11580		0.87	
2	1990-91	13520	16.75	1.02	17.33
3	1991-92	13442	-0.58	1.02	-0.8
4	1992-93	13650	1.55	1.07	5.27
5	1993-94	10805	-20.84	0.85	-20.43
6	1994-95	9343	-13.53	0.73	-14.17
7	1995-96	10957	17.27	0.82	12.35
8	1996-97	8702	-20.58	0.65	-20.98
9	1997-98	7298	-16.13	0.6	-7.32
10	1998-99	4741	-35.04	0.35	-42.14
11	1999-00	4054	-14.49	0.31	-10.54
12	2000-01	4000	-1.33	0.3	-5.12
13	2001-02	3850	-3.75	0.3	2.19
14	2002-03	3400	-11.69	0.29	-2.54
15	2003-04	2133	-37.26	0.17	-41.36
16	2004-05	2781	30.38	0.22	28.79
17	2005-06	2045	-26.47	0.15	-31.11
18	2006-07	1500	-26.65	0.12	-23.49
19	2007-08	1300	-13.33	0.1	-18.16
20	2008-09	1400	7.69	0.1	5.64
21	2009-10	1350	-3.57	0.11	6.19
23	Compound growth rate		-10.28	-12.4726	
	C.V		0.7	138.953	

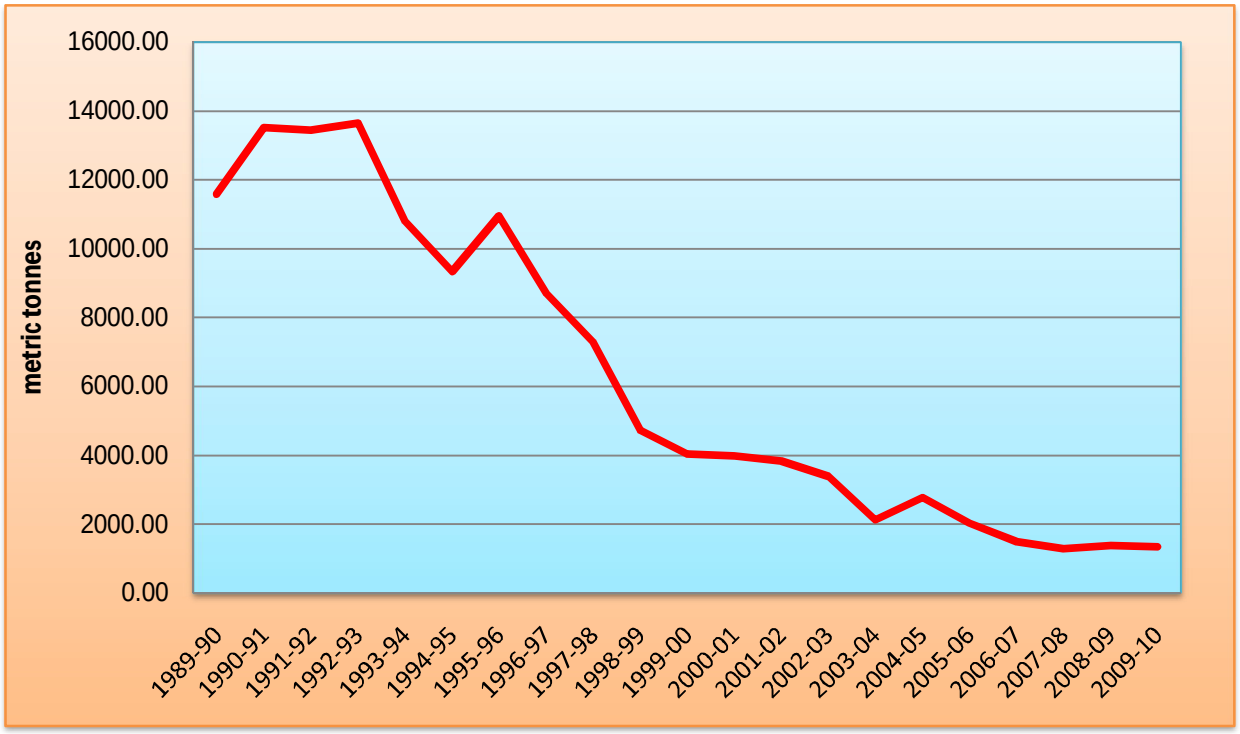

Figure 4.5: Trends in consumption of pesticide in Andhra Pradesh :1989-90 to 2009-10.

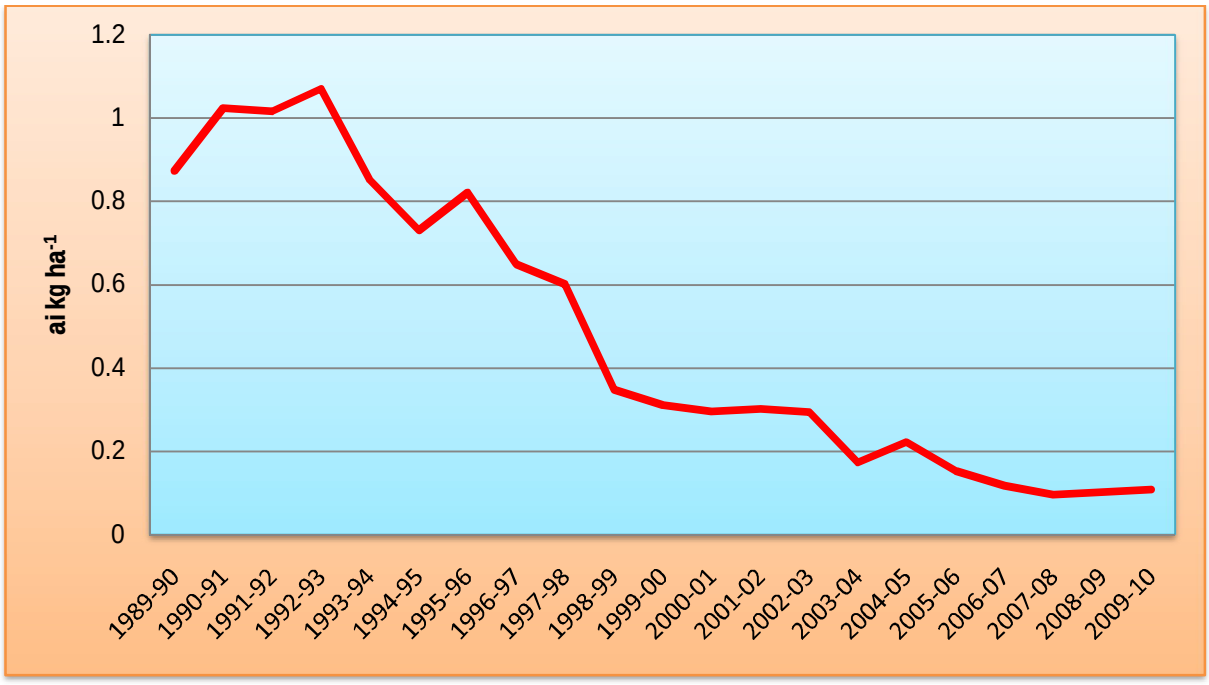

Figure 4.6 : Trends in consumption of pesticide per hectare in Andhra Pradesh :1989-90 to 2009-10.

4.1.2 Consumption of pesticides in Andhra Pradesh and among the districts.

Pesticide is considered as one of the most important input for increasing agricultural production since green revolution. Pesticide use has become more important in modern agriculture. And the use of pesticide in crop production increased since the 1990's (Chand and Birthal, 1997). In this section of discussion, time series analysis of pesticide consumption in the state level and district level will be discussed to draw valid conclusions. Generally use of pesticides in crop production is fall into the following groups namely- increase in importance of consumption of phosphorous and potash. During 1981-82, the ratio of N:K:P to total NPK consumption was 9.35:3.08:1 which declined to 3.95:2.07:1 during 2010-11.

Also the ratio of N:P:K per hectare consumption was reduced over the study period. The ratio of N:P:K per hectare consumption during TE (1981-84) was 8.33:2.84:1 which increased to 10.43:2.84:1 during TE(1991-94). It was further reduced to 5.01:2.17:1 and insecticides, herbicides, fungicides and others. Major crops which consume pesticides are cotton and chillies.

4.1.2.1 Consumption trends of Pesticides in Andhra Pradesh

The pesticide consumption in absolute terms, per hectare and their respective growth rates are work out and presented in table 4.22 from 1989-90 to 2009-10 and figure 4.5 and 4.6. The annual growth rates of the consumption of pesticide has shown a fluctuating downward trend over the years. In 1989-90, pesticide consumption was 11580 metric tonnes which decreased to 13650 metric tonnes in 1992-93, which was highest consumption in the study period. However, in 1993-94 it was reduced to 10805 metric tonnes by -20.84 per cent over the previous year, further reduced to 934 metric tonnes in 1994-95 (-13.53 %). It was increased again during 1995-96 (17.27 %). Later there was decreasing trend except in 2008-09, in which consumption increase over the previous year as shown in figures 4.3 and 4.4. The pesticide consumption during 2009-10 was 1350 metric tonnes which was almost 8 times less during 1989-90. The maximum annual growth rate was observed in the year 2004-05 (30 %) while the negative annual growth rate was found in 2003-04 (-37 %).

Table 4.23 District wise consumption of pesticide in Andhra Pradesh. (MT in technical grades).

Sl. No.	District	TE 1999-02	TE 2007-10	% change	Ranking as per consumption during	
					TE 1999-02	TE 2007-10
1	Srikakulam	28.67 (0.72)	4.93 (0.36)	-82.81	21	22
2	Vizianagaram	46.00 (1.16)	14.78 (1.09)	-67.87	20	21
3	Visakhapatnam	18.00 (0.45)	26.75 (1.98)	48.59	22	16
4	East Godavari	226.33 (5.70)	45.05 (3.34)	-80.10	6	13
5	West Godavari	192.67 (4.86)	67.57 (5.01)	-64.93	8	8
6	Krishna	170.33 (4.29)	59.83 (4.43)	-64.88	9	10.5
7	Guntur	484.67 (12.21)	166.11 (12.30)	-65.73	1	1
8	Prakasam	166.00 (4.18)	59.83 (4.43)	-63.96	10	10.5
9	Nellore	236.67 (5.96)	79.54 (5.89)	-66.39	5	5
10	Kurnool	394.33 (9.94)	149.22 (11.05)	-62.16	3	3
11	Anantapur	90.33 (2.28)	21.82 (1.62)	-75.85	18	18.5
12	Kadapa	116.33 (2.96)	24.64 (1.82)	-78.82	14	17
13	Chittoor	66.00 (1.66)	21.82 (1.62)	-66.94	19	18.5
14	Ranga Reddy	164.67 (4.15)	76.02 (5.63)	-53.84	11	6
15	Nizamabad	107.33 (2.70)	41.53 (3.08)	-61.31	16	14
16	Medak	99.33 (2.50)	33.79 (2.50)	-65.99	17	15
17	Mahbubnagar	149.33 (3.76)	73.91 (5.47)	-50.51	13	7
18	Nalgonda	213.67 (5.38)	58.42 (4.33)	-72.66	7	12
19	Warangal	283.33 (7.14)	80.94 (6.00)	-71.43	4	4
20	Khammam	445.00 (11.21)	156.26 (11.57)	-64.89	2	2
21	Karimnagar	160.67 (4.05)	66.16 (4.90)	-58.82	12	9
22	Adilabad	108.33 (2.73)	20.41 (1.51)	-81.16	15	20
23	Andhra Pradesh	3968.00 (100.00)	1350.00 (100.00)	-65.98		

Note: Figure in parenthesis indicates share of pesticide among the districts.

The per hectare pesticide consumption was also presented in table 4.22 and figure 4.6. The per hectare consumption also shows a decreasing trend over the year. It was observed from the table that pesticide consumption was 0.87 a.i. kg ha^{-1} during 1989-90, which increase above 1 a.i. kg ha^{-1} during the next three successive year. However from the year 1993-94, pesticide per hectare consumption was less than 1 a.i. kg ha^{-1}. And during 2009-10, pesticide consumption was 0.11 ai kg ha^{-1} which was nine times less compare to early 1990's. The reduction of per hectare consumption during 2000's in the state might be due to increase consumption of farm yard manure, use of crop variety which required less pesticide such as Bt cotton. The highest negative annual growth rate was observed during 1998-99 (-42 %) followed by 2003-04 (-41 %) while maximum annual growth rate was recorded during 2004-05 (28 %).

Both absolute and per hectare consumption of pesticide shows a negative growth rate of -10.28 per cent and -12.47 per cent during this two decades, which shows decrease in consumption over the year. The coefficient of variation was 0.70 per cent and 178.93 per cent from 1989-90 to 2010-11 for absolute and per hectare consumption respectively, which means more variation in per hectare consumption than absolute consumption in the state level over the year.

4.1.2.2 District wise consumption of pesticide in Andhra Pradesh.

The district wise average consumption of pesticides and that for the state as a whole is furnished in Table 4.23. It is evident from the table that between the two-triennium periods considered all the districts witnessed decrease in the consumption of pesticide except in one district.

The percentage increase in the average consumption of pesticides was noticed in Vizianagaram (48.59 %). The State as a whole recorded decrease in the average consumption of pesticide (-65.98). Among the districts, highest percentage decreased in pesticide consumption was noticed in Srikakulam (-82.81 %) followed by Adilabad (-81.16 %) and East Godavari (-80.10 %).

In the TE (1999-02), average total pesticide consumption was 3968 tonnes, which decreasd to 1350 tonnes in TE (2007-10). In the TE (1999-02), among the districts, highest pesticide consumption was observed in Guntur (484.67 tonnes) followed by Khammam (445.00 tonnes), Kurnool (394.33 tonnes) and Warangal (283.33 tonnes). This was because Guntur district is known for cotton and chillies and who resort to indiscriminate use of pesticide

among all districts. But in the second TE period also districts such as Guntur, Khammam and Kurnool used more than 150 MT of pesticide, which required to be reduced by taking special campaign by the extension institution as a preventive measure. However, lowest pesticide consumption was recorded in Visakhapatnam (18.00 tonnes) followed by Srikakulam (28.67 tonnes) and Vizianagaram (46.00 tonnes).

In TE 2007-10 also, among the districts, highest pesticide consumption was observed in Guntur (166.11 tonnes) followed by Khammam (156.26 tonnes), Kurnool (149.22 tonnes) and Warangal (80.94 tonnes). And lowest pesticide consumption was recorded in Srikakulam (4.93tonnes) followed by Vizianagaram (14.78 tonnes) and Adilabad (20.41 tonnes). It can be inferred that overall consumption of pesticides has shown decreasing trend.

To understand the share of each districts in terms of its contribution to the overall states consumption, the share percentages district wise are calculated and shown in the table 4.23. It could be seen that during the TE (1999-02), Guntur (12.21 %) share the highest consumption of pesticide followed by Khammam (11.21%). While lowest share in pesticide consumption was recorded in Visakhapatnam (0.45 %) followed by Srikakulam (0.72 %).

