STUDY OF NUTRIENT STATUS OF COTTON GROWING AREAS OF PRAKASAM DISTRICT

By
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THESIS SUBMITTED TO THE
ANDHRA PRADESH AGRICULTURAL UNIVERSITY
IN PART FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

MASTER OF SCIENCE IN AGRICULTURE

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
AGRICULTURAL COLLEGE
B A P A T L A
1 9 9 2

CERTIFICATE

Sri. **D. Ramesh Kumar** has satisfactorily prosecuted the course of research and that the thesis entitled **"Study of nutrient status of cotton growing areas of Prakasam district"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part there of has not been previously submitted by him for a degree of any University.

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CERTIFICATE

This is to certify that the thesis entitled "**Study of nutrient status of cotton growing areas of Prakasam district**" submitted in partial fulfilment of the requirements for the award of the degree of Master of Science in Agriculture of Andhra Pradesh Agricultural University, Hyderabad, is a record of the bonafide research work carried out by Sri. **D. Ramesh kumar** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

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

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Chairman of the Advisory Committee

Thesis approved by the Student's Advisory Committee.

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ACKNOWLEDGEMENT

I express my deep sense of gratitude to my major advisor Dr. V. **Bhanuprasad**, Associate Professor, Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla for suggesting the present research problem and for his inspiring guidance, constant encouragement during the course of investigation and valuable suggestion during the preparation of the thesis.

I express my fidelity to **K.Veeraiah**, Assistant Professor, Department of Soil Science and Agricultural Chemistry and Dr. **K. Rama Rao**, Associate Professor, Department of Agronomy, for their helpful suggestions, as members of the Advisory Committee.

I express my sincere thanks to Dr. **R.N. Pillai**, Professor and Head, Department of Soil Sciencce and Agricultural Chemistry, Dr. **G.V. Subbaiah**, Soil Scientist, Saline water scheme, Bapatla, **A.V. Reddy**, Dr. **G.V. Lakshmi**, Dr. B. **Seshaiah**, Sri. **P.V. Narasimha Rao**, Sri. **T. Mahendranadh** and Sri. **K. Hariprasada Rao** of the Department of Soil Science and Agricultural Chemistry for their encouraging cooperation during the course of investigation.

'I gratefully acknowledge the helpl rceived from Sri R. **Srinivasulu**, Assistant Professor, Department of Statistics and Mathematics.

My heartful thanks are due to my friends and well-wishers for their help during the course of my study Diction is not enough to express my sincere regards and heartful gratitude to my venerable parents, beloved sisters without whose encouragement and invaluable moral support the thesis would have not seen the light of the day.

I am thankful to APAU for providing financial assistance during the course of my postgraduation.

Last but by no means least my thanks go to NICE, Bapatla for the neat typing of the manuscript.

D. Ramesh Kumar

Date : 1.9.1992 (D. Ramesh Kumar)

DECLARATION

I, D. **Ramesh kumar**, hereby declare that the thesis entitled **"Study of nutrient status of cotton growing areas of Prakasam district"** submitted to Andhra Pradesh Agricultural University, for the degree of Master of Science in Agriculture is the result of original research work done by me. I also declare that any material contained in the thesis has not been published earlier.

D. Ramesh Kumar

Date : 1.9.1992

(D. Ramesh Kumar)

ABSTRACT

Title	:	"STUDY OF NUTRIENT STATUS OF COTTON GROWING AREAS OF PRAKASAM DISTRICT"
Author	:	**D. RAMESH KUMAR**
Major Advisor	:	Dr. V. **BHANU PRASAD**
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Discipline	:	SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
Degree to which thesis submitted	:	M.Sc (Ag.)
University	:	ANDHRA PRADESH AGRICULTURAL UNIVERSITY
Year of submission	:	1 9 9 2

An investigation was undertaken to study the available nutrient status of cotton growing soils of Prakasam district. Soil samples were collected from four mandals of the district representing major cotton growing area. These soils were found to be neutral in reaction, non saline, medium in available nitrogen, low in available phosphorus and high in available Potassium. These soils were calcareous with high cation exchange capacity. The most dominant exchangeable cation was calcium followed by magnesium, sodium and potassium.

All the soil samples contained micronutrients above the critical limits. The major nutrients such as N and K and secondary nutrients such as Ca and Mg had shown positive and significant correlation with one another and with soil characteristics, while phosphorus had shown negative and significant correlation with calcium carbonate and p^H.

Available zinc, iron, copper, and manganese contents of the soils exhibited a significant but negative correlation with calcium carbonate, cation exchange capacity and clay content. Available manganese, zinc and iron showed a significant negative correlation with p^H while copper showed significant positive correlation. Except manganese the remaining three micronutrients such as iron, copper, zinc showed significant positive correlation with organic carbon.

The results of the leaf samples analysis indicated that the index leaf contained optimum level of nitrogen, below optimum level of phosphorus, and above optimum level of potassium, calcium and magnesium. All the micronutrients were at sufficiency level.

All the major and secondary nutrients except phosphorus and magnesium had positive and significant correlation with one another and with soil characteristics, while phosphorus was negatively and significantly correlated with calcium carbonate and p^H whereas magnesium was negatively and significantly correlated with calcium carbonate.

The available iron, copper, zinc and manganese contents were negatively and significantly correlated with CEC, clay and $CaCO_3$ while available manganese, zinc and iron were negatively and significantly correlated with p^H in addition to above characteristics whereas the copper was positively and significantly correlated with pH. All the four cationic micronutrients were positively and significantly correlated with one another and also with major nutrients.

INTRODUCTION

INTRODUCTION

Food and clothing are the primary requirements to the man kind. Cotton is the foremost among the fibre crops of the world. Cotton textile industry is the oldest Agricultural Industry of India. Cotton is the world's most important commercial crop and despite increasing, production of artificial fibre it still retains its importance. This is due to the increase in world population, with rising standards of living and to the fact that there are many uses for which cotton cannot as yet be replaced by synthetics. Cotton has got certain characteristics which no synthetics combine to the same degree (washability, durability, strength, both when wet and dry good vapour transfer, chemical stability softness and elasticity etc. The seed contains oil which is used in soap industry and the oil cake is also used as feed for live stock.

Population standard of living and consumption ever increasing. The production of cotton fibre (lint) has been also increasing continuously, compared to 2.3 m bales in 1947-48 it increased to 13.59 m bales in 1989-90 and further increased to 11.5 m bales (170 kg each) in 1990-91 to meet the textile industry demands. The target of cotton fibre (lint) for 2001 AD will be projected at over 18 m bales (Suman et al, 1991).

Cotton is grown as a leading commercial fibre crop around the world. In India, it is grown in over 7.6 m ha with an annual production of 0.2 million tonnes (kapas) and 91 thousand tonnes lint. It occupies second place among the commercial crops grown in Andhra Pradesh. It ranks first among the commercial crops and grown over an area of 71,757 ha. In general, the cotton growing soils of Prakasam district are low in nutrient status causing nutrient deficiencies ultimately resulting in decreased yields. The present study is being taken up in four mandals of Prakasam district viz., Karamchedu, Parchur, Inkollu and Naguluppalapadu mandals of Prakasam district, where cotton is extensively grown with are aim to assess the nutrient status of soil and to find out the relationship between nutrient status of soil and yield of cotton kapas with the following objectives.

1. To study the nutrient status of cotton growing soils of Prakasam district.

2. To delineate the nutrient deficiency areas.

3. To correlate nutrients content in soils and content in index leaf at 65-75 DAS with seed cotton yield.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

MAJOR NUTRIENTS

Khare et al (1970) studied the uptake of N and its distribution in cotton plant in relation to yield of seed cotton. More than 90% of N was absorbed by the plant till the flower initiation stage. Its content was much higher in leaves up to the flower initiation stage and decreased considerably with age. The form of N applied did not make any difference in its content in the plant.

Shanmuga Sundaram and Sankaran (1978) conducted a field experiment to study the uptake pattern and response of CBS-156 hybrid cotton under different levels of nitrogen and reported that the uptake of N and K was higher under 80 and 120 Kg N/ha than control and 40 Kg N/ha at all stages (40, 80, 120 DAS).

A field experiment was conducted by Honora et al (1979) to study the effect of N, P and K application on drymatter yield, nutrient concentration and uptake at different stages of cotton (MCU-8). Drymatter yield significantly increased with the age of the crop,production was recorded at final picking stage. The nutrient concentration was maximum in seedling stage and decreased thereafter.

A soil test crop response field experiment was conducted by Raniperumal et al (1984) at Tamilnadu Agricultural

University farm, Coimbatore on Typic Ustiverts with cotton MCU-9 as a test crop. Four levels of N (0, 60, 120, 180 Kg/ha) 3 levels of P and K_2O (0, 17, 34 Kg/ha) and 3 levels of FYM (0, 6, 12 t/ha) were tried. The result indicated that N fertilization and FYM incorporation significantly influenced the yield where as P and K additions did not show any influence on yield.

Jambunathan et al (1986) carried out a study on the fertilizer needs of hybrid-4 cotton for three years (1979-80, 80-81 and 81-82). The results revealed that there was a significant improvement on yield of seed cotton and fibre bundle strength with increasing doses of nitrogen during 1979-80. Application of K and P did not contribute to any improvement in fibre quality for all the three seasons.

Nagwekar et al (1987) conducted an experiment to find out the optimum combination of N and spacing in relation to the varieties. 80 Kg N/ha enhanced the yield of cotton in all the three varieties of *G. hirsutum* tried, except for some marginal variations. Different N levels and plant population did not produce any significant effect on the quality of the fibre.

Shrivastava and Singh (1988) studied the growth, yield attributing and economic characters of cotton under irrigated field conditions with different levels of N and Zn at the JNKVV regional Agricultural research station Morena (MP) and report that the seed cotton yield increased linearly due to N and Zinc up to 80 Kg N and 50 Kg $ZnSo_4$/ha respectively. Neither N nor Zinc significantly affected ginning percentage, lint index and the staple length.

Jeyaraman (1988) studied the effect of application of 40 Kg N/ha by different methods on the yields of cotton grown in rainy season (Sept-Feb) of 1983-85. The crops given 50% N at sowing and the remaining N in a single or, two split dressings gave yields of 1.80 and 1.84 t/ha, respectively in 1983-84 and 1.04 and 1.33 t/ha in 1984-85 respectively compared to 1.66 and 0.92 t/ha for the same years with the full N rate applied at sowing. In 1984-85 the treatments gave yields of 1.04, 1.33 and 0.92 tonnes respectively. In crop given 50% at sowing broad cost or foliar application of the remaining N in 1-2 split dressing was less effective.