During the TE (2007-10) also, among the districts, Guntur share the highest consumption of pesticide followed by Khammam (11.57%). While lowest share in pesticide consumption was recorded in Srikakulam (0.36 %) followed by Vizianagaram (1.09 %).

From the above discussion, it is concluded that in Andhra Pradesh both in its absolute and per hectare consumption of pesticide was drastically reduced over the years. This might be due to increase used of FYM and implementation of integrated pest management practices. Guntur remained as the top consumer of pesticides over the study period. Over the years all the districts showed reduction in consumption except Visakhapatnam.

4.1.2.3 District wise per hectare consumption of pesticide in Andhra Pradesh

The district wise and state per hectare consumption of pesticide is illustrated in Table 4.24. The state recorded decrease in the average consumption of pesticide by -66.48

Table 4.24 District wise per hectare consumption of pesticide in Andhra Pradesh.(a.i. kg ha^{-1})

Sl. No	District	1999-02	2009-10	% change
1	Srikakulam	0.07	0.01	-83.75
2	Vizianagaram	0.10	0.04	-64.36
3	Visakhapatnam	0.04	0.07	73.63
4	East Godavari	0.30	0.06	-78.57
5	West Godavari	0.29	0.10	-65.23
6	Krishna	0.24	0.08	-66.79
7	Guntur	0.57	0.20	-64.12
8	Prakasam	0.27	0.09	-66.80
9	Nellore	0.69	0.19	-72.64
10	Kurnool	0.42	0.15	-64.51
11	Anantapur	0.08	0.02	-75.58
12	Kadapa	0.27	0.05	-81.03
13	Chittoor	0.14	0.05	-62.15
14	Ranga Reddy	0.52	0.33	-37.10
15	Nizamabad	0.28	0.09	-66.27
16	Medak	0.18	0.06	-66.28
17	Mahbubnagar	0.16	0.09	-45.78
18	Nalgonda	0.35	0.09	-74.46
19	Warangal	0.46	0.14	-70.51
20	Khammam	0.95	0.32	-66.29
21	Karimnagar	0.30	0.10	-66.09
22	Adilabad	0.19	0.03	-82.78
23	Andhra Pradesh	0.30	0.10	-66.48

Table 4.25. Variation in pesticide consumption per hectare of gross cultivated area across different districts –year wise

Years	Percentage of variation
1999-2000	112.98
2000-01	68.62
2001-02	56.80
2002-03	62.42
2003-04	84.44
2004-05	90.59
2005-06	72.79
2006-07	75.03
2007-08	76.69
2008-09	79.32
2009-10	77.21

per cent between the two-triennium periods. All the districts recorded decrease in the consumption of pesticide over the years except in one district. On contrary in the per hectare consumption of pesticide was increase in case of Visakhapatnam (73.63 %).

In the TE (1999-02), average per hectare consumption of pesticide was 0.30 kg ha^{-1}, which decreased to 0.10 kg ha^{-1} in TE (2007-10). In the TE (1999-02), among the districts, highest pesticide consumption was observed in Khammam (0.95 a.i. kg ha^{-1}) followed by Nellore (0.69 a.i. kg ha^{-1}), Guntur (0.57 a.i kg ha^{-1}) and Ranga Reddy (0.52 a.i. kg ha^{-1}). While lowest pesticide consumption was recorded in visakhapatnam (0.04 a.i. kg ha^{-1}) followed by Srikakulam (0.07 a.i. kg ha^{-1}) and Ananthapur (0.1 a.i. kg ha^{-1}).

In TE 2007-10, among the districts, highest pesticide per hectare consumption was observed in Ranga Reddy (0.33 kg ha^{-1}) followed by Khammam (0.32 kg ha^{-1}), Guntur (0.2 kg ha^{-1}) and Nellore (0.19 kg ha^{-1}). While the lowest pesticide per hectare consumption was recorded in Srikakulam (0.01 kg ha^{-1}) followed by Ananthapur (0.02 kg ha^{-1}) and Adilabad (0.03 kg ha^{-1}).

Among the districts with high per unit consumption of pesticides during the first TE period was Guntur and Khammam districts reduced the pesticide consumption to a greater extent. The need to capture the variation in consumption of pesticide per hectare, year wise has been worked out and presented in Table 4.24. The coefficient of variation among the districts was highest in 1999-2000 (112.98 %) while the lowest variation among the districts was observed in the year 2001-02 (56.80 %). It was observed from the table that , the variation in per hectare pesticide consumption was fluctuating between 1999-00 to 2004-05 and the variation among districts was reduced.

4.1.2.4 Trend in the coefficient of variation in pesticide consumption

The need to capture the variation in consumption of pesticide per hectare, year wise has been worked out and presented in table 4.29. The coefficient of variation among the districts was highest in 1999-2000 (112.98 %) while the lowest variation among the districts was observed in the year 2001-02 (56.80 %). It was observed from the table that , the variation in per hectare pesticide consumption was fluctuating between 1999-00 to 2004-05 and the variation among districts reduced.

4.1.2.5 District wise growth in consumption of pesticide in Andhra Pradesh

The district wise growth rate for 1999-2010 in the per hectare consumption of pesticide is presented in Table 4.26. A negative and significant growth rate of -12.58 per cent per annum in the per hectare consumption of pesticide in the state was noticed during the study period. All the districts, showed a negative growth rate except in Visakhapatnam district, which shows positive non significant growth rate. The highest negative growth rate was noticed in Adilabad (-19.15%) followed by Srikakulam (-17.92%), East Godavari (-17.73%) and Cuddapah (-17.55 %). The trend is favourable as more use of pesticides will leave pesticide residues in the grains, which is a concern at present. The negative growth in the last two decades might be attributed to impact of WTO agreement, discouraging exports of commodities containing pesticide residues.

4.1.3 Consumption of fertilizers and pesticides in sample farmers

So far the consumption pattern of fertilizers, pesticides for the state and upto district level using the secondary data a macro level was analyzed over a period time, splitting it into different periods to compare and valid influences are drawn. To supplement this it is also necessary to probe into micro level data to this possible extent. In this section, the pattern of fertilizers and pesticide use at the micro level based on farming household , a sample survey data obtained from the centrally sponsored project “Comprehensive scheme to study the cost of cultivation of principal crops in Andhra Pradesh’’, being supervised by the Department of Agricultural Economics, ANGRAU, Hyderabad. The sample size covered under the scheme in state is 600 farm holdings distributed among 60 tehsils.

4.1.3.1 General Characteristics of the sample Farmer

In the light of the ongoing structural changes and consequent changing contours of rural economy as a whole, the nature and pattern of farming also has been changing over time. In rural areas, the social status and identification of an individual, starts from the household to which the individual belongs. This is mostly determined by the personal characteristics of the farmer's household and so it is necessary to discuss the individual characteristics of the households. Before understanding the fertilizer and pesticide consumption, the overview of characteristics of sample farmers would help one to draw better conclusion. Therefore in this section, a brief account of general characteristics of the selected samples are presented. The details of the respondent in terms of sex, age, education, family size, etc., are discussed in table 4.27

Table 4.26. District wise growth in consumption of pesticide in Andhra Pradesh

Sl. No.	District	1999-10
1	Srikakulam	-17.92*
2	Vizianagaram	-12.36*
3	Visakhapatnam	12.50^{NS}
4	East Godavari	-17.73*
5	West Godavari	-11.08*
6	Krishna	-10.86**
7	Guntur	-12.79*
8	Prakasam	-10.81*
9	Nellore	-12.94*
10	Kurnool	-10.49*
11	Anantapur	-16.63*
12	Cuddapah	-17.55*
13	Chittoor	-13.12*
14	Hyderabad/ Ranga Reddy	-7.24**
15	Nizamabad	-8.70*
16	Medak	-11.01*
17	Mahbubnagar	-7.40*
18	Nalgonda	-12.85*
19	Warangal	-14.30*
20	Khammam	-9.98**
21	Karimnagar	-10.76***
22	Adilabad	-19.15*
23	Andhra Pradesh	-12.58*

*** denotes 1% significant**

**** denotes 5 % significant**

***** denotes 10 % significant**

Table 4.27 General characteristics of the sample farmers.

Sl. No.	Particulars	I	II	III	IV	V	Total
1.	Sample Size	120	120	120	120	120	600
2.	Age group						
	< 35 years (young age)	21 (17.5)	11 (9.17)	12 (10.00)	4 (3.33)	9 (7.5)	57 (9.5)
	35-55 years (middle age)	60 (50.00)	68 (56.67)	59 (49.17)	64 (53.33)	62 (51.67)	313 (52.17)
	> 55 years (old age)	39 (34.17)	41 (34.17)	49 (40.83)	52 (43.33)	49 (40.83)	230 (38.33)
3.	Education						
	Illiterate	34 (28.33)	32 (26.67)	21 (17.5)	24 (20.00)	21 (17.5)	132 (22.00)
	Upto primary	38 (31.67)	38 (31.67)	35 (29.17)	30 (25.00)	24 (20.00)	165 (37.5)
	Upto secondary	39 (32.5)	36 (30.00)	48 (40.00)	45 (37.50)	46 (38.33)	214 (35.67)
	Post secondary	9 (7.5)	14 (11.67)	16 (13.33)	21 (17.50)	29 (24.17)	89 (14.83)
3.	Family size						
	< 4	28 (23.33)	34 (28.33)	29 (24.17)	25 (20.83)	25 (20.83)	141 (23.50)
	4 to 6	80 (66.67)	68 (56.67)	73 (60.83)	71 (59.17)	68 (56.67)	360 (60.00)
	7 to 9	11 (9.17)	15 (12.50)	14 (11.67)	19 (15.83)	19 (15.83)	78 (13.00)
	10 and above	1 (0.83)	3 (2.50)	4 (3.33)	5 (4.17)	8 (6.67)	21 (3.5)

Table 4.28 Cropping pattern of sample farmers, Andhra Pradesh, 2010-11 (in percentages to gross cropped area).

Crop/ Category	I (< 1 ha)	II (1-2 ha)	III (2-4 ha)	IV (4-6 ha)	V (>6 ha)	Overall
Paddy	64.51	61.81	56.94	59.12	58.07	59.02
Maize	4.66	3.75	5.54	4.68	4.47	4.66
Jowar	0.95	0.65	1.13	1.08	1.14	1.05
Gram	1.77	3.10	3.30	3.39	3.83	3.39
Arhar/ redgram	1.39	0.59	1.65	1.79	2.92	2.00
Urad/ blackgram	3.26	4.66	4.38	4.36	4.58	4.40
Sugarcane (p)	1.82	2.84	2.12	2.10	1.48	1.95
Groundnut	4.15	4.23	4.10	3.54	4.68	4.18
Sugarcane (r)	0.80	2.19	2.52	2.43	3.14	2.56
Soybean	0.24	1.08	0.98	0.64	1.25	0.95
Chilli	0.76	1.16	0.63	0.62	0.83	0.77
Cotton (Bt)	9.76	9.70	12.84	10.60	9.17	10.35
Others	5.94	4.24	3.87	5.66	4.43	4.73
Gross cropped area(ha)	169.24 (100)	278.53 (100)	461.46 (100)	627.80 (100)	866.37 (100)	2403.40 (100)
Net cropped area(ha)	107.482	206.512	324.405	514.938	823.177	1977.11
Cropping intensity (%)	157.46	134.87	142.23	121.92	105.25	121.59

The study covered 120 respondents each from the five categories namely category I (<1 ha), category II (1-2 ha), category III (2-4 ha), category IV (4-6 ha) and category V (>6 ha). In the pooled sample majority of the respondents (52.17%) belonged to middle age group of above 35-55 years, while 38.33 per cent of them belonged to old age group (> 55 years) and only few farmers (9.50%) belonged to younger age group. In all the categories, middle age group has highest proportion followed by old age group and young age group. In the young age group, category I has more proportion of farmers than other groups. In contrary to this, in the old age group, category V has number of farmers than other groups. In the middle age group of category II there were more farmers. It can be understood that majority of the sample farmers are below 55 years which is interesting because they can contribute better for crop production than old age group.

About 22.00 per cent of the farmers are illiterate, while 37.50 per cent, 35.67 per cent and 14.83 per cent of the respondents respectively studied upto primary, secondary and post secondary level respectively. It can also seen in the table that literacy level is directly proportional to farm size. Proportion of illiterate was more category I, while proportion of farmer who studied post secondary was more in category V. One way, it confirms the educational opportunities are better for large farmers.

The highest proportion of farmer (60.00) has family size 4-6 members while 23.50, 13.00 and 3.5 per cent of farmer has less than 4,7-9 and 10 and above family member size, respectively. In all the categories majority of farmer fall on 4-6 family size group.

4.1.3.2 Cropping pattern of sample farmers

The cropping pattern deals with the percentage of area under each crop. Farmer cultivates various crops based on the agro-climatic conditions, resource availability and relative profitability. The crop wise percentage distribution of cropped area of the sample farmers during 2010-11 along with cropping intensity is presented in Table 4.38.

It can be seen from Table 4.32, for the state as a whole, the land use intensity was 121.59 per cent. Among the farmer category, the highest cropping intensity was recorded on category I (157.46%) followed by category III (142.23%) and was lowest on category V (105.25%). Thus, the results indicate that there was inverse relationship between the farm size and cropping intensity, which meant, as the size of farm increases the cropping intensity decreases. Even though there is good resource endowment position in case of large farmers, it was observed that small is the farm size, the land was used for a second

crop, which was evident by cropping intensity. The absence of alternative livelihoods might have forced the small farmers to go for second crop.

Overall, it was observed that paddy and cotton (Bt) were the two main crops of the sample farmers in Andhra Pradesh occupying about 70 per cent of gross cropped area. Maize and blackgram crops were the other main crops, which covered about 4.66 per cent and 4.44 per cent of gross cropped area, respectively. Soybean and chilli occupied less than 2 per cent of gross cropped area.

The highest proportionate area under paddy crop was observed in category I with 64.51 per cent of total cropped area followed by category II (61.81 %) and least was found in category V (58.07). The results indicated there is inversed relation between proportionate area under paddy and farm size. This was because the price risk is less in paddy as there is minimum support price implemented, which might be the reason for increasing relation between paddy sown area and farm size. This also indicated that, the small farmers also could diversity cropping pattern like large farmers. Cotton (Bt) was the next important crop which accounted for 10.35 per cent of gross cropped area. In all the categories, area under cotton was above 9 per cent of gross cropped area. The proportion of area under pulses was higher in larger farmers category compared to other category. This might be due to risk in production of pulses and large farmer has risk taking ability. The percentage area under maize crop was 4.66 per cent on an average. In case of rapeseed and mustard, the percentage area under this crop was 4.18 per cent and large farmers have highest proportion of area. Percentage area under the sugarcane (ratoon) was 2.56 per cent, which is large when compared to proportion of area under sugarcane (planted).

4.1.3.3 Crop wise fertilizer consumption

It is evident from the table 4.29 and figure 4.7 that per hectare consumption of total NPK, N, P and K was 196.07, 103.91, 59.98 and 32.18 kg ha^{-1} respectively. Out of the total fertilizer consumption in terms of NPK the highest was consumed by paddy (64.93 %) followed by cotton (Bt) (11.78%) and maize (5.57 %). Lowest proportion of NPK consumption was observed in black gram (0.03%), soybean (0.75%) and red gram (0.87%). Similarly, the proportion of N, P and K consumption followed the same trend as in the NPK. It was also noticed that more NPK was applied to sugarcane (p) (386.94 kg ha^{-1}) than in sugarcane (r) (350.79 kg ha^{-1}). Chilli and maize consumed 269.76 kg $ha^{-1}$and 229.15 kg

Table 4.29 Crop wise fertilizer consumption pattern of sample farmers. (kg ha^{-1})

	N		P		K		NPK	
Crop/ Fertilizer	kg ha^{-1}	Per cent share	kg ha^{-1}	Per cent share	kg ha^{-1}	Per cent share	kg ha^{-1}	Per cent share
Paddy	113.6	65.42	60.49	61.92	36.99	68.78	211.07	64.93
Maize	112.78	5.13	84.56	6.84	31.8	4.67	229.15	5.57
Jowar	118.62	1.16	55.32	0.96	7.88	0.25	181.82	0.95
Bengal gram	48	1.62	54.43	3.26	2.19	0.24	104.62	1.88
Arhar/ red gram	37.69	0.74	41.04	1.43	4.61	0.29	83.34	0.87
Urad/ blackgram	0.56	0.02	0.46	0.04	0.23	0.03	1.25	0.03
Sugarcane (p)	205.76	3.91	122.06	4.12	59.13	3.62	386.94	3.92
Sugarcane (r)	200.21	5	69.62	3.09	80.96	6.53	350.79	4.68
Groundnut	19.66	0.8	24.51	1.78	15.98	2.1	60.14	1.31
Soybean	71.54	0.66	44.95	0.74	33.23	0.99	149.72	0.74
Chilli	147.48	1.11	86.05	1.15	36.23	0.88	269.76	1.08
Cotton (Bt)	121.2	12.25	66.65	11.97	30.37	9.91	218.23	11.78
Other	62.33	2.19	43.49	2.71	15.09	1.71	120.91	2.26
Total	103.91	100 (11906.96)	59.98	100 (6422.70)	32.18	100 (3218)	196.07	100 (21547.67)

Source: CCS data

Note: Figures in brackets indicates total consumption of resoective nutrients in tonnes

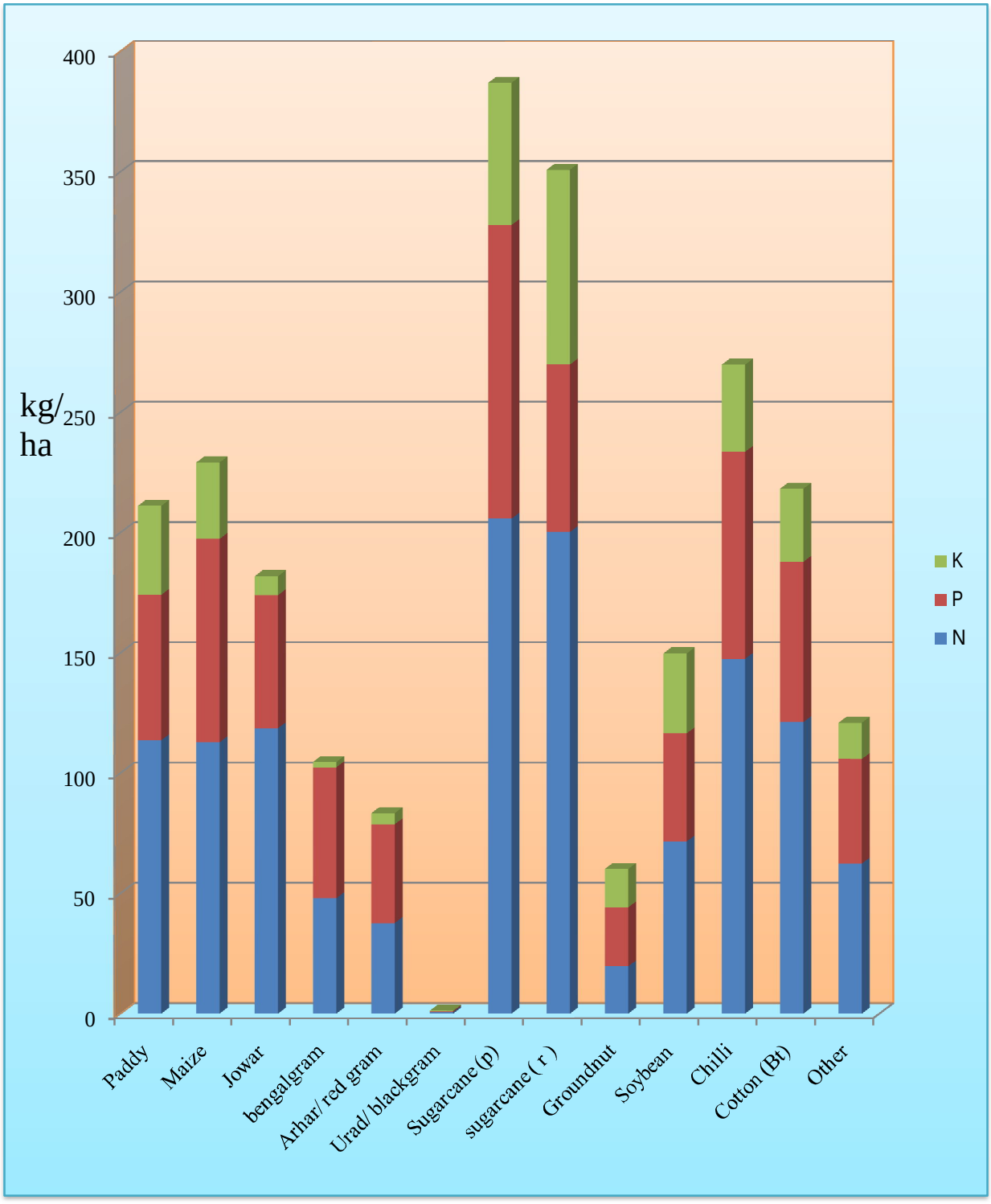

Figure 4. 7 Crop wise fertilizer consumption pattern of sample farmers. (kg ha^{-1})

ha^{-1} respectively. The lowest rate of NPK was recorded in black gram (1.25 kg ha^{-1}) followed by groundnut (60.14 kg ha^{-1}). The most important crop paddy consumed 253.08 kg ha^{-1}.

When nitrogen application alone was considered, the intense application of Nitrogen was observed in sugarcane planted and ratoon crops 205.76 kg ha^{-1} and 200.21 kg ha^{-1} respectively. Per unit nitrogen application was highest for chillies, cotton (Bt), jowar, paddy and maize.

The highest per hectare phosphorus consumption was observed in sugarcane (122.06 kg ha^{-1}), chilli (86.05 kg ha^{-1}) and maize (84.56 kg ha^{-1}). The per hectare consumption of phosphorus was lowest in urad (0.46%) followed by groundnut (24.51 kg ha^{-1}). In the case of phosphorous fertilizer, paddy, maize, sugarcane, cotton, groundnut respectively shared 61.91 per cent, 6.84 per cent, 8 per cent, 11.97 per cent, 1.78 per cent of total consumption. The share of pulses in phosphorous consumption was only 5 per cent in overall phosphorous consumption

In the case of potash fertilizer, paddy, cotton, sugarcane and maize crops respectively shared 68.78 per cent, 9.91 per cent, 10 per cent, 4.67 per cent of total potash consumption. The share of pulses in potash consumption was less than 1 per cent. The highest per hectare potash consumption was register in sugarcane (59.13 kg ha^{-1}) and lowest was observed in urad (0.23 kg ha^{-1}). The rate of consumption of potash in paddy, maize, groundnut and cotton was 36.99, 31.80, 15.98 and 30.37 kg ha^{-1} respectively.

With the popularization of using hybrid and improved variety in almost all the crops, there is increased in the fertilizer consumption per hectare. With the view to achieving more agricultural production and easy availability of chemical fertilizer by more production and subsidizing of fertilizer production, there is increase in the fertilizer consumption. But most of the farmers are not aware about the optimum use of fertilizer due to lack of scientific knowledge. The deviation from the recommended dose of fertilizer when compared to the actual fertilizer use in farmer's field may lead to long term soil deterioration, increased imbalance of plant nutrient in soil, which affects crop yield. this in turn ultimately affects the standard of living, income of farmers and it increase the toxins and pesticide residues in food intake. Any deviation from the scientific recommendation amounts to either loss of fertilizer or it will be remaining in the soil in the non available form to the plant disturbing the soil structure. So the pattern and its deviation

Table 4. 30 Fertilizer use and its deviation from recommended doses (kg ha^{-1})

Crops	Actual fertilizer application			Recommended dose of fertilizer			Deviation (%)		
	N	P	K	N	P	K	N	P	K
Paddy	113.6	60.49	36.99	120	60	40	-5.33	0.82	-7.53
Maize	112.78	84.56	31.8	125	50	40	-9.78	69.12	-20.50
Jowar	118.62	55.32	7.88	87.5	60	40	35.57	-7.80	-80.30
Bengal gram	48	54.43	2.19	20	50	40	140.00	8.86	-94.53
Arhar/ red gram	37.69	41.04	4.61	30	50	0	25.63	-17.92	α
Sugarcane (p)	205.76	122.06	59.13	150	100	120	37.17	22.06	-50.73
Groundnut	19.66	24.51	15.98	30	40	50	-34.47	-38.73	-68.04
Soybean	71.54	44.95	33.23	30	60	40	138.47	-25.08	-16.93
Chilli	147.48	86.05	36.23	150	100	125	-1.68	-13.95	-71.02
Cotton (Bt)	121.2	66.65	30.37	120	60	60	1.00	11.08	-49.38

Note : "+" denotes excess from recommended doses

"-" denotes less from recommended doses

of fertilizer consumption in farmer's of major cereal crop, oilseed, cash crop, pulses and minor crops are illustrated in table 4.30.

From the table it was observed that consumption of nitrogen nutrient per hectare of all the crops in farmer's field is excessively used than recommended dose. This might be due to easy availability of nitrogen fertilizer material compared to other fertilizers and the crop appears healthy immediate to the application of nitrogen. The maximum deviation in nitrogen consumption was observed in bengal gram (140.00 %) followed by soybean (138.47 %) and sugarcane (p) (37.17%). It is seen that more deviation is existing in case of pulse crops namely bengal gram and soybean which indicate knowledge gap that farmers might not be aware of symbiotic nitrogen fixation by legume crops. The major crop paddy and maize has less deviation from recommended dose which was 29.60 per cent and 4.6 per cent respectively.

Even though the deviation is less since more than 65 per cent of nitrogen is consumed by paddy, the excess nitrogen which will be lost by several ways would result in high cost. This suggests the popularization ill effects of excessive nitrogen and its losses should be carried out so that the cost of cultivation will be reduced.

However, in case of phosphorous, some crop shows under utilization. In case of paddy, farmers use was on par with the recommended dose. Excessive use of phosphorous was observed in maize (69.12 %) followed by sugarcane (p) (22.06 %). Excessive use of phosphorous is fixed in soil to make it converted into available form, the amount of clay, ph and temperature play an important role. Maximum under use of phosphorous was observed in groundnut (-38.73 %) followed by soybean (-25.08 %). The under utilization in groundnut effects the oil content and quality of groundnut produced. Again this also indicates the lacuna in imparting the knowledge scientific to farmers. Therefore, efforts are needed to organize farmers training on use of the applied fertilizer to the crop.

But in case of potash, all the crops show under utilization, but greater degree of deviation was recorded in Bengal gram (-94.53 %). This might be due to farmers do not take much interest to apply potash as they beven that in increases cost of production. In this next is jowar (-80.30 %) and chilli (-71.02 %) used less potash. However in major crops like paddy and maize deviation was less which was -7.53 per cent and -20.50 per cent, respectively. In cotton and groundnut crop deviation was moderate which was -49.38 per cent and 68.04 per cent respectively.

From the above discussion, it was concluded that deviation in fertilizer was less in major crop while it was more in pulses and minor crops. But still deviation from recommended dose prevails in all the crops which confirms lack of awareness of the farmers about efficient and balanced use of fertilizer. The table also shows that nitrogenous fertilizer constitutes major nutrients consumed among the sample farmer. Among all the fertilizers, major deviation (in terms of under utilization) was found in potash followed by phosphorous. Hence there is need for sound extension machinery in place to educate the farmers for efficient use of fertilizers in order to reap higher profits and restore the fertility of soil in long run.

4.1.3.4 Pesticide rate use by sample farmer

Pesticide use in crop cultivation has become a regular and inevitable feature in the study area even though most of the farmers discount the complexity involved in and consequence of indiscriminate use of pesticides. Among the sample farmers the pesticides used were grouped broadly into insecticides, weedicides and fungicides in terms of active ingredient.

The pesticide use per hectare and share of pesticide among different types by sample farmer for major crop is depicted in table 4.31and figure 4.8. From the table it is observed that highest total pesticide per hectare was consumed by cotton (1.90 a.i. kg ha^{-1}) followed by paddy (1.87 a.i. kg ha^{-1}) , maize (1.72 a.i. kg ha^{-1}) , groundnut (1.39 a.i. kg ha^{-1}) and redgram (0.92 a.i. kg ha^{-1}). Among the study crops, highest rate of insecticide was used in cotton (1.59 ai kg ha^{-1}) followed by groundnut (0.95 a.i. kg ha^{-1}) and paddy (0.77 a.i. kg ha^{-1}). The high dose of insecticide in cotton crop was due to indiscriminate use of insecticide in cotton crop as it is non food crop. Highest dose of weedicide was use in maize crop (0.75 a.i. kg ha^{-1}) followed by paddy (0.44 ai kg ha^{-1}). The dosage of weedicides in cotton was less (0.04 a.i. kg ha^{-1}) due to adoption of mechanical weed control in cotton.

In case of fungicide, paddy use highest dose (0.66 ai kg ha^{-1}) among the study crop followed by maize (0.42 a.i. kg ha^{-1}).

On an average one hectare of paddy area received 1.87 a.i kg ha^{-1} of technical grade pesticides. Insecticides were the most frequently used pesticides which accounted for bulk of the share (41.17 %) in total pesticides used and followed by Fungicides (35.29 %) and weedicides (23.53 %).

For cotton crop, major share of pesticide was occupied by insecticide (83.74 %) followed by fungicide (14.21 %) and weedicide (2.11%). However for maize crop, major pesticide was share by weedicide (43.63 %), as weed control is very essential in initial stage in maize crop. This was followed by insecticide (32.00%) and fungicide (24.37 %).

For groundnut crop, insecticide occupied the major share in total pesticide consumption (68.49 %) followed by weedicide (21.58 %) and fungicide (9.93 %).

For redgram, on an average one hectare area received 0.92 a.i. kg ha^{-1} of technical grade pesticides. Insecticides were the most frequently used pesticides which accounted for bulk of the share (52.17 %) in total pesticides used and followed by Fungicides (31.52%) and weedicides (16.30 %). The insecticide use was more than 50 per cent of pesticides in groundnut and red gram, which draws the attention of policy makers, since they might result in pesticide residues above the permissible limits, which might hinder smooth domestic and international trade.