Bhole and Varade (1988) made a study to determine the optimum levels of N, P and K for SRT-1 cotton in four types of soils with different fertilizer treatments and results indicated that 140 Kg N and 50 Kg P_2O_5/ha gave highest net returns on low to medium fertility soils. Low levels of fertilizers (60 Kg N and 20 Kg P_2O_5/ha) should be recommended for high fertility soils. Potassium had no significant effect on any of the soils.

Studies were conducted at cotton and millets experiment station Kovilpatti during rabi 1983 and 1984 by Chellamuthu (1989) to study the effect of spacing (45 X 30 cm and 60 X 30 cm) and fertilizer levels (N_0P_0, N_{20}, P_{20}, N_{40}, P_{20} and N_{60}, P_{20} Kg/ha) on flowering and earliness in four hirsutum cotton varieties. The results revealed that there was no significant difference between the varieties studied. The earliness of cotton was significantly influenced by both spacing and fertilizer levels. Days taken for first flowering and 50% flowering were also influenced by fertilizer levels. In respect of Bartletts index N_{40} P_{20} Kg/ha was found optimum considering the kapas yield.

Raghu Vamsi et al (1989) conducted a field experiment during Kharif (1985) and (1986) to study the N and P requirements of cotton grown in sodic black clay soil. Results indicated that the application of 125 Kg N and 80 Kg P_2O_5/ha was the optimum dose to get higher seed cotton yield.

Tomar et al (1989) reported that the application of 72 Kg N + 36 Kg P_2O_5/ha at sowing and 8 Kg N + 4 Kg P_2O_5/ha in two foliar sprays at the boll formation and development stages at 90 and 105 DAS respectively gave average seed cotton yield of 1.18 t/ha compared with 1.09 t/ha with the full N, P recommended dose at sowing and 0.75 t/ha without N and P.

Based on results of permanent manurial trails Basu (1992) stated that use of bulky organic manures along with fertilizers improve both soil and crop productivity. Seed cotton yield was increased substantially at Nagpur when half of the nitrogen was supplemented with FYM. Application of 12-18 tonnes of FYM and green manure per hectare increased the yield of cotton by 16-20 per cent at Coimbatore. Under rainfed situation, less fluctuation was cotton yield was observed with use of FYM. At Nagpur 40 kg P_2O_5 has been found to improve yield of cotton.

Mannikar and Pundarikakshudu (1990) stated that response of cotton to phosphorus and potassium had not been consistent. Little response to phosphorus was observed in cotton except in regions where available phosphorus in soil was deficient.

PHOSPHORUS

Kothandaraman and Krishnamurthy (1978) collected thirty eight soil samples from nine profiles representing the major soil groups viz., red, black, laterite, and alluvial soils and examined for organic P content. The organic P content of the soils ranged from 26 to 467 ppm and its percentage to total P varied was from 9.11 to 56.81. Highest organic P was recorded in the high level laterite soils. Organic P was rich in the surface layers and it was found to decrease with depth in most of the profiles.

Available P and K status in a soil after six crops was assessed by Mathan et al (1979) in the long term fertilizer experiments conducted at Coimbatore. The availability of P was changed by various fertilizer doses. There was depletion of available P in control plots. As the rate of P application increased the availability also increased. The available K was depleted over years except in 150% N, P, K dose (based on soil test) treatments and FYM applied plots.

Response of irrigated cotton to levels and sources of phosphorus was tested by Rama Krishna Reddy et al (1983) on medium black soils of Nandyal for two years. The results indicated that the application of phosphorus at 30 Kg P_2O_5/ha gave higher yields compared with control.

Application of 15 and 30 kg P_2O_5 /ha gave average seed cotton yields of 2.13 and 2.15 t/ha respectively compared with 1.90 t/ha without P application (Sharma et al 1988).

Mali et al (1987) stated that in field grown crop of cotton, phosphorus content of the entire portion of the plant above ground significantly increased when N_{50}, P_{25} and K_{25} combination of fertilizers were given. Phosphorus content increased with age up to 90 days irrespective of the genotype differences and remained more or less constant up to 110 days after sowing and showed a steady decline thereafter. The cultivars under study differed significantly in their P content. The highest yield of 23.42 Q/ha was recorded in cultivar NHH-44 followed by PA-32 (23.32 Q/ha). The P content in plant samples of different stages of growth from 70 to 150 days after sowing was significantly correlated with the yield of seed cotton.

Lakshmi et al (1987) stated that the equilibrium phosphate potential (EPP) values were higher in black soils (8.0 to 9.1) than in the alluvial (7.7 to 8.4) and the red soils (7.2 to 7.3). Relationships of EPP were highly significant and positive with p^H (r = 0.766) $CaCo_3$ (r = 0.802) and exchangeable Ca (r = 0.76) where as they were negative with oxides of alluminium and manganese. Buffer capacity tended to increase with clay content. Clay showed significantly positive relationship (r = 0.929) with buffer capacity when red soils were excluded from computation. Buffer capacity per unit clay was more in red soils than in black and alluvial soils.

A laboratory study was undertaken by Lalithakumari et al (1989) with 10 alluvial black soils ranging from low to high in available P status. Significant and positive correlation was observed between per cent yield response and total uptake of P in Bajra crop raised in these soils.

POTASSIUM

Gopichand et al (1988) collected eight surface (0-15cm) soil samples from cultivated fields representing the important soil groups of A.P and analysed for physico-chemical characteristics. The results indicated the total values of K were greater in coastal sand, red earth, red and alluvial soils while lower values were observed in black and laterite soils.

A green house experiment was conducted by Dhanwinder Singh et al (1991) with nineteen coarse textured soils having sand to loamy sand texture to assess the response of cotton (LH-900) to K application and reported that the NH_4OAC extractable K of these soils varied from 14.3 to 237.5 ppm. Ca and Mg contents in the leaves of cotton plant were not effected with K application. K/Ca and K/Mg ratios in cotton leaves helped in differentiating the K responsive soils from K non-responsive soils.

SECONDARY NUTRIENTS

Loganatham and Krishna Moorthy (1977) studied the depth of distribution of different forms of calcium, in eight soil profiles representing eight established soil series in Tamilnadu at the rate of two series under each of black, red, alluvial and laterite soil groups. The content of different forms of calcium such as total, exchangeable, water soluble and free calcium carbonate were estimated. Total calcium varied with the type of soil and it was in the order black > alluvial > red > laterite soils. In general it was highest in black soil and least in laterite soil. Free calcium carbonate was found to be present only in black, red and alluvial soil and was influenced by the soil topography.

Loganatham and Krishna Moorthy(1979) collected forty soil samples from all over South India comprising black, red, alluvial and laterite soils and analysed for total, exchangeable, water soluble and carbonate forms of Ca, Mg, K and Na. Simple correlation were worked out between different forms of Ca and other cations like Mg, K and Na. The study of interrelationships showed very high degree of association among them.

Mali and Malewar (1991) reported that application of N, P and K fertilizers resulted in a significant increase in the concentration of Ca and Mg in cotton plants at all the growth stages. The concentration of both the nutrients increased with increase in the age of plant up to 90 days and declined at subsequent stages.

MICRONUTRIENTS

Baser and Saxena (1970) found that water soluble and exchangeable manganese of Rajasthan soils were usually very low in all the soils irrespective of the soil type. Reducible manganese on an average ranged from 16.4 ppm in the desert soil of Nagore district to 394.4 ppm in the medium black soils of Jhalawar district. Desert soils, undifferentiated alluvial soils and gray brown soils of the state were deficient in manganese. The exchangeable and reducible manganese decreased with increase in p^H of the sandy loam and sandy clay loam soils with increase in organic matter level of the soils. Exchangeable manganese first decreased and then increased slightly while reducible manganese increased steadily. As the texture of the soil changed from sandy to clay the average values of exchangeable manganese decreased while those of reducible manganese increased.

Rai et al (1970) determined available iron, manganese, copper, zinc, molybdenum and boron status in deep black soils of Madhya Pradesh. These soils were sufficient in manganese and molybdenum, slightly deficient in boron and copper and moderately deficient in iron & zinc in view of percentage of samples falling in deficient range.

A significant and positive correlation was observed between available iron and organic carbon. Ammonium acetate extractable manganese showed a negative relationship with pH and positive with organic carbon while active manganese was negatively correlated only with organic carbon. Available copper and zinc were not related significantly with pH, organic carbon or calcium carbonate. Available molybdenum was found to be positively correlated with pH and calcium carbonate, and available boron with pH and organic carbon.

Seventy surface soil samples from 34 villages in Bhandara district of Maharastra were analysed by Badhe et al (1971) for available copper and manganese content. The status of available copper in these soils appeared to be marginal while that of manganese was adequate. A significant negative correlation was observed between p^H and available copper and manganese while a significant positive correlation was noticed between organic carbon and available copper.

In a pot culture experiment, response of sorghum (Jowar CSH-1) to the application of iron in shallow black soils of Madhya Pradesh was observed by Rai et al (1971). Availability of iron was low in these soils even after application of iron. No relationship was observed between plant and available and exchangeable iron with different reagents.

Rai *et al* (1972) determined available iron, manganese, zinc, molybdenum, copper and boron in shallow black soils of Madhya Pradesh and reported that these soils contained sufficient amount of manganese, molybdenum, copper and boron, but some soils were deficient in iron and zinc.

Soil p^H was found to be significantly and negatively correlated with exchangeable manganese available zinc and iron and positively related to active manganese and boron. Organic carbon had shown significant positive relationship with exchangeable manganese, available zinc, molybdenum, copper and boron. Calcium carbonate was significantly and negatively correlated with exchangeable manganese and available iron and positively related to active manganese and available boron.

Twenty four soil samples from 4 black and 2 red soil profiles from Mirzapur district under irrigated and unirrigated conditions were collected by Agarwal *et al* (1972) and analysed for different forms of Manganese. They contained 360-1180 ppm total, 74.5-193.4 ppm active, 60.0-178.0 ppm easily reducible, 7.5-23.8 ppm available, 5.8-21.0 ppm exchangeable and 1.3-3.6 ppm water soluble manganese. Black soils contained more total manganese than red soils. Both total and active manganese generally decreased with depth. Exchangeable manganese was found to be associated with clay content, ($r = 0.41$) and calcium carbonate ($r = 0.55$). Red soils contained more water soluble manganese than black soils which decreased with depth and clay (r = -0.65) but increased with organic carbon (r = 0.70).

Vittal and Sangwar (1974) analysed soil samples from six soil profiles of Nainital tarai for total and dithizone extractable (available) zinc, soil pH, organic carbon, soil texture and calcium carbonate. Total Zinc was found to be increasing with depth and it was attributed to the downward movement of zinc over a long period of time. Dithizone extractable zinc was found to be related to drainage conditions and decreased with depth in all the six soil profiles.

A preliminary survey of Nagarjuna Sagar Project right canal area was conducted by Shaik Abdul Karim and Rahiman (1975). The available Mn content of 48 surface soils representing red & black soil of NSP area of Guntur district has been determined.