4.1.4 Share of cost of fertilizer and pesticide in total cost.

Table 4.32 and figure 4.9, 4.10 and 4.11 shows the share of cost of fertilizer and pesticide in total cost of cultivation for major crops in various years. It can be seen from the table that, share of fertilizer and pesticide cost in total cost of cultivation was reduced over the year in the study crop. It was also further observed that in 1995-96, the percentage share of cost of fertilizer to total cost was more in maize (12.79 %) followed by paddy (10.45 %) and cotton(9.35 %). Similar result was observed in 2005-06 also but in 2009-10, cotton crop has highest percentage share of fertilizer to total cost (7.95 %) followed by maize (7.66 %) and paddy (5.50 %). The percentage share of cost of pesticide to total cost in all the study year was more in cotton followed by paddy and groundnut.

The percentage share of fertilizer and pesticide in total cost for paddy crop was found to be 12.49 per cent in 1995-96 which reduced to 11.81 per cent and 8.73 per cent in 2005-06 and 2009-10 respectively. It was observed that per cent share of fertilizer cost to total cost was reduced over the year. The per cent share of fertilizer cost in total cost of cultivation was 10.45 per cent in 1995-96 which reduced to 8.75 per cent and 5.50 per cent in 2005-06 and 2009-10 respectively. However, alternatively the percent share of cost of pesticide to total cost of production for the paddy crop has increased over the year. The per cent share of cost of pesticide in total cost of cultivation was 2.04 per cent in 1995-96, which increased to 3.06 per cent and 3.22 per cent in 2005-06 and 2009-10 respectively.

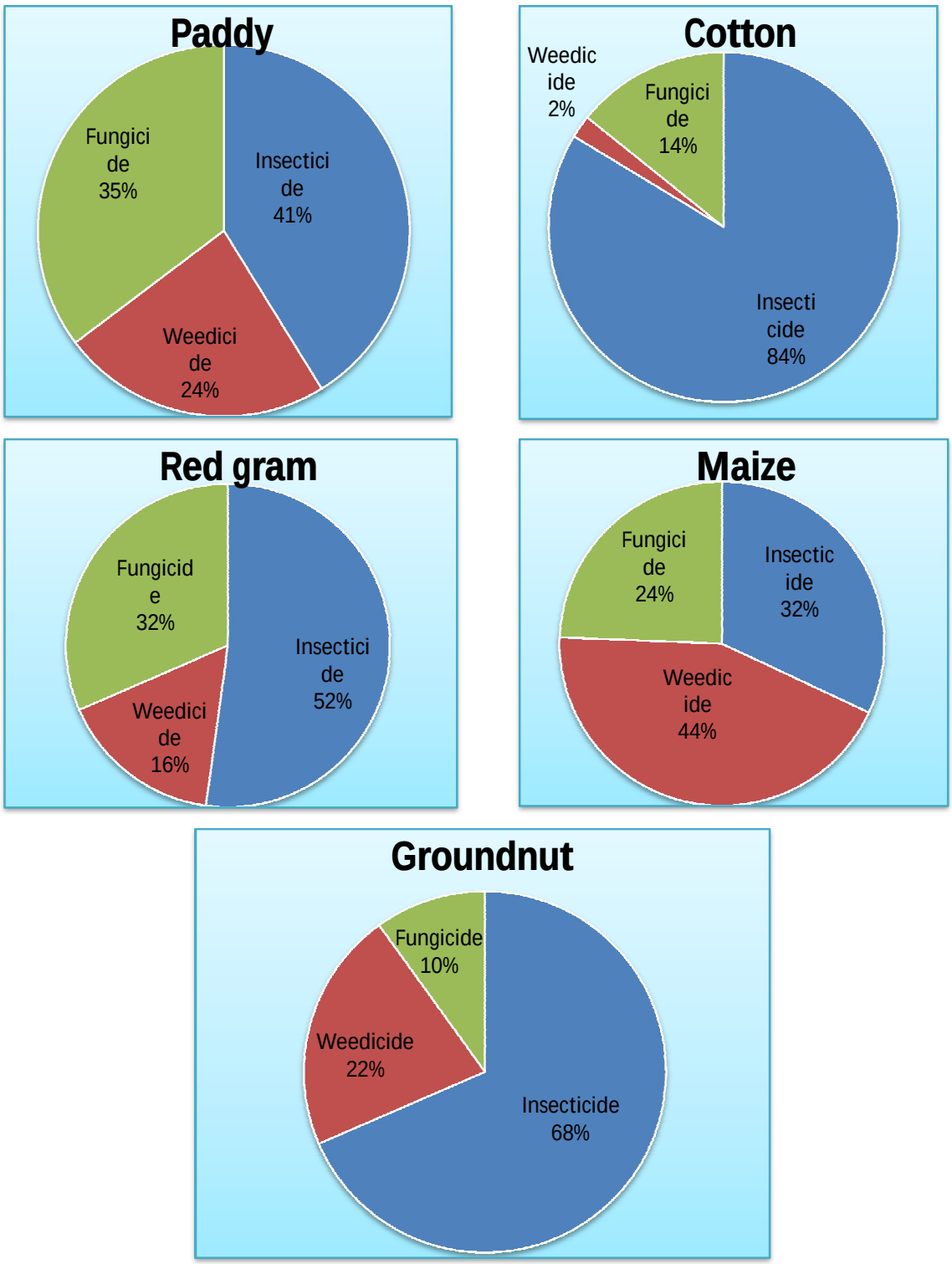

Figure 4.8. share of different type of pesticide use by sample farmer in different crops.

Table 4.31 Pesticide rate use by sample farmer. (ai kg ha^{-1})

Crops	Insecticide	Weedicide	Fungicide	Total
Paddy	0.77 (41.17)	0.44 (23.53)	0.66 (35.29)	1.87 (100.00)
Cotton	1.59 (83.74)	0.04 (2.11)	0.27 (14.21)	1.90 (100.00)
Maize	0.55 (32.00)	0.75 (43.63)	0.42 (24.37)	1.72 (100.00)
Groundnut	0.95 (68.49)	0.30 (21.58)	0.14 (9.93)	1.39 (100.00)
Red gram	0.48 (52.17)	0.15 (16.30)	0.29 (31.52)	0.92 (100.00)

Figures in parentheses indicates percentage

Similar result was observed for the maize crop as here also percentage share of cost of fertilizer and pesticide to total cost of cultivation was reduced over the year. The per cent share of cost of fertilizer and pesticide to total cost was 13.19 per cent in 1995-96 which reduced to 9.03 per cent in 2009-10. The share of fertilizer cost to total cost was reduced while the share of pesticide cost was increase over the year. The share of fertilizer cost was found out to be 12.79, which reduced to 7.66 per cent. But the share of cost of pesticide to total cost was reduced over the year. It was 0.39 per cent in 1995-96, which increased to 1.38 per cent in 2009-10.

For the cotton crop also, percentage share of fertilizer and pesticide to total cost of cultivation was reduced over the year. It was 19.54 per cent in 1995-96, which drastically reduced to 11.56 per cent in 2009-10. This reduction was mostly contributed by reducing highly in pesticide consumption over the year. The share of fertilizer and pesticide cost to total cost was reduced over the year. The share of fertilizer cost was found out to be 9.35 per cent, which reduced to 7.95 per cent. And the share of cost of pesticide to total cost was 10.19 per cent in 1995-96, which reduced to 3.61 per cent in 2009-10. This is due to the adoption of Bt cotton across the state.

The total share of fertilizer and pesticide to total cost of cultivation for groundnut crop was 6.25 per cent in 1995-96, which reduced to 4.77 per cent in 2009-10. The share of fertilizer cost to total cost was reduced while the share of cost of pesticide was increased over the year. The per cent share of fertilizer cost in total cost of cultivation was 5.58 per

Table 4.32. Share of cost of fertilizer and pesticide in total cost.

Crop	year	total cost (`ha^{-1})	cost of fertilizer		cost of pesticide		% share of cost of fertilizer and pesticide in total cost
			current price (` ha^{-1})	% in total cost	current price (` ha^{-1})	% in total cost	
Paddy	1995-96	17980.11	1879.43	10.45	366.04	2.04	12.49
	2005-06	29461.12	2579.25	8.75	900.32	3.06	11.81
	2009-10	54613.64	3005.75	5.50	1760.52	3.22	8.73
Maize	1995-96	10868.69	1390.51	12.79	42.82	0.39	13.19
	2005-06	19924.87	2352.94	11.81	204.22	1.02	12.83
	2009-10	38683.84	2962.07	7.66	532.72	1.38	9.03
Cotton	1995-96	23776.29	2222.84	9.35	2423.57	10.19	19.54
	2005-06	28413.66	2081.84	7.33	2029.73	7.14	14.47
	2009-10	42919.36	3411.89	7.95	1548.17	3.61	11.56
Groundnut	1995-96	11959.28	666.81	5.58	80.04	0.67	6.24
	2005-06	19812.15	961.45	4.85	223.06	1.13	5.98
	2009-10	35713.19	1329.80	3.72	373.09	1.04	4.77
Sugarcane	1995-96	38989.73	2191.21	5.62	123.47	0.32	5.94
	2005-06	69035.96	3283.17	4.76	981.00	1.42	6.18
	2009-10	103157.50	4086.98	3.96	765.22	0.74	4.70

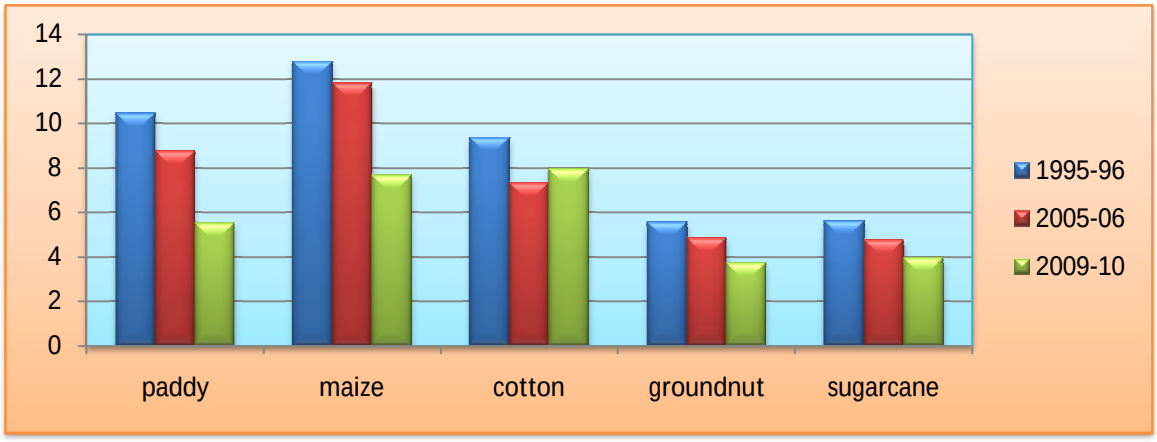

Figure 4.9 Share of cost of fertilizer in total cost

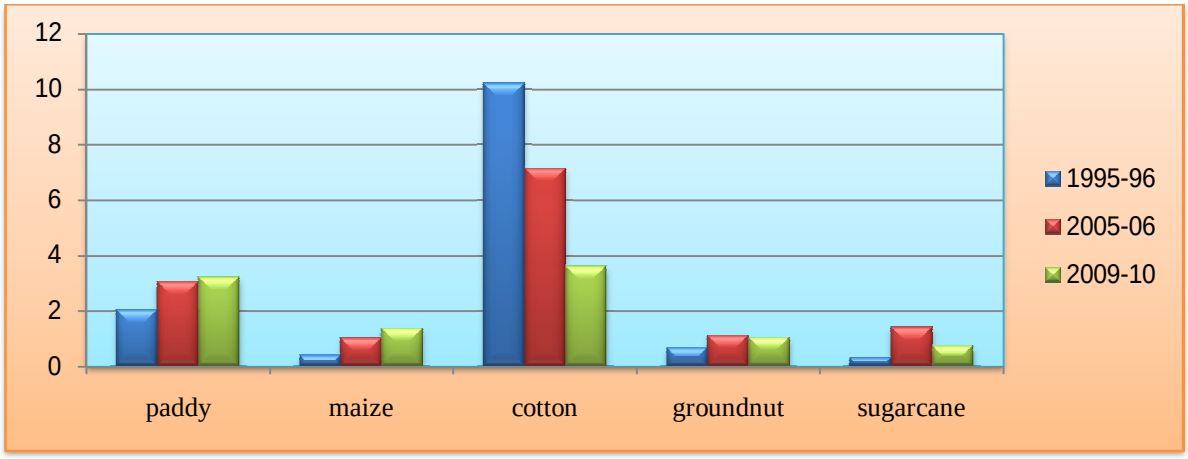

Figure 4.10 Share of cost of pesticide in total cost.

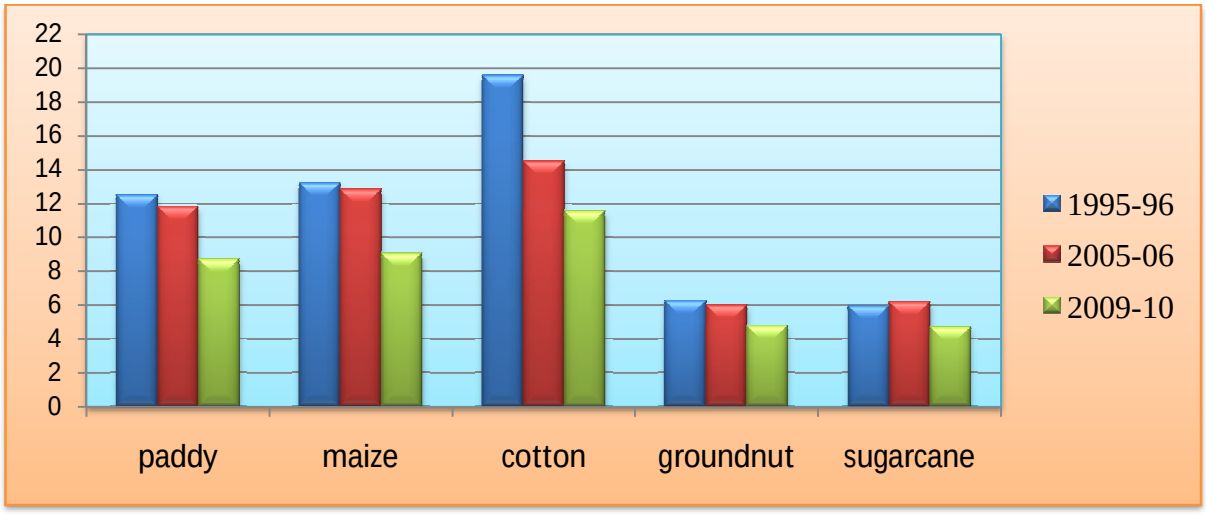

Figure 4.11 Share of cost of fertilizer and pesticide in total cost.

cent in 1995-96 which reduced to 4.85 per cent and 3.72 per cent in 2005-06 and 2009-10 respectively. And the per cent share of cost of pesticide in total cost of cultivation was 0.67 per cent in 1995-96, which increased to 1.04 per cent in 2009-10 .

For the sugarcane crop, the share of total fertilizer and pesticide cost was 5.94 per cent in 1995-96, which increased to 6.18 per cent in 2005-06. Nevertheless, the share was reduced to 4.70 per cent in 2009-10. The share of fertilizer cost was 5.62 per cent in 1995-96 while in 2009-10 the share was 3.96 per cent. The share of pesticide cost to total cost was 0.32 per cent in 1995-96, which increased to 1.42 per cent in 2005-06. Again it was reduced t0 0.74 per cent in 2009-10, indicating the reduction of pesticide in groundnut due to adopting of pest resistance variety of groundnut.

4.2 IMPACT OF FERTILIZER AND PESTICIDE ON PRODUCTIVITY.

In this section, the functional analysis was carried to find out the impact of various factors specially fertilizer and pesticides on the yield of various crop in sample farmer. Both multiple linear and Cobb- Douglas production was employ and choose the function which give good fit and higher number of significant of the independent factors.

4.2.1 Impact of fertilizer and pesticide on productivity of Paddy

Paddy is the most important crop of Andhra Pradesh. From the above cropping pattern discussion, it was observed that paddy cover about 60 per cent of the total gross crop area of sample farmers. And fertilizer and pesticide along with HYV variety are the major component that boosted the yield of paddy in the time of green revolution. It is important to analyze the impact of fertilizer and pesticide along with other factor.

To know the relative impact of fertilizer and pesticide in paddy yield, the output (Y) was regressed on different inputs like operational holding (ha), total human labour (hr ha^{-1}), seed rate (kg ha^{-1}), total animal labour (hr ha^{-1}), total NPK (kg ha^{-1}), tractor hour (hr ha^{-1}) and value of pesticide (` ha^{-1}). Cob-Douglas production function was choose over linear production function and estimated coefficient is furnished in Table 4.33.

The R^2 value was 0.26 which indicates that 26 per cent of the variations in paddy yield were influenced by the explanatory variables included in the model. It is evident from the

table that all the variable are positively influence except two variables which have negative effect. The coefficient of area under paddy crop was turn out to be 0.049 and significant at

Table 4.33 Impact of NPK and pesticide on paddy (Cobb- Douglas production function)

	coefficient	Std. Error	t - value
(Constant)	2.069	0.423	4.891
Area under paddy crop (ha)	0.049**	0.022	2.183
Value of Pesticides & Others (rs ha^{-1})	-0.001^{NS}	0.018	-0.028
Quantity of seed (kg ha^{-1})	0.111*	0.063	1.751
Total labour (hr ha^{-1})	0.058^{NS}	0.041	1.404
Total animal (hr ha^{-1})	0.016^{NS}	0.017	0.909
NPK (kg ha^{-1})	0.157***	0.056	2.82
Tractor (rs ha^{-1})	-0.006	0.005	-1.081
R square	0.26		
Adjusted R Square	0.20		
F	4.48***		
D-W statistics	0.52		
Returns to scale	2.453		

Table 4.34 Impact of fertilizer and pesticide on productivity of maize (multiple linear regression)

	Coefficient	Std. Error	t- value	Elasticity
(Constant)	20.321	8.336	2.438	
Area under maize crop (ha)	1.73^{NS}	2.617	0.661	0.068055
Quantity of seed (kg ha^{-1})	0.729*	0.409	1.785	0.012084
Total human labour (hr ha^{-1})	-0.006*	0.004	-1.73	8.19E-07
NPK (kg ha^{-1})	0.08***	0.027	2.932	0.000146
Total tractor hour (hr ha^{-1})	0.03^{NS}	0.038	0.79	2.05E-05
Value of pesticides & others (rs ha^{-1})	0.007**	0.003	2.128	1.11E-06
R Square	0.38			
Adjusted R square	0.34			
F	8.69***			
D-W statistics	1.15			
Returns to scale				0.080308

***- significant at 1 %
**- significant at 5 %
*- significant at 10 %
NS- Non significant.

5 per cent level, which means one per cent increase in area under paddy crop resulted an increase in paddy yield by 0.049 per cent. Human and animal labour has a positive impact on the yield of paddy but it was not significant. However, quantity of seed has a positive and significant impact on the paddy yield. It was observed from table that 1 per cent increase in quantity of seed paddy yield was increase by 0.11 per cent. Total NPK has a positive and significant impact on yield.1 per cent increase in NPK results in 0.15 per cent increase in paddy yield. cost of hire tractor hour and cost of pesticide has negative impact on the paddy yield. But its impact was non significant and one per cent increase in cost of pesticide and cost of hired tractor will reduce the yield of paddy by 0.001 and 0.006 per cent respectively.

The returns to scale is 2.45, which was the sum of elasticities. This implies that if all explanatory variables are simultaneously increased by one per cent, the total physical output of the paddy will increase by 2.45%. This value being greater than unity (1) means that the farmers are operating at the region of increasing returns to scale. Increasing returns portrays a case whereby an additional unit of input results in a larger increase in product than the preceding unit. This suggests that paddy farmers can increase their output by increasing the use of some of these key resources. This requires re-allocation of existing resources. It might be due to imbalance in the use of fertilizer probably a combination of inorganic fertilizer and organic fertilizer is needed.

From the above discussion, it was concluded that increase in the used of inputs such as operational holding (ha), total human labour (hr ha^{-1}), seed rate (kg ha^{-1}), total animal labour (hr ha^{-1}), total NPK (kg ha^{-1}) would increase yield while cost of hired tractor and pesticide reduce the yield. Among the factors which affects on paddy yield, NPK was the most important factor followed by land and seed. Cost of pesticide and hired cost of tractor has negative impact but non -significant. Adjustments are required in the use of resources for paddy production to increase the profitability of their paddy crop. Overall, it can be agreed that fertilizers are more influential on yield than pesticides.

4.2.2 Impact of fertilizer and pesticide on productivity of maize.

In this production function, the dependent variable is the maize yield per hectare and the explanatory variables are the area under maize crop, total human labour, tractor hour, quantity of seed, fertilizer (NPK) consumption per hectare and cost of pesticides. Multiple linear regression was prefer over Cobb Douglas for maize crop to see the impact of various factor as mention above on yield. So, the impact of fertilizer and pesticide on the maize crop is presented in table 4.34.

The production function shows a good fit too with a R^2 of 0.38. It was observed from the table that coefficient of area under maize crop and tractor hour was positive and non –significant. This shows that above two factors has positive effect on productivity of maize but it was not significant. However, total human labour was negative and significant at 10 per cent. It means 1 hour increase in human labour will decrease the yield of maize by 0.006 qt ha^{-1}. The quantity of seed has positive effect on yield. 1 kg increase in seed quantity there will be 0.72 qt increase in yield. Fertilizer consumption and cost of pesticide is statistically significant at 1 and 5 per cent level. It was revealed that 1 kg increase in NPK will increase the yield by 0.08 kg. Similarly, one rupee increase in expenditure of pesticide leads to increase yield of maize by 0.007 qt. Elasticity of production (Ep) was found to be 0.08 showing a decreasing returns to scale. This implies that if inputs are increased by 100 % then there will be less than 100 % increase in output.

So the major factor which affect yield in the above equation is the quantity of seed and per hectare fertilizer consumption and the farmer face decreasing return to scale.

4.2.3 Impact of fertilizer and pesticide on productivity of Groundnut

The functional analysis for groundnut productivity to analyzed relative impact of various inputs on groundnut yield specially for fertilizer and pesticide is illustrated in table 4.35. Cobb Douglas production function was choose over linear production function. The table indicated that the regression mode is significant at 1% level as shown by F statistic. This implies that the whole equation is at best fit. The R^2 of 0.63 indicated that 63.00 % of the variability in the output of groundnut is accounted for by the various independent variables used.

The area under groundnut cultivation had an elasticity of 0.23, indicating that one per cent increase in the land area would bring 0.23 per cent increase in the production. The regression analysis shows that the coefficient of seeds is 0.39 and is significant at 15% level of significant which implies that 1% increase in seeds input increases the net output

by 0.39 %. Also The positive value of seed coefficient means higher seed rate in kg ha^{-1} implies greater that number of crops stands per hectare and consequently higher yield, except where there is over- crowding leading to competition for nutrients and low yields.

The human labour and cost of pesticide applied in the cultivation had significant and positive elasticity coefficients of 0.68 and 0.07, with implication that human labour contributes positively to the output while positive elasticity of cost of pesticides indicates that even increase in the cost of pesticide does not hinder in the reduction of yield. The coefficient of fertilizer (NPK) was 0.074 and non significant. The positive was in accordance with the expected sign meaning that that quantity of fertilizer applied was directly related to the output while the statistical insignificance of the coefficient implies that fertilizer was not a determinant of output in groundnut production. Similarly, the animal labour on groundnut production has positive but non significant indicating that animal labour contributes positively to the output, though the effect is not real.

The returns to scale is 1.57 which was the sum of elasticities. This value being greater than unity (1) meant that the farmers are operating at the region of increasing returns to scale. Increasing returns portrays a case whereby an additional unit of input results in a larger increase in product than the preceding unit. This suggests that groundnut famers in the area can increase their output by increasing the use of some of these utilised key resources. This requires re-allocation of existing resources. This implies that if all explanatory variables are simultaneously increased by one percent, the total physical output of the groundnut will increase by 1.57%. This implies that production was in the irrational zone of production (stage 1) and that the percentage change in the variable input. That is factor input were not efficiently allocated and utilized. Opportunities still exists to increase groundnut output in the study area by increasing the level of above mentioned productive resources.

From the above discussion, it was concluded that, most important input in groundnut productivity was human labour followed by seed and area. While fertilizer quantity has positive but non-significant impact on yield. The cost of pesticide per hectare has positive impact on groundnut yield, indicating that increase in cost of pesticide does not hinder the yield of groundnut. Groundnut exhibit increasing returns to scale indicating

opportunities still exists to increase groundnut output in the study area by increasing the level of productive resources.

Table 4.35 Impact of fertilizer and pesticide on productivity of groundnut. (Cobb- Douglas)

Variable	B	Std. Error	t value
Constant	-5.427	1.48	-3.668
Area under groundnut crop (ha)	0.234**	0.111	2.103
Quantity of Seed (kg ha^{-1})	0.394@	0.257	1.531
Total human Labour (hr ha^{-1})	0.684**	0.27	2.531
Animal labour (hr ha^{-1})	0.116	0.083	1.391
NPK (kg ha^{-1})	0.074	0.178	0.415
Value of Pesticides & others(`ha^{-1})	0.07**	0.03	2.338
R square	0.63		
Adjusted r square	0.57		
F	10.76***		
D-w statistics	1.53		
Return to scale	1.57		

Table 4.36 Impact of NPK and pesticide on cotton (linear).

variable	B	Std. Error	t value	elasticity
(Constant)	13.135	1.958	6.709	
Area under cotton (ha)	-0.026^{NS}	0.319	-0.082	-0.00297
Quantity of seed (kg ha^{-1})	-1.963**	0.764	-2.568	-0.18586
Total human labour (hr ha^{-1})	0.003***	0.001	3.17	0.315199
Animal labour (hr ha^{-1})	-0.009**	0.004	-2.156	-0.02763
NPK (kg ha^{-1})	0.007^{NS}	0.005	1.371	0.115957
Value of Pesticides & Others (` ha^{-1})	-0.001*	0.001	-1.843	-0.12096
R Square	0.219			
Adjusted R Square	0.163			
F	3.915			
Durbin-Watson	0.521			
Return to scale				0.093726

***- significant at 1 %

**- significant at 5 %
*- significant at 10 %
@- significant at 15 %
NS-Non-significant

4.2.4 Impact of fertilizer and pesticide on productivity of cotton

The effects of fertilizer and pesticide on cotton yield were investigated through multiple regression analysis. The linear multiple type production function was estimated using the ordinary least square (OLS) method. The assessed factors include seed rate, area under cotton, value of pesticides, animal labour, human labour and NPK. Results of regression analysis are reported in table 4.36. The R^2 value of 0.21 can be regarded as quite a good fit in view of the cross-sectional data involved in this study, it implied that about 21% variation in yield is explained by the independent variables included in the model. The regression mode is significant at 1% level as shown by F statistic. This implied that the whole equation is at best fit.

The influence of the independent variables on cotton yield is discussed in detail as follows. It can be seen from the table 4.35 that area under cotton crop and fertilizer are non significant while remaining factors are significant. Again human labour and fertilizer are positively affecting the yield of cotton while the remaining factor are affecting negatively. The coefficient of area under cotton crop was –0.026 and non significant, which shows that cotton yield is negatively influenced by of any change in area under Bt cotton. Negative impact might be due to the fact that farmer is unable to manage plucking the cotton bolls at the peak harvest time if the area is more and could not harvest in time. It is more likely happen when area is large. Given the other factors, seed rate determines the plant population in a field of certain crop and thus, is an important factor in determining yield. The coefficient of seed rate was -1.96 and significant at 5 per cent. It means 1 kg increase in seed rate will decrease the yield by 1.9 kg of cotton. The negative impact of quantity of seed on yield may be due to congested plant population would result in reduced yield of Bt cotton. The coefficient of value of pesticide was -0.001 and significant at 10 per cent level of significant. This shows that cost of pesticide has negative impact on yield. Increase in the expenditure on pesticide might be detrimental to the beneficial insect, which may reduce the yield of Bt cotton. Use of bullock labour has negative impact on the yield of Bt cotton. From the regression coefficient, it can be inferred that that one hour increase

in animal labour in per hectare will reduce the yield of Bt cotton. However, total human labour has positive effect on yield. Its coefficient was 0.003 and significant at 1 per cent level. Human labour is the most important factor for cotton cultivation. Agricultural practice like weeding and specially in plucking of cotton bolls were done by mnually. So increase in human labour hour in plucking of cotton balls at right time reduced the yield loss and ultimately increase the yield.The coefficient of fertilizer (NPK) was positive and in accordance with the expected sign meaning that the quantity of fertilizer applied was directly related to the output while the statistical insignificance of the coefficient implies that fertilizer was not a determinant of output in cotton production. The output elasticities summed up to 0.08, denotes that cotton production is characterized by decreasing returns to scale. Hence, a 1 per cent increase in the current utilization of all inputs would bring about 0.76 percent reduction in yield.

From the above discussion it was concluded that human labour was the most important factor while increase in the cost of pesticide had negative effect on yield. while NPK has positive impact on yield but it was not an important factor in increasing the yield. the return to scale show decreasing return for cotton cultivation by using the above mention inputs.

4.3 Factor affecting fertilizer and pesticide consumption

After thorough examination of fertilizer and pesticide consumption pattern at macro level by using secondary data (at state and districts levels) and micro level for a specified period. It is appropriate at this juncture to use secondary data and the primary data of cost of cultivation scheme data pertaining to 600 farmers, further to have a deeper understanding and use the data to probe into the factors affecting fertilizer and pesticide consumption.