The available manganese as estimated by 3N $NH_4H_2PO_4$ was far above the critical limit in both the soil types except in three of the forty eight samples. The available manganese recorded a significant negative correlation (-0.4215) with soil pH and significant positive relation (N = 0.6199) with the organic matter.

The soils of Assam in general were found to be rich in total copper (347 to 775 ppm) and the surface soils contained higher amount of copper. The content of available copper varied from 0.87 to 2.50 ppm which amounted to 0.13 to 0.70% of the total content (Chakraborty et al 1979).

A field experiment was conducted by Ramanathan and Nagarajan (1980) on Zinc deficient (0.2 ppm normal neutral ammonium acetate dithizone extractable zinc) redloam soil of Agricultural Research Station, Bhavanagar, to determine the response of CBS-156 cotton to application of Zinc at different levels (0,15,30,45,60,75 & 90 kg $ZnSo_4$/ha) zinc application resulted in significant increase in yield of cotton kapas. Application of zinc at 75 kg $ZnSO_4$ /ha registered 27% increase in kapas yield over control.

Rajendra Prasad (1981) collected profile samples from five villages in Guntur region (A.P), where tobacco, cotton, turmeric, and chillies were grown and analysed for total and available forms of Copper. Total Copper ranged between 17.50 and 89.00 ppm and available copper from 1.2 to 2.4 ppm. There was an irregular distribution of total copper in all soil profiles available copper was maximum in the top layers of all the soil profiles.

Sharma and Gupta (1989) conducted a field experiment during 1982 & 1983 to evaluate the effect of Zinc on seed cotton yield at farmers' field in Hissar district. The results revealed that Zinc application at all levels increased the seed cotton yield significantly during both the years the response varied from 3.2 to 3.9 Q/ha with the application of 25 and 50 kg $ZnSO_4$/ha.

Sathyanarayana and Ramamurthy (1989) reported that the iron uptake by sorghum plant was more when compared with other micronutrients and followed by manganese and copper. The uptake of zinc was intermediate between manganese and copper.

Takkar et al (1989) studied 154 soil samples for micronutrient status in Prakasam district of which 70 per cent of the samples showed deficiency with respect to Zn (mean 0.691) and no deficiency was observed in case of Cu (with mean 4.1 ppm), Mn (mean 24 ppm) and Fe (mean 45 ppm).

CORRELATION STUDIES

Raychaudhary and Landey (1960) reported that in alluvial saline soils (Punjab) and alluvial sandy soils (Rajasthan) the availability of phosphorus increased with decreasing pH. In case of alluvial loamy (U.P), red (Mysore) and laterite (Kerala) soils the availability of phosphorus decreased with decreasing pH. They also reported that potassium generally decreased with decreasing pH in case of alluvial sandy soils (Rajasthan) and laterite soils (Kerala) while in other cases the availability was maximum at a definite pH value.

Sharma and Shinde (1968) observed significant positive correlation between available manganese and organic carbon in the black soils of Indore. The same was reported by Patel et al (1972) for South Gujarat soils.

Sharma and Motiramani (1969), Mishra et al (1976), Chakraborthy et al (1981) and Singh (1990) observed that the available Zinc was negatively correlated with pH and positively correlated with organic carbon. According to Yashodha Pradan and Kanwar (1987) available Zinc showed inverse relationship with soil pH, but no significant correlation was found with organic carbon.

Tripathi et al (1969) reported that the soil pH, $CaCO_3$ and organic matter did not have any significant relationship with available Zinc in soils of Maharastra.

Mahapatra and Kibe (1972) stated that available Manganese was negatively correlated with pH and CEC in the soils of Maharastra. The same trend was observed by Patel et al (1972) for south Gujarat soils.

Joshi et al (1973) and Thakur et al (1976) reported that the values of correlation coefficient indicated that the relationship between available nitrogen and organic carbon was positive and highly significant. The same was also reported by Dubey et al (1972) for black soils of Madhya Pradesh, Sud and Sharma (1982) for brown hill soils in Simla district of Himachal Pradesh and Verma et al (1980) for alluvial soils of Faizabad, Karai soils of Azamgarh and Tarai soils of Gonda.

Rajendra Prasad (1981) reported that the total Copper showed a negative correlation with organic carbon and no correlation with pH, Calcium carbonate and clay fraction of black soils.

Saha et al (1982) reported that Fe, Cu had significant positive correlation with pH whereas Zn did not show any significant relation with pH while iron was positively correlated with organic carbon whereas manganese was negatively correlated with organic carbon.

According to Sakal et al (1985) the available copper showed a negative and significant correlation with p^H and free $CaCO_3$ where as the other available micronutrients such as Fe, Mn and Zn did not show any relationship.

Kuladeep Singh (1987) reported that in soils of Yamuna river plain of Eastern Haryana the available zinc and iron were positively correlated with organic carbon where as available copper correlated positively with pH and organic carbon.

Singh et al (1987) reported that pH and organic carbon did not show any relationship with available zinc.

Sakal et al (1988) observed that Zn, Cu, Fe and Mn had shown significant negative correlation with pH and positive correlation with organic carbon.

Madhavi (1989) stated that available Zn, Fe, Cu and Mn exhibited a significant negative correlation with $CaCO_3$, CEC and clay content. The available Mn and Cu showed significant positive correlation with pH and organic carbon.

According to Room Singh and Omaniwar (1987) the olsen's phosphorus had shown negative association with soil pH.

Tiwari and Mishra (1990) reported that available Zn and Mn were negatively correlated with soil pH and positively correlated with organic carbon, whereas copper and iron were found to be positively correlated with pH and organic carbon.

Kanthaliya and Bhatt (1991) reported that the available 'N' was positively correlated with organic carbon while the relationship of organic carbon with available phosphorus was not significant. An increase in availability of potassium was observed with increase in organic carbon content of soils.

SOIL TESTING RATES

Muhr et al (1965) suggested the following ratings for various nutrients in soils to categoriese into low medium and high classes.

	Nutrient	Low	Medium	High
1.	Organic carbon percent (as a measure of available nitrogen)	<0.5	0.5 - 0.75	>0.75
2.	Available P_2O_5 kg ha^{-1}	<22.4	22.4 - 56	>56
3.	Available K_2O kg ha^{-1}	<168	168 - 336	>336

Ramamurthy and Bajaj (1969) used the following ratings for various nutrients to categorise the soils into low, medium and high classes.

	Nutrient	Low	Medium	High
1.	Organic carbon percent (as a measure of available nitrogen)	<0.5	0.5 - 0.75	>0.75
2.	Available nitrogen kg ha^{-1}	<280	280 - 560	>560
3.	Available P_2O_5 kg ha^{-1}	<10	10 - 24.6	>24.6
4	Available K_2O kg ha^{-1}	<108	108 - 280	>280

Critical limits for micronutrients in the soils of Andhra Pradesh (ICAR, 1988-89).

Nutrient	Black soil	Red soil
Cu	0.2 ppm	0.2 ppm
Fe	4.0 ppm	4.0 ppm
Mn	2.0 ppm	2.0 ppm
Zn	0.7 ppm	0.6 ppm

The rates adopted for soil reaction (P^H) total soluble salts content (EC), available phosphorus and available potassium in the soil testing laboratories of Andhra Pradesh to group soils in to various categories are furnished below (Department of Agriculture, 1985).

Soil reaction P^H (1:2.5soil water suspension).

	Class	Light soils	Heavy soils
1.	Acidic	<6.0	<6.0
2.	Neutral	6.1 to 7.5	6.1 to 7.5
3.	Weakly alkaline	7.6 to 8.0	7.6 to 8.5
4.	Tending to become alkali	8.1 to 8.5	8.6 to 9.0
5.	Alkali	>8.5	>9.0

Total soluble salts content (EC dS m^{-1} 1:2.5 soil water extract).

	Class	Sandy	Loamy	Clayey
1.	Normal	<1.0	<1.5	<2.0
2.	Critical for germination	1.1 to 2.0	1.6to 3.0	2.1 to 4.0
3.	Critical for growth of salt sensitive crops	2.1 to 3.0	3.1to 4.5	4.1 to 6.0
4.	Injurious to most crops	>3.0	>4.5	>6.0

Computing nutrient index

The formula suggested by Parkar *et al* (1951) for computing the soil nutrient index is followed. Nutrient index is calculated by giving weightage to the number of soil samples falling under low medium and high fertility classes.

$$\text{Nutrient index} = \frac{\text{No.of samples falling under low category } X_1 + \text{No.of samples falling under medium category } X_2 + \text{No.of samples falling under high category } X_3}{\text{Total number of samples analysed for nutrients in any given area}}$$

Nutrient index can also be computed by giving weightage to the percentage of samples falling under low, medium and high fertility classes.

$$\text{Nutrient index} = \frac{\text{\% of samples falling under low category } X_1 + \text{\% of samples falling under medium category } X_2 + \text{\% of samples falling under high category } X_3}{100}$$

Plant testing rates

The critical limits for major nutrients as proposed by Subbarao (1975).

N	4.30 - 5.50%
P	0.31 - 0.45%
K	0.50 - 1.25%
Ca	1.25 - 2.25%
Mg	0.15 - 0.30%

Sufficient ranges for micronutrients as proposed by Venkateswarlu (1975).

Mn	30 - 200 ppm
Fe	40 - 500 ppm
Zn	20 - 40 ppm
Cu	11 - 17 ppm

MATERIALS AND METHODS

MATERIALS AND METHODS

The details pertaining to the methodology adopted and the materials used in the investigation "On study of nutrient status of cotton growing areas of Prakasam district" are presented in this chapter.

3.1 COLLECTION OF SOIL SAMPLES

Following the random sampling techniques representative soil samples from 0-30 cm depth were collected from cotton growing areas of Prakasam district in Andhra Pradesh during rabi 1991. A total of 100 soil and cotton leaf samples covering the part of the cotton growing area of the district were collected at 65 to 75 DAS for analysis and also the seed cotton yields from the same fields after harvest were collected. The details of the soil and cotton leaf samples given in table 1 and the yield data given in appendix-I.

3.1.1 Preparation of soil samples

Soil samples collected were air dried in shade and ground with a wooden hammer and passed through a 2 mm sieve.

The leaf samples were dried in a oven at 60^{o}C for 24 hrs. and ground on agate mortar and pestle.

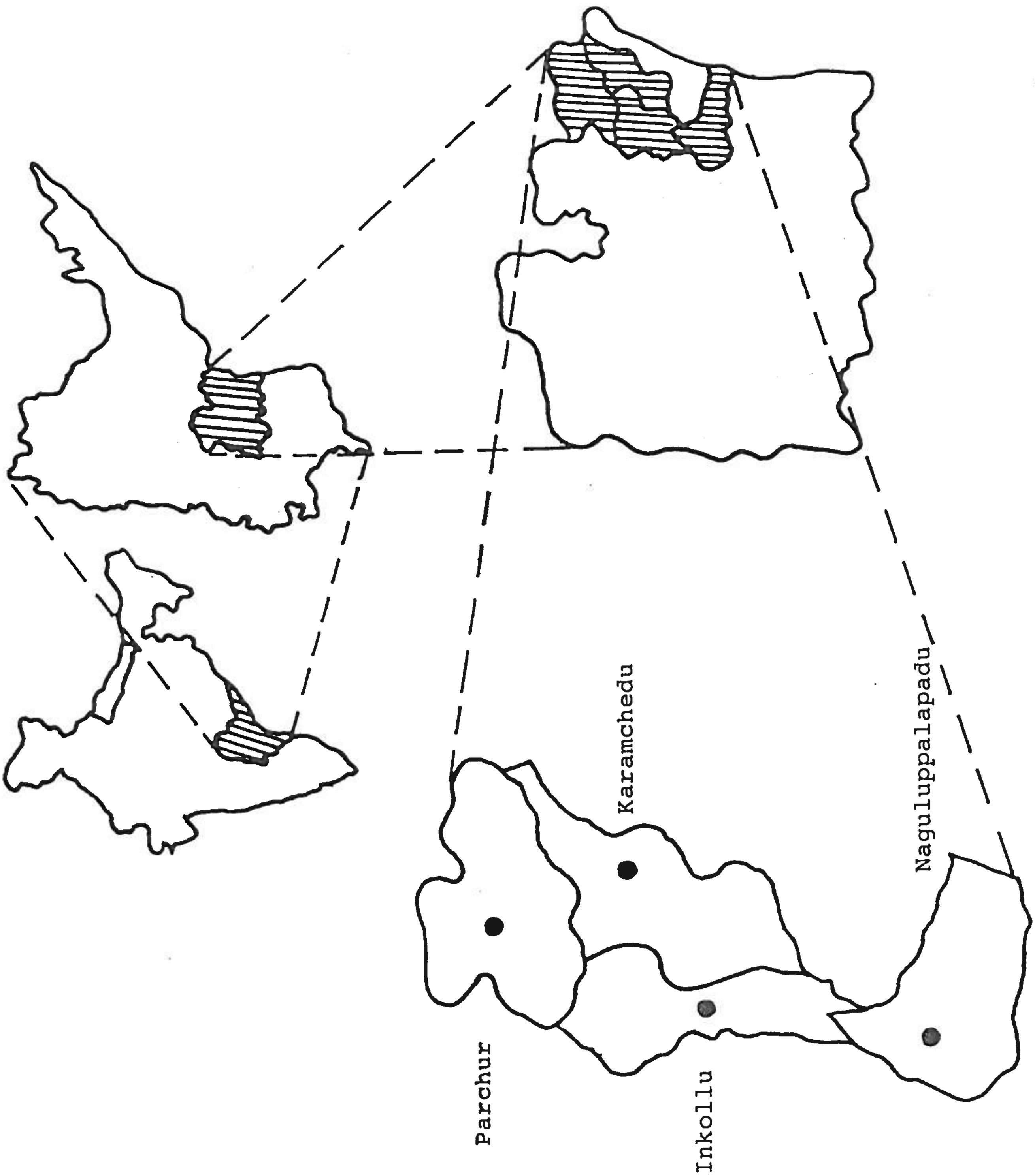
Karamchedu
Naguluppalapadu
Parchur
Inkollu

Table 1 : Details of soil and leaf samples collected

Soil and Leaf sample No (1)	Name of the farmer (2) Sarvashri	Name of the village (3)	Name of the Mandal (4)
1	K.Sriramulu	Kollavaripalem	Parchur
2	K.Venkateswara Rao	,,	,,
3	A.Subba Rao	,,	,,
4	K.Venkateswarlu	,,	,,
5	K.Dasaradha Ramaiah	,,	,,
6	T.Vasu	,,	,,
7	K.Purnchandra Rao	,,	,,
8	K.Nagababu	,,	,,
9	A.Ramakrishna	,,	,,
10	A.Rambabu	,,	,,
11	K.Chinavenkata Rao	Parchur	Parchur
12	Ch.Ramarao	,,	,,
13	Ch.Pushpa	,,	,,
14	A.Venkatanarayana	,,	,,
15	G.Subbarao	,,	,,
16	K.Ramakoteswara Rao	,,	,,
17	G.Sundarammma	,,	,,
18	G.venkanna	,,	,,

19	M.Venkateswara Rao	,,	,,
20	Ch.Subbarao	,,	,,
21	K.Rosaiah	Nagulapadu	Parchur
22	A.Venkateswara rao	,,	,,
23	S.Ragavalu	,,	,,
24	A.Venkateswara Rao	,,	,,
25	K.Pitchaiah	,,	,,
26	P.Venkatasubbaiah	,,	,,
27	J.Nageswara Rao	,,	,,
28	U.Venkateswarlu	,,	,,
29	K.Subbaraidu	,,	,,
30	K.Subba Rao	,,	,,
31	P.Venkata Subba Reddy	Nuthalapadu	Parchur
32	Y.Anki Reddy	,,	,,
33	P.Narayana Rao	,,	,,
34	P.Subba Rao	,,	,,
35	P.Pulla Reddy	,,	,,
36	K.Sambi Reddy	,,	,,
37	B.Ramakrishana Reddy	,,	,,
38	B.Raja Gopal Reddy	,,	,,
39	Y.Sambi Reddy	,,	,,
40	Y.Rami Reddy	,,	,,
41	K.Koti Reddy	,,	,,
42	B.Bramha Reddy	,,	,,
43	B.Anji Reddy	,,	,,

44	K.Lakshma Reddy	,,	,,
45	K.Nagi Reddy	,,	,,
46	B.Pulla Reddy	,,	,,
47	K.Subba Reddy	,,	,,
48	K.Venkata Reddy	,,	,,
49	K.Pulla Reddy	,,	,,
50	K.Jayarami Reddy	,,	,,
51	K.Darsah Bude	Daggupadu	Karamchedu
52	S.Karesandi	,,	,,
53	P.Subani	,,	,,
54	S.Vali	,,	,,
55	S.Rangarai	,,	,,
56	B.Venkata Rao	,,	,,
57	B.Budigiya	,,	,,
58	P.Yerrabbai	,,	,,
59	B.Sriramuliu	,,	,,
60	P.Rahiman	,,	,,
61	D.Rambabu	Inkollu	Inkollu
62	V.Adinarayana	,,	,,
63	R.Manikyam	,,	,,
64	K.Nagaiah	,,	,,
65	K.Rajaiah	,,	,,
66	K.Sambaiah	,,	,,
67	P.Radha Krishna Murthy	,,	,,
68	G.Suraiah	,,	,,

69	K.Lakshmaiah	,,	,,
70	G.Srinivasalu	,,	,,
71	K.Bramahiah	Bhemavaram	Inkollu
72	B.Anjaneyulu	,,	,,
73	L.Nagaiah	,,	,,
74	S.Kotaiah	,,	,,
75	A.Govindam	,,	,,
76	K.Abbulueddy	,,	,,
77	G.Peddabbaiah	,,	,,
78	A.Venkateswarlu	,,	,,
79	K.Rambabu	,,	,,
80	R.Mahendra	,,	,,
81	M.Subba Rao	Uppugundur	Naguluppala Padu
82	B.Seshaiah	,,	,,
83	V.Mohan Rao	,,	,,
84	G.Lakshminarayana	,,	,,
85	G.Chittabbai	,,	,,
86	B.Musalaiah	,,	,,
87	G.Muttaiah	,,	,,
88	G.Biragio	,,	,,
89	B.Sivaji	,,	,,
90	B.Srinivasulu	,,	,,
91	Ch.Anjaneyulu	Mattigunta	,,
92	Ch.Rama Rao	,,	,,

93	Ch.Ragavaiah	''	''
94	Ch.Krishnaiah	''	''
95	Ch.Subba Rao	''	''
96	Ch.Chenchaiah	''	''
97	Y.Surendra	''	''
98	B.Subba Rao	''	''
99	P.Srinivasulu	''	''
100	Ch.Rama swami	''	''

3.2 METHODS OF ANALYSIS

3.2.1 Mechanical analysis

Particle size analysis was carried out by Bouyoucos Hydrometer method as per the details given by Piper (1966).

3.2.2 Bulk density

The bulk density of the soil was determined by clod method as per the details furnished by Sekera (1931).

3.2.3 Soil reaction (p^H)

The p^H of the soil samples was determined in 1:2.5 (soil:water) suspension using a glass electrode p^H meter (Jackson,1973).

3.2.4 Electrical conductivity

The electrical conductivity of the soil samples was measured in 1:2.5(soil:water) extract by using conductivity bridge (Jackson, 1973).

3.2.5 Organic carbon

Organic carbon was estimated by wet digestion method of Walkley and Black as described by Jackson (1973).

3.2.6 Free calcium carbonate

Free calcium carbonate was estimated by rapid titration method as described by Piper (1966).

3.2.7 Cation exchange capacity

The cation exchange capacity of the soils was estimated by the neutral normal sodium acetate method as per the details furnished by Bower et al (1952).

3.2.8 Exchangeable calcium and magnesium

The exchangeable calcium and magnesium contents were determined by versenate titration of neutral normal ammonium acetate extract as per the procedure described by Jackson (1973).

3.2.9 Exchangeable sodium

The exchangeable sodium content was determined in neutral normal ammonium acetate extract using flame photometer as per the details provided by Bower et al (1952).

3.2.10 Exchangeable potassium

The exchangeable potassium content was estimated by the neutral normal ammonium acetate method as per the details provided by Bower et al (1952).

3.2.11 Available nitrogen

Available nitrogen content of the soil was determined by alkaline permanganate method as described by Subbiah and Asija (1956).

3.2.12 Available phosphorus

Available phosphorus content of the soils was extracted with Olsen's extractant (0.5 M $NaHCO_3$ of p^H 8.5) and phosphorus in the extract was determined by Murphy and Riley method as described by Watanabe and Olsen (1965).

3.2.13 Available potassium

Available potassium content of the soil samples was determined by using neutral normal ammonium acetate as the extractant using flame photometer (Muhr et al., 1965).

3.2.14 Available micronutrients

The available micronutrient cations viz., zinc, copper, iron and manganese were extracted with DTPA extractant (Lindsay and Norvell, 1978) and the extract was analysed for zinc, copper, iron and manganese with atomic absorption spectrophotometer (Hitachi 170-30) using appropriate absorption lines.

3.3 LEAF ANALYSIS

Leaf samples were digested using diacid mixture containing HNO_3 and $HClO_4$ in the ratio of 7:3 and final volume made upto 100 ml with double distilled water. The following methods were adopted for estimation of different elements in the extract.