In this section, the influence of various factor that determine the level of fertilizer and pesticide consumption were examined. Considering the nature and purpose of fertilizers and pesticide used the influence of the determinants is examined separately for fertilizer and pesticide. The analysis is carried out on two sets of data as follows:

1. cross section data pertaining to fertilizer and pesticide consumption of sample farmers.

2. the time series data from1981-82 to 2010-11 at state level for chemical fertilizer only. Determinant of pesticide did not carried out due to lacuna in data pertaining to pesticides.

For this purpose variables viz: per cent area under irrigated area, price of fertilizer, per cent area of HYV crops to gross cropped area, farm size, cost of pesticide, human labour wages etc were considered. Multiple linear regression model was used to study simultaneous impact of per cent area under irrigation, price of fertilizer, percentage area of HYVP crops to gross cropped area, farm size, cost of pesticide, human labour wages etc

4.3.1 Factor affecting fertilizer consumption of sample farmers.

Fertilizer consumption by farmers are different for different farmers due to diversity in cropping pattern, variation in farm size, economic status and soil type fertility, type of crops cultivated etc. The farmers are categorized into five category base on farm size and it was consider that farmers in same category has same socio- economic condition. These five category (category I (less than 1 ha), category II (1-2 ha), category III (2-4 ha), category IV (4-6 ha) and category V (above 6 ha) are mention in the methodology. In order to examine the factors influencing the consumption for chemical fertilizer functional analysis was carried out for each category of farmer.

4.3.1.1 Factors affecting fertilizer consumption of category I sample farmers.

In order to understand the determinants of fertilizer use in category I farmer, fertilizer use level were regressed on the set of explanatory variables, viz., total area, cropping intensity, percentage of area under irrigation, farm yard manure percentage of area under high fertilizer use cropped, hired labour wages, relative price, cost of irrigation charges and cost of pesticide. The result of the regression analysis is presented in table 4.37. From the table it was observed that R^2 value was 0.35 indicating that the explanatory variables in the model have accounted for over 35 per cent variation in fertilizer use. The model was significant at 1 per cent level. All the variables considered are positively affecting except cost of irrigation charges turn out to be negative though most of the variables are non- significant. Out of the nine factors considered in the analysis only three viz., per cent area under high fertilizer use crop, wages and relative price of output to fertilizer price turn out to be significantly influence on the fertilizer consumption in category I farmer.

From the table it was revealed that the most important factor was per cent of area under high fertilizer used cropped. The regression coefficient of per cent area under high fertilizer use cropped was 96.33 and significant at 1 per cent level. This implies that one hectare increase in the cultivation of high fertilizer use cropped, would result in increased the fertilizer consumption by 96.33 kg ha^{-1}. This finding are in conformity with earlier

Table 4.37 Factor affecting fertilizer consumption in category I sample farmer.

variable	coefficient	Std. Error	t value
(Constant)	30.13	40.92	0.736
Farm size (ha)	16.02^{NS}	18.04	0.888
Cropping intensity (%)	0.002^{NS}	0.13	0.014
Proportion of area irrigated (%)	3.69^{NS}	22.92	0.161
Per ha use of farm yard manure	0.28^{NS}	0.31	0.909
Proportion of area under fertilizer intensive crop. (%)	96.33***	22.4	4.3
Wages (`)	0.003***	0	3.815
Relative price	0.39***	0.13	3.072
Value of irrigation charges (`)	-0.05^{NS}	0.04	-1.116
Value of pesticides & others (`)	0.003^{NS}	0.01	0.588
F	6.35***		
R square	0.35		
Adjusted r square	0.3		
Durbin-Watson	1.36		

Table 4.38 Factor affecting fertilizer consumption in category II sample farmer

variable	coefficient	Std. Error	t value
constant	25.89	47.50	0.55
Farm size (ha)	8.84^{NS}	11.27	0.78
Cropping intensity (%)	-0.18$^{@}$	0.13	-1.44
Proportion of area irrigated	51.61**	22.91	2.25
Per ha use of farm yard manure	0.20^{NS}	0.21	0.99
Proportion of area under high fertilizer used crop (%)	94.75***	29.89	3.17
Wages (` ha^{-1})	0.00***	0.00	4.13
Relative price	0.14^{NS}	0.11	1.22
Value of Irrigation Charges (` ha^{-1})	-0.07^{NS}	0.05	-1.40
Value of Pesticides & Others (` ha^{-1})	0.01*	0.01	1.77
R Square	0.36		
Adjusted R Square	0.30		
Std. Error of the Estimate	73.21		
Durbin-Watson	1.58		
F	6.54*		

*** denotes significant at 1% level
** denotes significant at 5% level
*denotes significant at 10% level
NS denotes Non significant.

finding of Bezbaruah and Roy (2002) and Parthasarathy and Rao (1986). The second most important factor was relative price of output to fertilizer price. The coefficient of relative price indicate that one unit increase in the relative price of output, fertilizer consumption will increased by 0.34 kg ha^{-1}. The regression coefficient of wages was 0.003 and significant at 1 per cent level. It indicates that expenditure on human labour has positive effect on fertilizer consumption.

From the above discussion, it was concluded that all the factor consider has positive effect on fertilizer consumption except cost of irrigation charges. The most important determinant was area under fertilizer intensive cropped followed by relative price of output to fertilizer price and wages. For the category I farmer area under irrigation was not the important factor for fertilizer use which turn out to be contrasting with the earlier studies. Similarly, price of output are more important the price of fertilizer. This might be due to prolong subsidies on the price of fertilizer, which become non-deciding factor for the use of chemical fertilizer.

4.3.1.2 Factors affecting fertilizer consumption in category II sample farmer.

The multiple regression analysis was carried out for estimating the influence of factors on fertilizer consumption. Table 4.38 shows the result of multiple regressions. The R^2 value of 0.36 indicates that the fit was good that is, 36 per cent of the variation in fertilizer use was caused by 9 explanatory variables. F value emerged statistically significant at 1 per cent level. Thus, it may be inferred that the overall regression model was statistically significant. Out of nine factors considered, five factors are significantly influence the use of fertilizer. Cropping intensity and value of irrigation charges influenced negatively in fertilizer consumption. The result of the linear regression was presented in table 4.30.

From the table it was observed that coefficient of cropping intensity was -0.18 and significant at 15 per cent level. This shows that less fertilizer use as the frequency of cultivation increased. This finding is contrast with earlier finding as it was proved that fertilizer used will increase with the increased in frequency of cultivation (Jaga and Patel,

2012). The coefficient of per cent area irrigated was 51.61 and significant at 5 per cent level indicating that one unit increase in area irrigated would result in increased fertilizer

Table 4.39 Factor affecting fertilizer consumption in category III sample farmer.

variable	B	Std. Error	t value
(Constant)	123.69	59.52	2.08
Farm size (ha)	-5.68^{NS}	11.87	-0.48
Cropping intensity (%)	-0.14$^{@}$	0.09	-1.56
Proportion of area irrigated (%)	-26.75 ^{NS}	26.94	-0.99
Per ha use of farm yard manure (qt ha^{-1})	-0.51*	0.27	-1.91
Proportion of area under fertilizer intensive crop (%)	108.01***	30.59	3.53
Wages (` ha^{-1})	0.00***	0.00	4.54
Relative price	0.09^{NS}	0.13	0.68
Value of irrigation charges (` ha^{-1})	-0.07@	0.04	-1.55
Value of pesticides & others (` ha^{-1})	0.00	0.01	0.36
R square	0.36		
Adjusted r square	0.30		
Std. Error of the estimate	76.79		
Durbin-watson	1.41		
F	6.63***		

Table 4.40 Factor affecting fertilizer consumption in category IV sample farmer.

variable	B	Std. Error	t value
constant	47.85	58.22	0.82
Farm size (ha)	2.80	8.59	0.33
Cropping intensity (%)	-0.21*	0.12	-1.84
Proportion of area irrigated (%)	15.77	24.41	0.65
Per ha use of farm yard manure (qt ha^{-1})	0.23	0.24	0.95
Proportion of area under fertilizer intensive crop (%)	104.35***	22.65	4.61
Wages (` ha^{-1})	0.003*	0.00	4.73
Relative price	0.25***	0.14	1.82
Value of irrigation charges (` ha^{-1})	0.001	0.03	0.03
Value of pesticides & others (` ha^{-1})	0.001	0.01	-0.18
R square	0.37		
Adjusted r square	0.32		
Durbin-watson	1.69		
F	7.06***		

*** denotes significant at 1% level
** denotes significant at 5% level
*denotes significant at 10% level
NS denotes Non significant.

consumption by 51.61 kg ha^{-1} (Parathasarathy and Rao, 1986). The coefficient of area under high fertilizer use cropped revealed that one per cent change in cropping pattern towards high fertilizer using crops is likely to increase the fertilizer used by 96 per cent.

Wages and expenditure on pesticide will increase the use of fertilizer marginally. However relative price turn out to be non-significant in fertilizer consumption. This shows that non price factor are more important than price factor for fertilizer used in category II. Expenditure on irrigation charges have negatively influence though its effect was not significant.

From the above discussion it was concluded that in category II farmers also per cent of area under high fertilizer used cropped was the most important factor in fertilizer used followed by proportion of area irrigated. Non price factor was more important than price factor and cropping intensity become negatively influencing in use of fertilizer used.

4.3.1.3 Factors affecting fertilizer consumption in category III sample farmer.

The results of multiple linear regression for fertilizer consumption for category III farmer is presented in table 4.39. The R^2 value (0.36) indicates that explanatory variables in the model have accounted for 36 per cent variation in fertilizer use. The model was significant at one per cent level. Out of nine factors consider, five are significantly influence in fertilizer consumption.

From the table it was observed that proportion of area under high fertilizer used and wages have positive effect while cropping intensity, FYM, expenditure on irrigation has negative effect on fertilizer consumption. For 1 per cent increase in cropping intensity, fertilizer consumption will reduced by 0.14 kg ha^{-1}. This finding is contrast with the earlier finding (Jaga and Patel, 2012). The coefficient of FYM was -0.51, which means FYM act as substitutes for fertilizer. Then planning is necessary for the efficient use of manures and fertilizer for the optimal use of these production inputs (Ramasamy *et al.*, 1986). The area under high fertilizer used cropped has a coefficient of 108.01 which means fertilizer consumption will increase by 108.01 kg when area under high fertilizer used cropped has

increase by one hectare. Expenditure on wages has positive effect on fertilizer use. This means human labour increase has enhanced the fertilizer consumption. Expenditure on irrigation charges has negative effect on fertilizer consumption. Relative price has a positive coefficient but non-significant. It means price of output relative to price of fertilizer is not the deciding factor for fertilizer used. Farm size and proportion of area irrigated are non-significant.

The cropping intensity has negative influence on consumption because, second crop such as blackgram in paddy fields after kharif used residual moisture and available fertilizer where there is a reduced fertilizer in terms of external application.

From the above discussion, it was concluded that per cent area under high fertilizer used cropped was the most important factor followed by FYM for fertilizer consumption in category III farmer.

4.3.1.4 Factors affecting fertilizer consumption in category IV sample farmer.

The result of the regression analysis carried out by multiple linear regression model using the ordinary least square (OLS) method. The assessed factors includes total area, cropping intensity, farm yard manure, percentage of area under high fertilizer use cropped, wages, relative price, cost of irrigation charges and cost of pesticide. Results of regression analysis are reported in table 4.40. The R2 value of 0.37 can be regarded as quite a good fit in view of the cross-sectional data involved in this study, it implies that about 37% variation in yield is explained by the independent variables included in the model. The regression mode is significant at 1% level as shown by F statistic. This implies that the whole equation is at best fit.

From the table it was reported that out of nine factors included in the analysis, four are significantly affecting the fertilizer consumption. The coefficient of farm size was non significant. These implies that there are no real variation in the extent of application of fertilizer with respect to variation in farm size. (Bezbaruah and Roy, 2002). The coefficient of proportion of area under irrigation and FYM are positive but non-significant. The coefficient of per cent area under high fertilizer used crop was 104.35 and was significant. This shows that if one unit increase the area under high fertilizer consuming crop, consumption of fertilizer will be increased by 104.35 kg ha^{-1} (Bezbaruah and Roy, 2002 and Parthasarathy and Rao, 1986).

The coefficient of relative pricing of output was 0.25 and significant at 10 per cent level showing that price of output relative to price of fertilizer was one of the important factor in deciding factor for fertilizer usage. The coefficient on expenditure on irrigation and pesticide are non-significant.

From the above discussion it can be concluded that per cent area under high fertilizer used crop was the most important factor in deciding fertilizer used followed by relative price. In this category cropping intensity does not intensify the use of fertilizer and irrigation is not the deciding factor for fertilizer used.

4.3.1.5 Factors affecting fertilizer consumption in category V sample farmer

To know the relative factors affecting fertilizer consumption in category V farmer, the per hectare fertilizer consumption (Y) was regressed on different inputs like operational holding (ha), cropping intensity, proportion of area irrigated, FYM, proportion of area under high fertilizer used cropped, wages, relative price and expenditure on irrigation charges. Multiple linear regression function results was used to estimate the coefficient and is furnished in Table 4.41.

From the table it was reported that the value of R^2 was 0.40 and the value of F was 8.78 and significant at 5 per cent. Out of eight factors considered, only three factors significantly influence the fertilizer consumption which are proportion of area under high fertilizer used cropped, wages and expenditure on irrigation charges. It was observed that coefficient of proportion of area under high fertilizer used cropped was 94.63 and significant at 1 per cent level. It means 94.63 kg ha^{-1} of fertilizer consumption will increase if the farmer increase the area under high fertilizer used cropped by 1 hectare (Bezbaruah and Roy, 2002 and Parthasarathy and Rao, 1986). Similarly, expenditure on wages has a positive impact on fertilizer used. It is because more hired labour means more human labour for fertilizer application and other cultural practices such as weeding which induced the fertilizer consumption. But irrigation charges has a negative impact on fertilizer consumption as the effective use of fertilizer by the plant depend on the availability of moisture. The reason may be some of the expenditure deviated to the irrigation charges which might force to reduce the expenditure on fertilizer and ultimately less per hectare consumption of fertilizer. Proportion of area irrigated and relative price was not the

important factor in fertilizer consumption in category V farmer. FYM has negative coefficient though non-significant showing that FYM acts as a substitute for fertilizer.

From the above discussion it was concluded that, for category V farmer the most important factor which affecting fertilizer used was area under high fertilizer used cropped. Proportion of irrigated area and relative output price are not the important factor for deciding fertilizer used.

4.3.1.6 Factors affecting fertilizer consumption in Andhra Pradesh. (time series data).

In this section, the factors influencing N, P,K and NPK consumption in Andhra Pradesh by using time series data were considered for functional analysis. For this purpose variables viz: per cent irrigated area, cropping intensity, per cent area under HYV, output price and NPK price (deflated) for 30 years (1981-2010) were considered. Multiple linear regression model was used to study simultaneous impact of the above mention factors on N, P,K and NPK consumption separately.

Table 4.42 presents results of the N,P,K and NPK fertilizer consumption regression analysis. The estimated coefficient of nitrogen are acceptable from both economic theory and statistical view point. The signs on all the coefficients are as hypothesized and the model is significant at one per cent level.

The coefficient for the cropping intensity and output price had positive impact on nitrogen fertilizer consumption. While price of fertilizer had a significant negative impact on nitrogen fertilizer consumption. The coefficient of cropping intensity was 2.52 implied that one unit increase in cropping intensity will lead to increase in nitrogen fertilizer used by 2.5 units. On the other hand the coefficient of output price was 0.052 and significant at 10 per cent level. On the contrary price of nitrogen fertilizer recorded -3.28 coefficient which meant that price of nitrogen fertilizer had adverse effect on fertilizer consumption. The coefficient of area under HYV and irrigation was positive (0.39) but non significant. The non significance of HYV might be due to less area coverage under HYV in Andhra Pradesh. Irrigation might not be the criteria for fertilizer consumption. Among the non price factors, cropping intensity was the most important factor in influencing nitrogen fertilizer consumption. between the price of fertilizer and output price, former turn out to be the more powerful in influencing the nitrogen consumption. This cropping intensity might

be important because, farmer definitely apply nitrogenous fertilizer even for a second crop sown in rabi. Moreover since the data is at macro level it is not dominated by paddy area which resulted in a second crop in many cases.

Table 4.41 Factor affecting fertilizer consumption in category V sample farmer.

Factor	Coefficient	Std. Error	t value
constant	63.72	38.91	1.64
Farm size (ha)	0.97^{NS}	3.2	0.3
Cropping intensity (%)	-0.17^{NS}	0.13	-1.33
Proportion of area irrigated (%)	26.87^{NS}	22.07	1.22
Per ha use of farm yard manure (Qt ha^{-1})	-0.27^{NS}	0.37	-0.73
Proportion of area under fertilizer intensive crop (%)	94.63***	21.78	4.35
Wages (` ha^{-1})	0.001***	0	4.8
Relative price	0.09^{NS}	0.1	0.91
Value of Irrigation Charges (` ha^{-1})	$-0.06^{@}$	0.04	-1.51
R Square	0.40		
Adjusted R Square	0.35		
Durbin-Watson	1.42		
F	8.78***		

Table: 4. 42 Factor affecting N,P,K and NPK consumption

N	N	P	K	NPK
(Constant)	-234.106** (99.81)	-3.791* (69.85)	81.049 (72.41)	-157.189 (208.68)
IRRI (%)	0.62^{NS} (0.537)	0.639^{NS} (0.37)	0.415^{NS} (0.39)	1.68@ (1.12)
CI (%)	2.521*** (0.86)	-0.021*** (0.602)	-0.683^{NS} (0.62)	1.815^{NS} (1.79)
HYV (%)	0.298^{NS} (0.393)	0.508^{NS} (0.27)	0.138^{NS} (0.28)	0.931^{NS} (0.82)
Po (` qt^{-1})	0.052* (0.028)	0.055NS (0.02)	0.04* (0.02)	0.149** (0.06)
Pf (` kg^{-1})	-3.286*** (0.648)	-2.071^{NS} (0.45)	-1.815*** (0.47)	-7.152*** (1.35)
R SQUARE	0.948	0.918	0.797	0.936
ADJUSTED R SQUARE	0.937	0.901	0.754	0.922
F	87.546***	53.566***	18.798***	69.86***
D-W STATISTICS	1.682	1.42	0.548	1.324

***- significant at 1 %

**- significant at 5 %
*- significant at 10 %
@- significant at 15 %
NS- Non significant.
Figure in the parentheses indicates std error

For phosphorous fertilizer, the variables included in the model explained about 90 per cent of the variation in the consumption of phosphatic fertilizer. Only one variable e.i. cropping intensity was significant and adversely affecting the phosphorous consumption. This shows that phosphorous fertilizer consumption does not increase as the frequency of cultivation increased. This confirms that when the kharif area is sown with rabi crop, farmers consider that phosphorous is not mandatory to be applied.

The variable included in the potash fertilizer consumption model explain about 75 per cent of the total variation in fertilizer use. output price and potash fertilizer price are significantly influencing the K2O consumption.

For NPK fertilizer the variable included in the model explained about 92 per cent and model was statistically significant and had theoretically expected sign. Price of fertilizer was negatively related with the fertilizer consumption while price of output, per cent irrigation had a positive relationship with fertilizer consumption. The result shows that among the non price factor irrigation was the most important and among the price factor, fertilizer price was most important factor

From the above discussion, it was concluded that area under hybrid was not the important factor in all the cases. Irrigation area was significant in the total NPK consumption. Only cropping intensity was significant in N and phosphorous consumption. Both the output price and input price are significant in all the cases except in phosphorous consumption, output price was non significant . Between the input and output price, former was the most powerful factor in influencing fertilizer consumption. So it is necessary to prioritize reduce input price policy mechanism over higher output prices and high output price benefit a small proportion of farmer while low input price will increase fertilizer consumption on millions of small and marginal farmers.

Cropping intensity figured out as positive contributor and sometimes as a negative contributor in fertilizer consumption.

4.3.2 Factor affecting pesticide consumption of sample farmers.

pesticide consumption by farmers are different from different farmers due to different cropping pattern, farm size, economic level and soil condition, type of crops

Table 4.43 Factor affecting expenditure on pesticide on paddy (log- linear)

	Coefficient	Std. Error	t value
Constant	-1.46	0.83	-1.76
Area under paddy crop (ha)	0.06	0.05NS	1.16
Value of seed (` ha-1)	0.32	0.14**	2.23
NPK (kg ha^{-1})	0.81	0.17***	4.71
Value of main product (`ha^{-1})	0.15	0.12NS	1.27
R Square	0.22		
Adjusted R Square	0.21		
Durbin-Watson	0.51		
F	28.87***		

Table 4.44 Factor affecting expenditure on pesticide on cotton (linear)

	Coefficient	Std. Error	t value
Constant	1119.83	370.09	3.03
Area under cotton crop (ha)	-122.65**	61.47	-2.00
Value of seed (` ha^{-1})	-0.06NS	0.10	-0.62
NPK (kg ha^{-1})	5.95***	0.61	9.69
Value of main product (`ha^{-1})	0.003NS	0.00	-0.78
R Square	0.48		
Adjusted R Square	0.46		
Durbin-Watson	1.57		
F	24.01***		

Table 4.45 Factor affecting expenditure on pesticide on maize (linear)

	Coefficient	Std. Error	t value
Constant	-1377.04	407.51	-3.38
Area under maize crop (ha)	248.05**	99.74	2.49
Value of seed (` ha^{-1})	0.38**	0.15	2.49
NPK (kg ha^{-1})	3.47*	1.86	1.87
Value of main product (` ha^{-1})	0.01^{NS}	0.01	0.83
R Square	0.64		
Adjusted R Square	0.60		

Durbin-Watson	1.14		
F	16.57***		

*** denotes significant at 1% level
** denotes significant at 5% level
*denotes significant at 10% level
NS denotes Non significant

cultivated. In order to examine the factors influencing the consumption for pesticide, functional analysis was carried out for paddy, cotton and maize.

4.3.2.1 Factor affecting pesticide consumption of paddy.

A log linear regression model was estimated by considering the expenditure on pesticides as the dependent variable. Area under paddy (ha), seed (` $ha^{-1}$), value of output (` ha^{-1}) and NPK (kg ha^{-1}) were taken as independent variables. The result of regression was presented in table 4.43. the value of R^2 was 0.22 and F value was 28.87 which is significant at one per cent level.

The regression coefficient of area under paddy was 0.06 and is non-significant. This indicates that area under paddy is not the real factor, which affects expenditure on pesticide. The coefficient of fertilizers consumption per hectare was 0.81 and significant at one per cent level. It means one per cent increase in fertilizer consumption will increase the expenditure on pesticide. This is due to the more pest and disease are likely to occur in high fertilizer consumption crops. The coefficient on value of seed was 0.32 and significant at 5 per cent indicating that one per cent increase in expenditure on seed will increase the expenditure on pesticide by 0.32 per cent. This might be due to using of costly seed which need seed inoculation or seed treatment. The value of main product per hectare turn out to be non significant.

From the above discussion it was concluded that for paddy crop expenditure on pesticide was dependent on the amount of fertilizer used followed by value of seed.

4.3.2.2 Factor affecting pesticide consumption of Bt Cotton .

A linear model was applied to considering the expenditure on pesticides as the dependent variable and area under cotton (ha), expenditure on seed (rs ha^{-1}), fertilizer (kg ha^{-1}), value of main product (rs ha^{-1}) were taken as independent variables. The independent

variable included in the model explained 48.0 per cent of the total variation in expenditure on pesticide. The F value was 24.01 and significant at one per cent.

From the table 4.44 it was reported that the coefficient of area under cotton crop was -112.65. It means area under Bt cotton has reverse effect on expenditure on pesticide. One unit increase in the area under Bt cotton will lead to decrease in expenditure by Rs112.65. This is because Bt cotton need less pesticide.. The coefficient of fertilizer consumption was5.95 and significant at one per cent level indicating that one unit increase in fertilizer consumption will increase the expenditure on pesticide by ` 5.95 ha^{-1}. However coefficient of seed and value of main product was non-significant.

From the above discussion it was observed that area under cotton crop was the most important determinant in expenditure on pesticide followed by NPK consumption.

4.3.2.3 Factor affecting pesticide consumption of maize .

Table 4.45 shows the result of linear regression of expenditure of pesticide on maize crop. The value of R^2 was 64 and F value was 16.57 and significant at one per cent level. Out of four variable consider, three are turn out to be significantly influencing the expenditure on pesticide.

From the table it was revealed that area under maize has positive relation with the expenditure with pesticide. This might be due to more weed problem in maize cultivation, so more expenditure on weedicide if the area under maize increase. The coefficient of value of seed was 0.38 , which means one unit increase in value of seed will increase the expenditure on pesticide by 0.38 per cent. The reason may be costly maize seed need more seed treatment. Similarly the coefficient of NPK was 3.47 which means NPK consumption enhances the expenditure on pesticide in maize cultivation.

From the above discussion it can be concluded that area under maize crop was the most important factor followed by NPK consumption for expenditure of pesticide. Value of main product was not the deciding factor for expenditure on pesticide.

4.4 Projection of fertilizer and pesticide

In this section, the future projection of fertilizer and pesticide consumption are discussed separately for fertilizer and pesticide at state level and district wise.

4.4.1 Projection of fertilizer in Andhra Pradesh

The fertilizer requirement forecast was shown in table 4.46 and figure 4.12, 4.13, 4.14 and 4.1, were generated by an estimated model using historical fertilizer consumption data. The total demand for fertilizer (NPK) is projected to about 5001.94 thousand tonnes by 2015-16, which increase to 7551.85 thousand tonnes and 10387.17 thousand tonnes in 2020-21 and 2024-25 respectively. The demand for nitrogen is expected to be 2647.63 thousand tonnes by 2015-16. And it is projected to reach about 3605.55 thousand tonnes

Table :4.46 Projected demand for N, P & K in Andhra Pradesh (000'tonnes)

Year of projection	N	P	K	NPK
2015-16	2647.63	1497.62	862.06	5001.94
2016-17	2856.83	1639.54	943.25	5432.78
2017-18	3085.58	1794.17	1030.21	5901.46
2018-19	3334.83	1962.1	1123.15	6409.71
2019-2020	3605.55	2143.9	1222.27	6959.26
2020-21	3898.69	2340.15	1327.79	7551.85
2021-22	4215.21	2551.44	1439.9	8189.2
2022-23	4556.06	2778.34	1558.81	8873.05
2023-24	4922.2	3021.43	1684.74	9605.13
2024-25	5314.59	3281.29	1817.89	10387.17

Table :4.47 Projected demand for NPK in Andhra Pradesh- district wise –next five years (tonnes)

Sl. No.	District	2015-16	2016-17	2017-18	2018-19	2019-2020
1	Srikakulam	73236.5	78012.31	83222.54	88889.33	95034.82
2	Vizianagaram	80015.7	88201.89	97198.98	107046.1	117782.3
3	Visakhapatnam	47141.92	50472.4	54179.15	58283.85	62808.14
4	East Godavari	207485.3	215599.3	224373.7	233849.1	244066.3
5	West Godavari	414562.8	449705.1	488263.9	530406	576297.9
6	Krishna	329833.7	356325.4	385576.6	417731.4	452934.1
7	Guntur	574879.4	638077.7	707221.9	782575	864399.6
8	Prakasam	202329.1	215646	230000	245439.3	262012.4
9	Nellore	283679.5	315922.9	351255.7	389818	431750
10	Kurnool	346128.8	372912.8	401536.8	432070.3	464583
11	Anantapur	173418.1	188284	204398.7	221819.7	240604.4
12	Cuddapah	150434.7	166330.7	183804.2	202931.2	223787.3
13	Chittoor	114450.8	124003.5	134443.6	145813.7	158156.6
14	Hyderabad/	95718.06	86544.2	75819.74	63470.34	49421.66

	Ranga Reddy					
15	Nizamabad	235754.1	255488.1	276738.2	299561.9	324017.1
16	Medak	164870	181518.5	199629.1	219266.6	240495.7
17	Mahbubnagar	217428.7	241197.6	267243.9	295673.1	326590.5
18	Nalgonda	358012.8	392101.7	429024.3	468903.2	511861.1
19	Warangal	232140.1	249777.9	269052.5	290046.2	312841.4
20	Khammam	216817.6	237089.2	259152.1	283087.7	308977.3
21	Karimnagar	281637.1	300335.2	320314.6	341629.8	364335.2
22	Adilabad	214891.4	238664.2	264415.8	292225.6	322173.3
23	Andhra Pradesh	5001937	5432768	5901447	6409696	6959259