3.3.1 Total nitrogen

Total nitrogen content in the leaf samples was determined by Microkjeldahl method as described by Bremner (1965).

3.3.2 Phosphorus

The phosphorus content of the leaf samples was determined by the method of Vanadomolybdophosphoric acid yellow colour method as described by Jackson (1973).

3.3.3 Potassium

The potassium content of the leaf samples was determined in diacid extract by flame photometer as described by Jackson (1973).

3.3.4 Calcium and Magnesium

The calcium and magnesium contents of the leaf samples were determined by Versenate method as described by Jackson (1973).

3.3.5 Micronutrients

The micronutrients like zinc, copper, iron and manganese were determined in diacid extract by Atomic absorption spectrophotometer method as described by Lindsay and Norvell (1978).

3.4 STATISTICAL ANALYSIS

Correlation coefficient

The correlation coefficient as given by Panse and Sukhatme (1978) was used to ascertain the significant relationship, if any between the dependent and independent variables.

Multiple Linear Regression (MLR)

This statistical tool as given by Nageswara Rao (1983) was used in the investigation to study the effect independent variables.

X_1 = available nitrogen	X_2 = Leaf nitrogen
X_3 = available phosphorus	X_4 = Leaf Phosphours
X_5 = available potassium	X_6 = Leaf potassium
X_7 = exchangeable calcium	X_8 = Leaf calcium
X_9 = exchangeable magnesium	X_{10} = Leaf magnesium
X_{11} = available iron	X_{12} = Leaf iron
X_{13} = available copper	X_{14} = Leaf copper
X_{15} = available manganese	X_{16} = Leaf manganese
X_{17} = available zinc	X_{18} = leaf zinc
X_{19} = exchangeable potassium	X_{20} = exchangeable sodium
X_{21} = CEC	X_{22} = clay
X_{23} = p^H	X_{24} = EC
X_{25} = organic carbon	X_{26} = $CaCO_3$

(Bulk density, sand and silt were excluded in analysis)

Coefficient of multiple determination :

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

R^2 is always less than unity and when it is expressed in percentage, it measures the extent of variation in dependent variables (Y) which can be explained by the independent variables (X_iS).

The data pertinent to 29 independent variables of individual soil and leaf samples was given in Appendix-1, among 29 parameters analysed 26 independent variables (excluding bulk density, sand and silt) were selected for correlating with yield. Correlation matrix containing 'r' values of all variables studied is presented in the appendix II.

Partial regression coefficients and coefficient of determination (R^2) values of different varieties of cotton studied were given in Appendix-III.

RESULTS

RESULTS

In the present investigation hundred soil samples were collected from four mandals viz., (1) Karamchedu (2) Parchur (3) Inkollu (4) Naguluppalapadu in Prakasam district and were analysed for physico-chemical characteristics and for available macro and micronutrients.

The results of the present investigation are presented under the following major sections with appropriate subsections as

1. Physical and chemical characteristics of the soil samples.
2. Distribution of available major and micronutrients in the soil samples and their correlation with yield and soil characteristics.
3. Analysis of plant samples and correlation with yield and soil characteristics.

4.1 PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE SOIL SAMPLES

4.1.1 Mechanical analysis

Soil test summary pertaining to the distribution of soil samples into categories with reference to particle size analysis is presented in Table 2.

Table 2 : Per cent clay, silt and sand in soil samples of different mandals

S. No.	Mandal	No. of samples		Range From	Range To	Mean
1.	Karamchedu	10	Clay	30.0	42.0	37.0
			Silt	13.3	21.6	18.5
			Sand	36.3	56.6	48.0
2.	Parchur	50	Clay	24.0	47.0	36.5
			Silt	10.1	25.0	18.0
			Sand	28.6	62.8	47.0
3.	Inkollu	20	Clay	29.0	44.0	37.0
			Silt	14.8	23.2	19.5
			Sand	32.7	57.1	45.0
4.	Naguluppalapadu	20	Clay	27.0	40.0	36.0
			Silt	11.9	20.2	17.5
			Sand	39.7	61.0	51.0
	Overall values	100	Clay	24.0	47.0	36.5
			Silt	10.1	25.0	18.2
			Sand	28.6	62.8	47.7

The clay content of the soils ranged from 24 to 47% with a mean value of 36.5%. The sand content ranged from 28.6 to 62.8% with a mean values of 47.7%. The silt content ranged from 10.1 to 25% with a mean value of 18.2%.

4.1.2 Bulk density

Soil test summary pertaining to the distribution of soil samples into categories with reference to bulk density is presented in Table 3.

The bulk density of the soil samples ranged from 1.8 to 2.1 with a mean value of 2.0.

4.1.3 Soil reaction (pH)

Soil test summary pertaining to the distribution of soil samples into categories with reference to soil reaction is presented in Table 4.

The results revealed that the pH values of the soil samples varied from 6.4 to 8.4 with a mean value of 7.6. Sixty two per cent of the soil samples were found to be weakly alkaline and the remaining 38 per cent samples were neutral in reaction based on the prescribed limits (Anonymous, 1985). On the whole these soils were weakly alkaline in reaction (mean 7.6).

Table 3 : **Bulk density range of the soil samples collected from different mandals**

S. No.	Mandal	No. of samples	Range From	Range To	Mean
1.	Karamchedu	10	1.8	2.0	2.0
2.	Parchur	50	1.8	2.1	2.1
3.	Inkollu	20	1.8	2.0	1.9
4.	Naguluppalapadu	20	1.8	2.1	2.0
	Overall values	100	1.8	2.1	2.0

Table 4 : p^H range of the soil samples collected from different mandals

S. No.	Mandal	No. of samples	Range	Mean	% samples under each category: Weakly calcareous	Strongly calcareous
1.	Karamchedu	10	7.0-7.9	7.5	70	30
2.	Parchur	50	6.5-8.3	7.6	38	62
3.	Inkollu	20	7.0-7.9	7.5	45	55
4.	Naguluppalapadu	20	6.4-8.4	7.7	20	80
	Over all values	100	6.4-8.4	7.6	38	62

Neutral soil = pH 7.0 to 7.5
Weakly alkaline = pH 7.6 to 8.5 (Anonymous, 1985)

4.1.4 Electrical conductivity

Soil test summary pertaining to the distribution of soil samples into categories with reference to electrical conductivity is presented in Table 5.

The overall electrical conductivity (EC) of the soils ranged from 0.32 to 0.80 dS m^{-1} with a mean value of 0.54 dS m^{-1}. All the soils were found to be normal with regard to the electrical conductivity (Anonymous, 1985).

4.1.5 Calcium carbonate

Soil test summary pertaining to the distribution of soil samples into categories with reference to calcium carbonate is presented in Table 6.

The calcium carbonate content of the soil samples ranged from 4.0 to 12.0 per cent with a mean value of 8.0 per cent. The soil samples of Naguluppalapadu recorded the highest mean value of calcium carbonate content (8.8%), while the soil samples of Inkollu mandal recorded the lowest mean value of 7.5 per cent calcium carbonate. Soil samples from the remaining two mandals Karamchedu and Parchur were found to be 7.6 and 8.2 per cent respectively. Ninety per cent of the soil samples from Karamchedu, Parchur, Inkollu and Naguluppalapadu mandals were found to be strongly calcareous (>5% $CaCO_3$), while 10 per cent of the soil samples of these mandals were found to be weakly calcareous (<5% $CaCO_3$).

Table 5 : Electrical conductivity (dS m^{-1}) range of the soil samples collected from different mandals

S. No.	Mandal	No. of samples	Range	Mean	% samples under category normal
1.	Karamchedu	10	0.42-0.72	0.56	100
2.	Parchur	50	0.32-0.80	0.54	100
3.	Inkollu	20	0.47-0.74	0.60	100
4.	Naguluppalapadu	20	0.38-0.64	0.48	100
	Over all values	100	0.32-0.80	0.54	100

Normal = < 2 dSm^{-1} (Anonymous, 1985)

Table 6 : **Calcium carbonate status (%) of the soil samples collected from different mandals**

S. No.	Mandal	No. of samples	Range	Mean	% samples under category: Weakly calcareous	Strongly calcareous
1.	Karamchedu	10	4.0-9.5	7.6	10	90
2.	Parchur	50	4.0-10.0	8.2	8	92
3.	Inkollu	20	4.0-9.5	7.5	10	90
4.	Naguluppalapadu	20	4.3-12.0	8.8	5	95
	Over all values	100	4.0-12.0	8.0	10	90

Weakly calcareous = < 5% $CaCO_3$
Strongly calcareous = > 5% $CaCO_3$ (Subbaiah, 1984)

4.1.4 Cation exchange capacity (CEC)

Soil test summary pertaining to the distribution of soil samples into categories with reference to CEC is presented in Table 7.

The cation exchange capacity (CEC) of the soils varied from 19.5 to 43.5 cmol(p+)kg^{-1} soil with a mean value of 32 cmol(p+)kg^{-1} soil. The mean CEC values of the soil samples of Karamchedu, Parchur and Inkollu mandals were found to be high, ranging from 30 to 35 cmol(p+)kg^{-1} soil, while it was <30 cmol(p+)kg^{-1} soil in the soil samples of Naguluppalapadu mandal. The result further revealed that in all the soils, the contents of the exchangeable cations were found to be in the order of Ca^{2+} > Mg^{+2} > Na^{+} > K^{+}. The exchangeable Ca^{2+} was found to be the most dominant cation ranging from 12.13 to 30.0 cmol(p+)kg^{-1} soil with mean value of 21.0 cmol(p+)kg^{-1} soil and the Ca^{2+} saturation on the exchange complex varied from 62.0 to 68.0 per cent. Highest mean value of exchangeable calcium (21.5 cmol(p+)kg^{-1}) was recorded by the soils of Karamchedu, while the soils of Naguluppalapadu mandal recorded a lowest mean value of 20.0 cmol(P^{+}) kg^{-1} soil. The mean values for soils of the Parchur and Inkollu mandals were found to be 20.8 and 21.0 cmol(p+)kg^{-1} soil respectively. The Ca^{2+} saturation on the exchange complex was 71 per cent for soils of Naguluppalapadu, 68 per cent for soils of Parchur mandal 64 per cent for

Table 7 : Cation exchange capacity and exchangeable cations of the soils of different mandals

S. No.	Mandal	Total No. of samples	Exchangeable cations cmol(p+)kg^{-1}) Ca^{2+} From to	Ca^{2+} Mean	Mg^{2+} From to	Mg^{2+} Mean	K^{+} From to	K^{+} Mean	Na^{+} From to	Na^{+} Mean	Total CEC (cmol(p+)kg^{-1} soil) From to	Total CEC Mean
1.	Karamchedu	10	16.00-26.42	21.5	3.20-5.28	4.3	0.32-0.54	0.46	2.90-4.52	3.6	24.0-39.0	35
2.	Parchur	50	12.13-30.00	20.8	2.99-6.00	4.2	0.24-0.60	0.41	2.02-5.00	3.5	19.5-43.5	30
3.	Inkollu	20	17.14-27.85	21.0	3.42-5.57	4.7	0.35-0.55	0.48	2.97-4.64	3.8	25.0-41.0	33
4.	Naguluppala Padu	20	14.28-24.28	20.0	2.85-4.85	4.0	0.28-0.48	0.36	2.38-4.04	3.0	22.5-35.0	28
	Over all values	100	12.13 30	21.0	2.85 6.0	4.3	0.24 0.6	0.42	2.02 5	3.5	19.5 43.5	32

soils of Inkollu mandal and 60 per cent for soils of Karamchedu mandal.