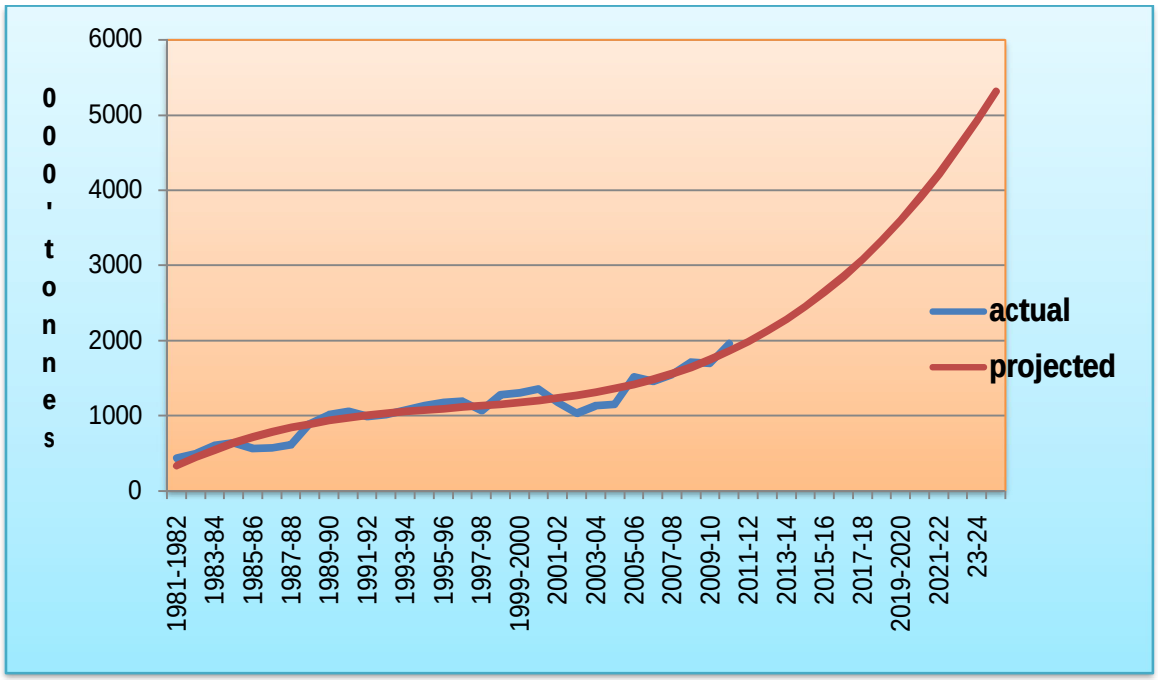

Figure 4.12 Nitrogen demand projection

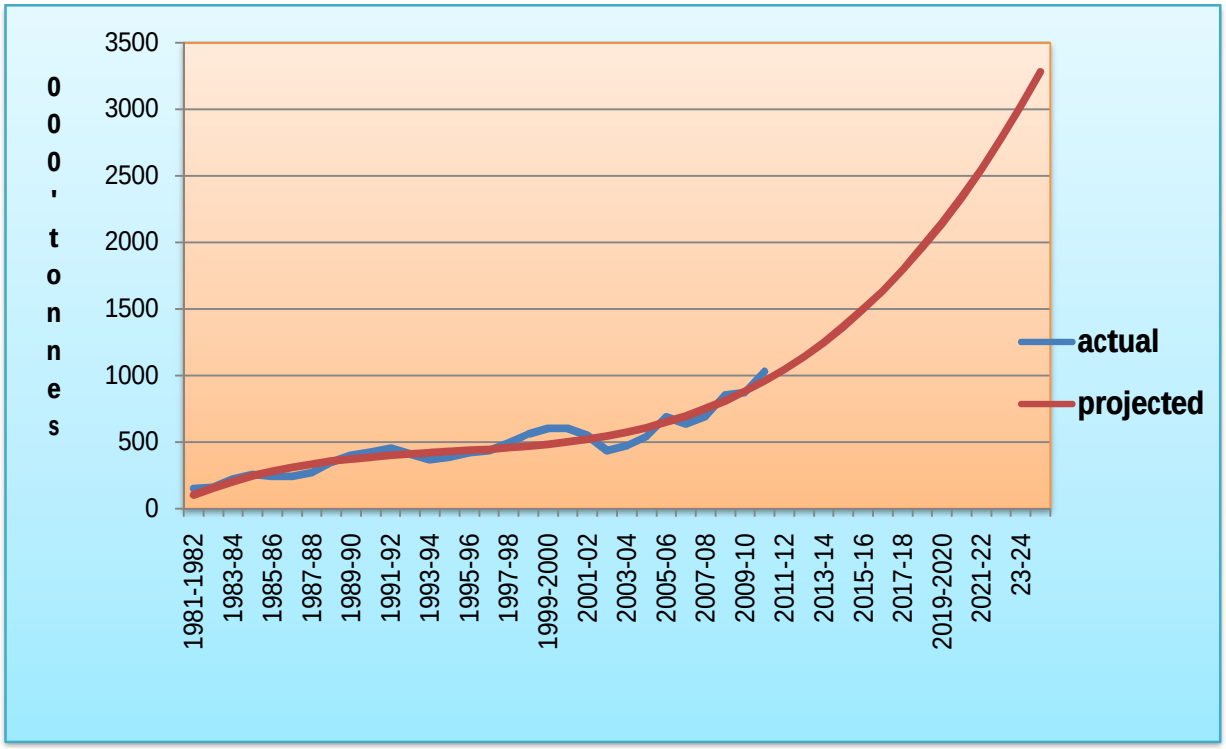

Figure 4.13 Phosphorous demand projection

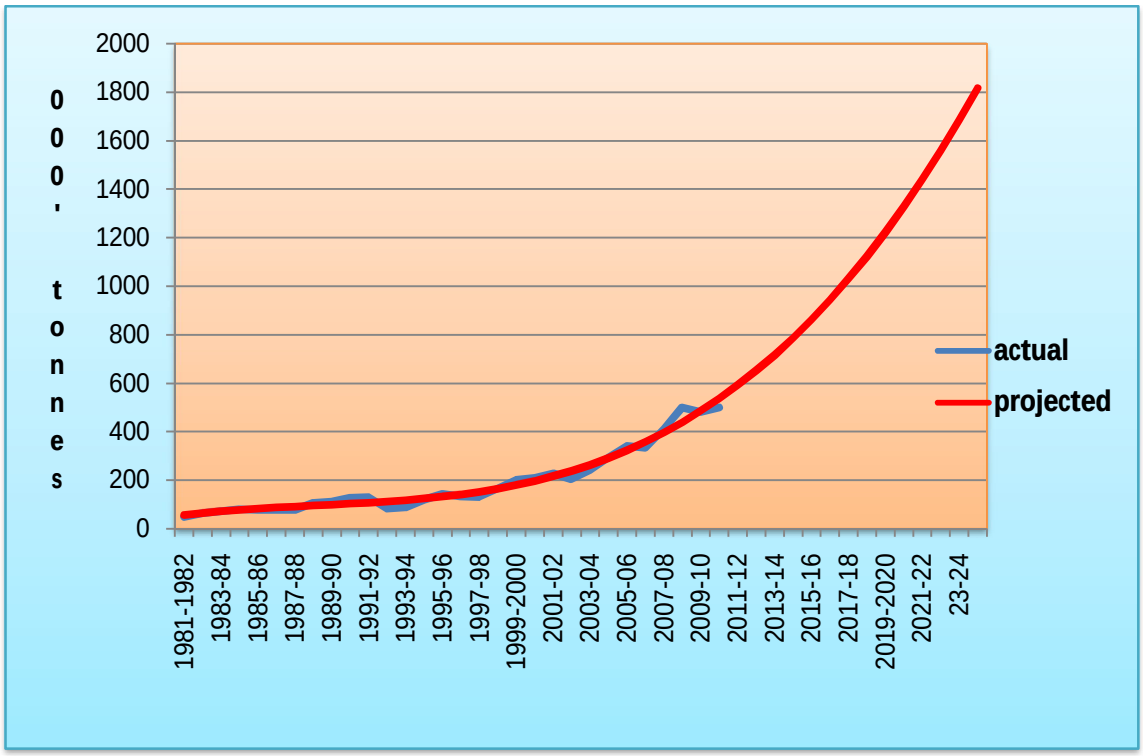

Figure 4.14: Potash demand projection

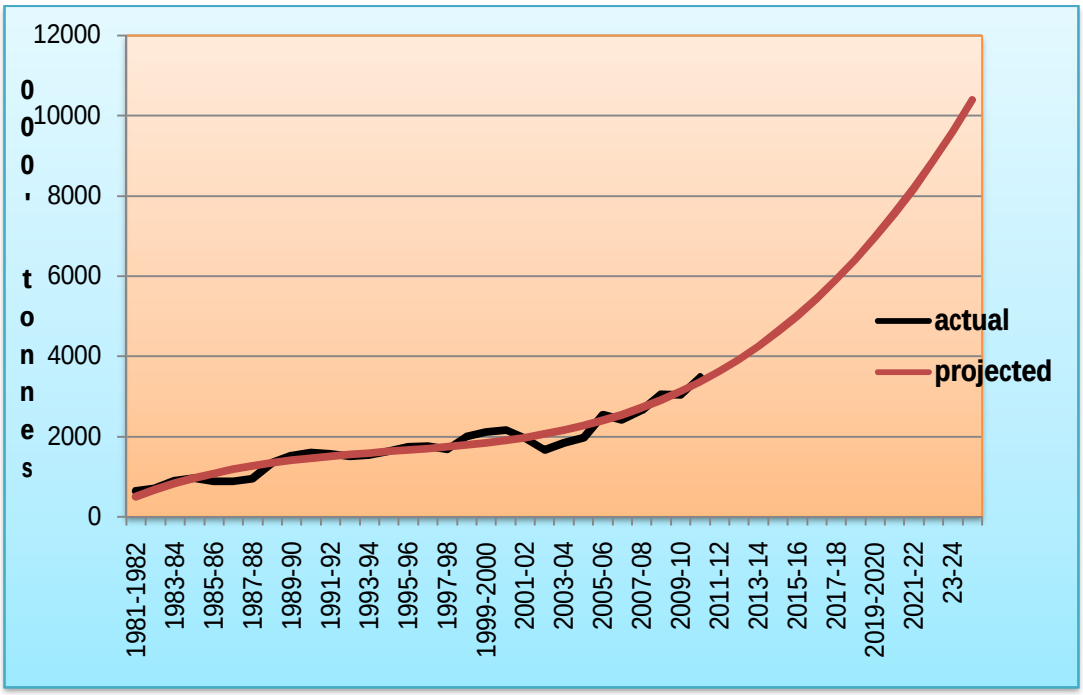

Figure 4.15: NPK demand projection

and 5314.59 thousand tonnes during 2020-21 and 2024-25, respectively. For phosphorous fertilizers, the demand is projected to be around 1497.62 thousand tonnes by 2015-16 and reach the level of 3281.29 thousand tonnes by 2024-25.

Similarly, the demand for Potash fertilizers would be 862.06 thousand tonnes by 2015-16 and 1817.89 thousand tonnes in 2024-25.

4.2.2 District wise fertilizer projection

The district wise projected demand for NPK is presented in Table 4.47. There will be a continuous increase in the demand for NPK fertilizer in almost all the districts except in Ranga Reddy district. The demand for NPK in the state may increase from 5001937 tonnes in 2015-16 to 6959259 tonnes by 2020-21.

The highest demand for NPK fertilizer in the district would be Guntur, which is projected to be 574879.40 tonnes in 2015-16 and 864399.6 tonnes in 2019-20. The second highest NPK demand would be West Godavari (414562.8 tonnes) followed by Nalgonda (358012.8 tonnes) and Kurnool (346128.8 tonnes) during 2015-16. Lowest demand for NPK during 2015-16 would be Vishakapatnam (47141.92 tonnes) followed by Srikakulam (73236.5 tonnes), Vizianagaram (80015.70 tonnes) and Ranga Reddy (95718.06 tonnes)

districts. Similar trend is observe in 2019-20. The lowest NPK demand is expected to be Ranga Reddy district (49421.66 tonnes) followed by Visakhapatnam (62808.14 tonnes).

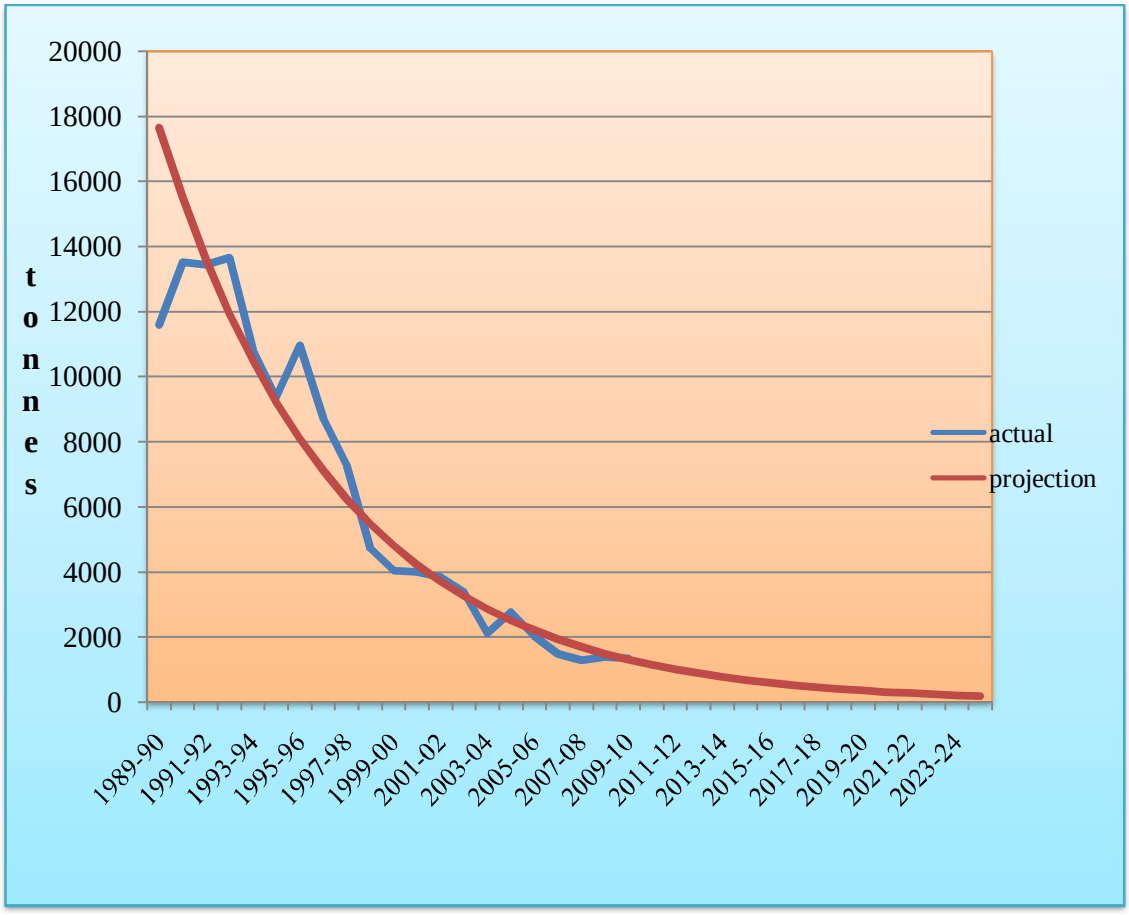

Figure 4.16: Pesticides demand projection

4.4.3 Pesticide projection

Table 4.47 Projection of pesticide.(Tonnes) technical grade.

year	projected
2015-16	600.84
2016-17	527.59
2017-18	463.28
2018-19	406.80
2019-20	357.21
2020-21	313.67
2021-22	275.43
2022-23	241.85
2023-24	212.37
2024-25	186.48

The future projection of pesticide (technical grade) was presented in table 4.47 and figure 4.16. From the present study, it was expected that by the year 2020-21, the pesticide consumption for Andhra Pradesh would be decrease to313.67 tonnes. And it might further decrease to 186.48 tonnes in 2024. The decreasing trend of pesticide might be due to due of more affective pesticide which required less doses, adoption of IPM and increasing organic farming.

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