Magnesium was the second most dominant cation and ranged from 2.85 to 6.0 cmol(p+)kg^{-1} soil, with a mean value of 4.3 cmol(p+)kg^{-1} soil. A maximum mean value of 4.7 cmol(p+)kg^{-1} soil was noticed in Inkollu mandal, while the minimum mean value of 4.0 cmol(p+)kg^{-1} soil was observed in Naguluppalapadu mandal.

Exchangeable sodium content ranged from 2.0 to 5.0 cmol(P^{+})kg^{-1} soil, with a mean value of 3.5 cmol(p+)kg^{-1} soil. The highest mean value of exchangeable sodium content was observed for soil samples of Inkollu mandal (3.8 cmol(p+)kg^{-1} soil) while the lowest mean value (3.0 cmol(p+)kg^{-1} soil) was recorded for soil samples of Naguluppalapadu mandal.

Regarding the exchangeable potassium, the value ranged from 0.24 to 0.60 cmol(p+)kg^{-1} soil with a mean value of 0.42. The highest mean value of (0.48 cmol(p+)kg^{-1} soil) exchangeable potassium was observed in soils of Inkollu mandal and the lowest mean value of 0.36 cmol(p+)kg^{-1} soil was noticed in soils of Naguluppalapadu mandal. The mean values of remaining two mandals, Karamchedu and Parchur were found to be 0.41 and 0.46 cmol(p+)kg^{-1} soil respectively.

4.1.5 Organic carbon

Soil test summary pertaining to the distribution of soil samples into categories with reference to organic carbon is presented in Table 8.

The organic carbon content in soil samples ranged from 0.40 to 1.0 per cent with a mean value of 0.79 per cent. The highest mean value of 0.78 per cent organic carbon was found to be the soil samples of Karamchedu mandal, while the lowest mean value was recorded by the soil samples of Naguluppalapadu mandal (0.6%). The mean organic carbon content of the soils of the remaining two mandals, Parchur and Inkollu were found to be between 0.69 and 0.75 per cent respectively. The soils were classified under low, medium and high categories based on the limits proposed by Ramamurthy and Bajaj (1969). Accordingly, 55 per cent of the soil samples of Inkollu mandal were found to be high in organic carbon content, while 75 per cent of the soil samples of Naguluppalapadu were medium in organic carbon content. On the whole, 36 per cent of soil samples were found to be high in organic carbon content, while 55 per cent of the soil samples were medium and 9 per cent of the soil samples were low in organic carbon content.

Table 8 : Organic carbon status (%) of the soil samples collected from different mandals

S. No.	Mandal	No. of samples	Range	Mean	% samples under each category			Nutrient index	Fertility status
					Low	Medium	High		
1.	Karamchedu	10	0.53-0.90	0.78	-	50	50	2.50	High
2.	Parchur	50	0.40-1.00	0.69	8	52	40	2.32	Medium
3.	Inkollu	20	0.59-0.92	0.75	15	45	40	2.25	Medium
4.	Naguluppala-padu	20	0.47-0.80	0.60	10	75	15	2.05	Medium
	Over all values	100	0.40-1.00	0.79	9	55	36	2.28	

Low = < 0.5%
Meidum = 0.5-0.75%
High = > 0.75% (Ramamurthy and Bajaj, 1969)

4.2 DISTRIBUTION OF AVAILABLE MAJOR AND MICRONUTRIENTS IN THE SOIL SAMPLES AND THEIR CORRELATION WITH YIELD AND SOIL CHARACTERISTICS

4.2.1 Available nitrogen

Soil test summary pertaining to the distribution of soil samples into categories with reference to available nitrogen is presented in Table 9.

The data revealed that the available nitrogen content of the soils ranged from 202 to 500 kg ha^{-1} with a mean value of 347 kg ha^{-1}. The maximum available N content was recorded in the case of the soils of Inkollu mandal (mean 375 kg ha^{-1}), while the lowest available nitrogen was observed in soils of Naguluppalapadu mandal (mean 309 kg ha^{-1}). The mean value of available nitrogen content of the remaining two mandals, Parchur and Karamchedu were found to be 345 and 359 kg ha^{-1} respectively. In general, 84 per cent of the soils were found to be medium in available nitrogen content, while the remaining 16 per cent of soils were found to be low. The available nitrogen was significantly and positively correlated with organic carbon (r= 0.265) and with all other nutrients and the soil characteristics.

4.2.2 Available phosphorus

Soil test summary pertaining to the distribution of

Table 9 : Available nitrogen status (Kg ha^{-1}) of the soils of different mandals

S. No.	Mandal	No. of samples	Range	Mean	% samples under each category: Low	% samples under each category: Medium	Nutrient index	Fertility status
1.	Karamchedu	10	290 - 452	359	10	90	1.90	Medium
2.	Parchur	50	202 - 500	345	16	84	1.84	Medium
3.	Inkollu	20	285 - 464	375	-	100	2.00	Medium
4.	Naguluppala-padu	20	238 - 404	309	35	65	1.65	Low
	Over all values	100	202 - 500	347	16	84	1.84	

Low = < 280 kg ha^{-1}
Meidum = 280-560
High = > 560 (Ramamurthy and Bajaj, 1969)

Table 10 : Available phosphorus (Kg ha^{-1}) of the soils of different mandals

S. No.	Mandal	No. of samples	Range	Mean	% samples under each category		Nutrient index	Fertility status
					Low	Medium		
1.	Karamchedu	10	13.33-26.66	17.9	100	-	1.00	Low
2.	Parchur	50	10.11-25.00	17.0	86	14	1.14	Low
3.	Inkollu	20	14.28-23.20	18.8	70	30	1.00	Low
4.	Naguluppala-padu	20	11.90-20.28	15.5	100	-	1.00	Low
	Over all values	100	10.11-25.00	17.4	89	11	1.01	Low

Low = < 22.4 kg ha^{-1}
Meidum = 22.4 to 56.0 kg ha^{-1}
High = > 56.0 kg ha^{-1}

(Muhr *et al.*, 1965)

soil samples into categories with reference to available phosphorus is presented in Table 10.

The available phosphorus content of the soil samples were found to vary from 10.0 to 25.0 kg ha^{-1} with a mean value of 17.4 kg ha^{-1}. The maximum available phosphorus content was recorded in the soils of Inkollu mandal (mean 18.8 kg ha^{-1}) followed by Karamchedu mandal (mean 17.9 kg ha^{-1}) and Parchur mandal (mean 17.0 kg ha^{-1}), while it was least in the soils of Naguluppalapadu mandal (mean 15.5 kg ha^{-1}). Accordingly 30 per cent of the soil samples of Inkollu and Parchur mandals were found to be medium in available phosphorus content, while all the soil samples of Karamchedu and Naguluppalapadu mandals were found to be low in available phosphorus status.

The available phosphorus had significant and positive correlation with CEC (r = 0.916), clay (r = 0.858) organic carbon (r = 0.265) and negative correlation with p^H (r = -0.607) and $CaCO_3$ (r = -0.583).

4.2.3 Available potassium

Soil test summary pertaining to the distribution of soil samples into categories with reference to available potassium is presented in Table 11.

The data indicated that the available potassium content of the soils ranged from 319 to 771 kg ha^{-1} (mean 548 kg

Table 11 : **Available potassium (Kg ha^{-1}) of the soil samples of different mandals**

S. No.	Mandal	No. of samples	Range	Mean	% samples under category high	Nutrient index	Fertility status
1.	Karamchedu	10	421 - 695	565	100	3.0	High
2.	Parchur	50	319 - 771	546	100	3.0	High
3.	Inkollu	20	451 - 733	593	100	3.0	High
4.	Naguluppa-lapadu	20	376 - 639	489	100	3.0	High
	Over all values	100	319 - 771	548	100	3.0	High

Low = < 108 kg ha^{-1}
Meidum = 108-280 kg ha^{-1}
High = > 280 kg ha^{-1} (Ramamurthy and Bajaj, 1969)

ha^{-1}). The soils of Inkollu mandal showed the highest available potassium content (mean 593 kg ha^{-1}), while the lowest mean value of the same was observed in the soils of Naguluppalapadu mandal (489 kg ha^{-1}). The available potassium content of the remaining two mandals, Karamchedu and Parchur were found to be 565 and 546 respectively. In other words, all the soil samples in the study area were high in available potassium content.

The available potassium content had positive and significant correlation with all other available nutrients such as N, P, Ca, Mg, Fe, Cu, Mn, Zn and the soil characteristics like p^H, CEC, Clay $CaCO_3$ and OC.

4.2.4 **Iron**

Soil test summary pertaining to the distribution of soil samples into categories with reference to iron is presented in Table 12.

The available iron content of the soils ranged from 3.4 to 8.5 ppm with a mean value of 5.9 ppm. The maximum (mean 6.4 ppm) and minimum (mean 5.0 ppm) contents were recorded in the soil samples of Inkollu and Naguluppalapadu. Except 2 per cent samples of the Parchur mandal, remaining 98 per cent samples were found to be above the critical limit (DTPA extractable), whereas in the remaining mandals almost all the samples were found to be above critical limit.

Table 12 : **Available Fe status (ppm) of the soil samples of different mandals**

S. No.	Mandal	No. of samples	Range	Mean	% samples: Below critical level	% samples: Above critical level
1.	Karamchedu	10	4.53-7.48	6.1	-	100
2.	Parchur	50	3.43-8.50	5.9	2	98
3.	Inkollu	20	5.05-7.89	6.4	-	100
4.	Naguluppa-lapadu	20	4.04-6.88	5.2	-	100
	Overall values	100	3.43-8.50	5.9		

Critical limit for soil iron = 4.0 ppm (ICAR, 1988-89)

The available iron was negatively and significantly correlated with CEC (r = -0.910), clay (r = -0.855) pH (r = -0.614) and $CaCO_3$ (r = -0.563). It was positively and significantly correlated with other available nutrients like N, P, K, Ca, Mg, Cu, Mn, Zn and OC.

4.2.5 **Available copper**

Soil test summary pertaining to the distribution of soil samples into categories with reference to available copper is presented in Table 13.

The available copper content of the soil samples was found to vary from 0.40 to 1.0 ppm with an average value of 0.68 ppm. The highest mean value of available copper was found for the soils of Inkollu mandal (0.75 ppm) while the lowest mean value of the same was observed for the soils of Naguluppalapadu mandal (0.61 ppm). The mean values of available copper of the remaining two mandals, Parchur and Karamchedu were found to be 0.68 and 0.71 respectively.

The available copper content was negatively and significantly correlated with $CaCO_3$ (r= -0.52), CEC (r = -0.915) and clay (r = -0.859). It was positively and significantly correlated with other nutrients.

4.2.6 **Available manganese**

Soil test summary pertaining to the distribution of

Table 13 : **Available Cu status (ppm) of the soil samples of different mandals**

S. No.	Mandal	No. of samples	Range	Mean	% samples above critical level
1.	Karamchedu	10	0.53-0.88	0.71	100
2.	Parchur	50	0.40-1.00	0.68	100
3.	Inkollu	20	0.57-0.92	0.75	100
4.	Naguluppa-lapadu	20	0.47-0.80	0.61	100
	Overall values	100	0.40-1.00	0.68	100

Critical limit for soil copper = 0.2 ppm (ICAR, 1988-89)

Table 14 : **Available Mn status (ppm) of the soil samples of different mandals**

S. No.	Mandal	No. of samples	Range	Mean	% samples above critical level
1.	Karamchedu	10	2.66-4.40	3.58	100
2.	Parchur	50	2.02-5.00	3.45	100
3.	Inkollu	20	2.92-4.64	3.77	100
4.	Naguluppa-lapadu	20	2.38-4.04	3.07	100
	Overall values	100	2.02-5.00	3.46	100

Critical limit for soil Manganese = 2.0 ppm (ICAR, 1988-89) soil samples into categories with reference to available manganese is presented in Table 14.

The available manganese content of the soils was found to vary from 2.02 to 5.0 with an average value of 3.46 ppm. The highest mean value of available manganese was found for soils of Inkollu mandal (3.77 ppm), while the lowest mean value of the same was observed for the soils of Naguluppalapadu mandal (3.07 ppm). The mean values of available manganese of the remaining two mandals, Parchur and Karamchedu were found to be 3.45 and 3.58 respectively.

The manganese content was negatively and significantly correlated with CEC (r = -0.90), clay (r = -0.85) p^h (r = -0.6130 and $CaCO_3$ (r = -0.55) while with other available nutrients it was positively and significantly correlated.

4.2.7 Available zinc

Soil test summary pertaining to the distribution of soil samples into categories with reference to available zinc is presented in Table 15.

The results revealed that the available zinc content of the soil samples ranged from 0.8 to 2.0 ppm with a mean value of 1.38 ppm. The mean value for available zinc content was found to be highest for soils of Inkollu mandal (1.50 ppm), while the least mean value of available zinc was found to be for the Naguluppalapadu mandal (1.23). Whereas

Table 15 : **Available Zn status (ppm) of the soil samples of different mandals**

S. No.	Mandal	No. of samples	Range	Mean	% samples above critical level
1.	Karamchedu	10	1.06-1.76	1.48	100
2.	Parchur	50	0.80-2.00	1.38	100
3.	Inkollu	20	1.14-1.88	1.50	100
4.	Naguluppa-lapadu	20	0.95-1.61	1.28	100
	Overall values	100	0.80-2.00	1.38	100

Critical limit for soil zinc = 0.7 ppm (ICAR, 1988-89) the mean values of available zinc for soils of the remaining two mandals, Parchur and Karamchedu were found to be 1.38 and 1.48 respectively.

The available zinc showed negative and significant correlation with CEC (r = -0.917), clay (r = -0.86), p^H (r = -0.605) and $CaCO_3$ (r = -0.56) while with other available nutrients it showed a positive and significant correlation.

4.3 LEAF ANALYSIS

The nutrient content of the leaf samples were classified into optimum, below optimum and above optimum level with regard to the major nutrients N, P, K, Ca and Mg in accordance with the limits proposed by Subba Rao (1975).

The micronutrient content of the leaf samples were classified into sufficiency, below sufficiency and above sufficiency with regard to micro nutrients Fe, Cu, Mn and Zn in accordance with the levels proposed by Venkateswarulu and edited by Kanwar (1975).

4.3.1 Nitrogen content

Leaf analysis summary pertaining to the distribution of leaf samples into categories in respect of nitrogen content is presented in Table 16.

The data showed that the nitrogen content of the leaf samples ranged from 3.96 to 5.75 per cent with a mean value

Table 16 : **Nitrogen content (%) of the leaf samples**

S. No.	Mandal	No. of samples	Range	Mean	% samples: Below opt. level	% samples: Opt. level	% samples: Above opt. level
1.	Karamchedu	10	4.35-5.42	4.88	-	100	-
2.	Parchur	50	3.96-5.75	4.85	6	90	4
3.	Inkollu	20	4.32-5.53	4.92	5	95	-
4.	Naguluppalapadu	20	4.14-5.17	4.67	10	90	-
	Overall values	100	3.96-5.75	4.83	6	92	2

Opt. level of nitrogen for cotton leaf = 4.3-5.5% (Subba Rao, 1975) of 4.83 per cent. The maximum mean value nitrogen content was found for the leaf samples collected from Inkollu mandal (4.92%) while the lowest mean value was observed for leaf samples of Naguluppalapadu mandal (4.67%). The nitrogen content of the leaf samples of the remaining two mandals, Parchur and Karamchedu were found to be 4.85 and 4.88 respectively. In general, 6 per cent of the leaf samples contained nitrogen below optimum level while 92 per cent leaf samples contained nitrogen optimum level and 2 per cent of the leaf samples contained nitrogen above the optimum level.

The nitrogen content in the leaf samples was positively and significantly correlated with all other nutrients such as P,K,Ca,Mg,Fe,Cu,Mn,Zn and also with soil characteristics like OC, CEC, clay, pH, $CaCO_3$.

4.3.2 **Phophorus content**

Leaf analysis summary pertaining to the distribution of leaf samples into categories in respect of phosphorus content is presented in Table 17.

The phosphorus content of the leaf samples ranged from 0.10 to 0.40 per cent with a mean value of 0.24 per cent. The mean maximum Phosphorus content was found for the leaf samples of Inkollu mandal (0.27%) while the lowest mean value was observed for leaf samples of Naguluppalapadu

Table 17 : **Phosphorus content (%) of the leaf samples**

S. No.	Mandal	No. of samples	Range	Mean	% samples: Below opt. level	% samples: Opt. level
1.	Karamchedu	10	0.16-0.34	0.26	70	30
2.	Parchur	50	0.10-0.40	0.24	74	26
3.	Inkollu	30	0.18-0.36	0.27	55	45
4.	Naguluppa-lapadu	20	0.13-0.30	0.20	100	-
	Overall values	100	0.10-0.40	0.24	75	25

Opt. level of phosphorus for cotton leaf = 0.31-0.45% (Subba Rao, 1975) mandal (0.20%). The mean values of phosphorus content of the leaf samples of the remaining two mandals, Parchur and Karamchedu were found to be 0.24 and 0.26 respectively. In general, 75 per cent of the leaf samples contained phosphorus below optimum level while 25% of leaf samples contained optimum level.

The Phosphorus content in the leaf samples was negatively and significantly correlated with pH (r = -0.588) and calcium carbonate (r = -0.533), while it was positively and significantly correlated with all other nutrients in cotton leaf and soil characteristics.

4.3.3 Potassium content

Leaf analysis summary pertaining to the distribution of leaf samples into categories in respect of potassium content is presented in Table 18.

The Potassium content of the leaf samples were found to vary from 1.21 to 3.0 per cent with a mean value of 2.1 per cent. The mean maximum value of potassium content was found for the leaf samples of Inkollu mandal (2.3%) followed by Karamchedu mandal (mean 2.0%) and Parchur mandal (mean 2.1%) while it was least for the leaf samples of Naguluppalapadu mandal (mean 1.9%). Hundred per cent of the leaf samples contained the potassium above the optimum level in Karamchedu, Inkollu and Naguluppalapadu mandals, while 98 per cent

Table 18 : **Potassium content (%) of the leaf samples**

S. No.	Mandal	No. of samples	Range	Mean	% samples: Opt. level	% samples: Above Opt. level
1.	Karamchedu	10	1.60-2.64	2.0	-	100
2.	Parchur	50	1.21-3.00	2.1	2	98
3.	Inkollu	20	1.71-2.78	2.3	-	100
4.	Naguluppalapadu	20	1.42-2.42	1.9	-	100
	Overall values	100	1.21-3.00	2.1	2	98

Opt. level of potassium for cotton leaf = 0.5-1.25% (Subba Rao, 1975) of the leaf samples showed above optimum level of potassium, while 2 per cent of the leaf samples showed the optimum level of potassium in Parchur mandal.

The Potassium content in the leaf samples was positively and significantly correlated with all other nutrients and soil characteristics.

4.3.4 Calcium content

Leaf analysis summary pertaining to the distribution of leaf samples into categories in respect of calcium content is presented in Table 19.

The calcium content of leaf samples were found to vary from 1.66 to 4.0 per cent with a mean value of 2.8 per cent. The maximum calcium content was recorded in the leaf samples of Inkollu mandal (mean 3.00%) followed by Karamchedu mandal (mean 2.86) and Parchur mandal (mean 2.8%) while it was least for the leaf samples of Naguluppalapadu mandal (mean 2.5%). The leaf samples were classified into optimum, below optimum and above optimum level. Out of 100 samples collected 82 per cent of the leaf samples were above optimum level and the remaining 18 per cent of the leaf samples were at optimum level.

The calcium content was positively and significantly correlated with all other nutrients (N,P,K,Mg, Fe,Cu,Mn and Zn) and soil characteristics (CEC, pH, clay $CaCO_3$ and organic carbon).

Table 19 : **Calcium content (%) of the leaf samples**

S. No.	Mandal	No. of samples	Range	Mean	% samples Opt. level	% samples Above Opt. level
1.	Karamchedu	10	2.13-3.52	2.9	10	90
2.	Parchur	50	1.66-4.00	2.8	20	80
3.	Inkollu	20	2.28-3.71	3.0	-	100
4.	Naguluppalapadu	20	1.90-3.23	2.5	35	65
	Overall values	100	1.66-4.00	2.8	18	82

Opt. level of calcium for cotton leaf = 1.25-2.25% (Subba Rao, 1975)

4.3.5 Magnesium content

Leaf analysis summary pertaining to the distribution of leaf samples into categories in respect of magnesium content is presented in Table 20.

The magnesium content of the leaf samples were found to vary from 0.24 to 0.6 per cent with a mean value of 0.40 per cent. The maximum mean value of magnesium content was found for the leaf samples of Inkollu mandal (0.44%) followed by Karamchedu mandal (mean 0.42%) and Parchur mandal (mean 0.41%) while it was least for the leaf samples of Naguluppalapadu Mandal (mean 0.36%). Out of 100 samples analysed 96 per cent of samples were above the optimum level and remaining 4 per cent were at optimum level.

The magnesium content in the leaf samples was negatively and significantly correlated with $CaCO_3$ (r = -0.53) and positively and significantly correlated with other nutrients (N,P,K,Ca,Fe,Cu,Mn and Zn) and soil characteristics (pH, CEC, clay, organic carbon).

4.3.6 Iron content

Leaf analysis summary pertaining to the distribution of leaf samples into categories in respect of iron content is presented in Table 21.

The iron content of the leaf samples ranged from 80 to 200 ppm, with a mean value of 139 ppm. The maximum (mean

Table 20 : **Magnesium content (%) of the leaf samples**

S. No.	Mandal	No. of samples	Range	Mean	% samples	
					Opt. level	Above Opt. level
1.	Karamchedu	10	0.32-0.52	0.42	-	100
2.	Parchur	50	0.24-0.60	0.41	6	94
3.	Inkollu	20	0.34-0.55	0.44	-	100
4.	Naguluppalapadu	20	0.28-0.48	0.36	5	95
	Overall values	100	0.24-0.60	0.40	4	96

Opt. level of Magensium for cotton leaf = 0.15-0.30% (Subba Rao, 1975)

Table 21 : **Iron content of the cotton leaf samples in ppm**

S. No.	Mandal	No. of samples	Range	Mean	% samples under sufficiency category
1.	Karamchedu	10	106-176	143	100
2.	Parchur	50	80-200	141	100
3.	Inkollu	20	114-185	150	100
4.	Naguluppa-lapadu	20	95-161	123	100
Overall values		100	80-200	139	100

Sufficiency level of iron in cotton leaf = 40-500ppm
(Venkateswarlu, 1975)

150 ppm) and minimum (mean 123.8 ppm) contents were recorded in the leaf samples of Inkollu and Naguluppalapadu mandals, while the remaining mandals Karamchedu, Parchur contained (mean 143) and (mean 141 ppm) respectively. All the leaf samples in all the four mandals were found to be sufficient in iron content.

The iron content the leaf samples was negatively and significantly correlated with CEC (r = -0.899), clay (r = -0.839), pH (r = -0.614) and $CaCO_3$ (r = -0.563). It was positively and significantly correlated with the other nutrients (N,P,K, Ca,Mg,Cu,Mn and Zn) and soil characteristics (OC and pH).

4.3.7 Copper content

Leaf analysis summary pertaining to the distribution of leaf samples into categories in respect of copper content is presented in Table 22.

The Copper content of the leaf samples ranged from 11.23 to 16 ppm, with a mean value of 13.56 ppm. The maximum (mean 14.04 ppm) and minimum (mean 12.92 ppm) contents were recorded for the leaf samples of Inkollu and Naguluppalapadu mandal while the remaining mandals Karamchedu, Parchur contained (mean 13.73) and (mean 13.57 ppm) respectively. All most all the leaf samples were sufficient in copper content.

Table 22 : Copper content of the cotton leaf samples in ppm

S. No.	Mandal	No.of samples	Range	Mean	% samples under sufficiency category
1.	Karamchedu	10	12.26-15.04	13.73	100
2.	Parchur	50	11.23-16.00	13.57	100
3.	Inkollu	20	12.76-15.42	14.04	100
4.	Naguluppa-lapadu	20	11.80-14.47	12.92	100
	Overall values	100	11.23-16.00	13.56	100

Sufficiency level of copper in cotton leaf = 11-17ppm
(Venkateswarlu, 1975)

The copper content was negatively and significantly correlated with CEC (r = -0.911), clay (r = -0.855) and $CaCO_3$ (r = -0.563) while it was positively and significantly correlated with other nutrients (N,P,K,Ca,Mg,Fe,Mn and Zn) and soil characteristics (OC and pH).

4.3.8 **Manganese content**

Leaf analysis summary pertaining to the distribution of leaf samples into categories in respect of manganese content is presented in Table 23.

The manganese content of the leaf samples ranged from 40 to 100 ppm, with a mean value of 69 ppm. The maximum (mean 74 ppm) and minimum (mean 62 ppm) contents were recorded for the leaf samples of Inkollu and Naguluppalapadu mandals, while the remaining mandals Karamchedu, Parchur contained (mean 71) and (mean 69 ppm) respectively. All the leaf samples in all mandals were found to be sufficient in manganese content.

The manganese content was negatively and significantly correlated with CEC (r = -0.801), clay (r = -0.752), pH (r = -0.499), $CaCO_3$ (r = -0.525) and organic carbon (r = -0.241), while it was positively and significantly correlated with other nutrients (N,P,K,Ca,Mg,Fe,Cu and Zn).

Table 23 : **Manganese content of the cotton leaf samples in ppm**

S. No.	Mandal	No.of samples	Range	Mean	% samples under sufficiency category
1.	Karamchedu	10	53-88	71	100
2.	Parchur	50	40-100	69	100
3.	Inkollu	20	57-92	74	100
4.	Naguluppa-lapadu	20	47-80	62	100
Overall values		100	40-100	69	100

Sufficiency level of Manganese in cotton leaf = 30-200ppm
(Venkateswarlu, 1975)

4.3.9 Zinc content

Leaf analysis summary pertaining to the distribution of leaf samples into categories in respect of zinc content is presented in Table 24.

The zinc content of the leaf samples ranged from 24 to 60 ppm, with a mean value of 41 ppm. The maximum (mean 45 ppm) and minimum (mean 35 ppm) contents were recorded in the leaf samples of Inkollu and Naguluppalapadu mandals respectively, while the remaining mandals Karamchedu, Parchur contained (mean 43) and (mean 41 ppm) respectively. Sixty per cent of the leaf samples were found to be sufficient in zinc content, while the remaining 40 per cent of the leaf samples were above the sufficient level in zinc content.

The zinc content was negatively and significantly correlated with CEC (r = -0.912), clay (r = -0.858), pH (r = -0.612) and $CaCO_3$ (r = -0.565), while it was positively and significantly correlated with other nutrients (N,P,K,Ca,Mg, Fe,Cu,Mn) and soil characteristics (OC).

Table 24 : **Zinc content of the cotton leaf samples in ppm**

S. No.	Mandal	No. of samples	Range	Mean	% samples under sufficiency level	% samples under above sufficiency level
1.	Karamchedu	10	32-52	43	50	50
2.	Parchur	50	24-60	41	60	40
3.	Inkollu	20	35-54	45	50	50
4.	Naguluppalapadu	20	28-48	35	75	25
	Overall values	100	24-60	41	60	40

Sufficiency level of zinc in cotton leaf = 20-40ppm (Venkateswarlu, 1975)

Table 25 : **Varietal comparision**

Variety	Yield mean	R^2(macro)	R^2(micro)
MCU-5	1470	84.92	79.46
LKA-861	1723	71.14	83.29
H-44	2243	99.99	97.42
Shoba	1821	91.47	91.95

H 44 > Sobha > LKA 861 > MCU 5

R^2 values for macronutrients :
99.99(H-44) > 91.47(Shobha) > 84.92(MCU 5) > 71.14(LKA 861)

Micronutrients :
97.42(H-44) > 91.95(Shobha) > 83.29(LKA-861) > 79.46(MCU-5)

DISCUSSION

DISCUSSION

The results pertaining to the present investigation entitled "Study of nutrient status of cotton growing areas of Prakasam district" have been discussed in this chapter.

5.1 PHYSICO-CHEMICAL CHARACTERISTICS OF THE SOILS

5.1.1 Soil reaction

Out of 100 soil samples tested, 38 per cent of the soil samples were neutral in soil reaction, while the remaining 62 per cent of the soil samples were weakly alkaline as per the prescribed ratings (Anonymous, 1985). Neutral or weakly alkaline soil reaction, could be maintained despite the heavy use of acid producing nitrogenous fertilizers particularly urea, because of the presence of free calcium carbonate in these soils which could be neutralising the acidity produced by the added fertilizers. The same trend was reported by Madhavi (1989) for turmeric growing soils of Guntur district.

5.1.2 Electrical conductivity

Electrical conductivity of the soils ranged from 0.32 to 0.80 dS m^{-1} with a mean value of 0.54 dS m^{-1}. All the soil samples were normal in electrical conductivity as per the prescribed rating of <2 dS m^{-1} for clay loam soils (Anonymous, 1985). The electrical conductivity of the soils indicated that the soils in the study area were found to be well drained and/or water used for irrigation might be free from soluble salts.

5.1.3 Calcium carbonate

The results revealed that the calcium carbonate content of the soils ranged from 4 to 12.0 per cent with a mean value of 8.0 per cent. The highest calcium carbonate content was recorded in the soils of Naguluppalapadu mandal (mean 8.8 per cent) while the least value was recorded in the soils of Inkollu mandal (mean 7.5 per cent). On the whole, 90 per cent of soil samples were strongly calcareous and recorded more than 5 per cent calcium carbonate whereas the remaining 10 per cent of the soil samples were weakly calcareous and recorded less than 5 per cent calcium carbonate. Such ratings of soils based on calcium carbonate content were proposed by Subbaiah (1984). High calcium carbonate content of these soils may exert a profound influence on the release, fixation and adsorption of plant nutrients by these soils.

5.1.4 Organic carbon

Organic carbon content of the soil samples ranged from

0.40 to 1.0 per cent with a mean value 0.79 per cent. As per the ratings suggested by Ramamurthy and Bajaj (1969) categorisation of the soils was carried out with regard to organic carbon. Of the total 9 per cent of the soil samples were found to be low, 55 per cent of the soil samples were medium and 36 per cent of the soil samples were high in the organic carbon content. Karamchedu recorded the highest (mean 0.78%) and Naguluppalapadu recorded lowest (mean 0.60 %). The average nutrient index for organic carbon was found to be medium. This might be attributed to continuous application of bulky organic manures like farm yard manure, sheep penning or cattle penning every year. The high content of clay in these soils might have also retained and conserved organic matter. Similar results were reported by Narayana Rao (1986) for the black soils of Agricultural College Farm, Bapatla.

5.1.5 Cation exchange capacity (CEC)

The cation exchange capacity of the soils under study ranged from 19.5 to 43.5 cmol(p+)kg^{-1} soil with a mean value of 32 cmol(p+)kg^{-1} soil. The highest value of cation exchange capacity was recorded in the soils of Karamchedu mandal (mean 35 cmol(p+)kg^{-1} soil), while the least value of the same was observed in the soils of Naguluppalapadu mandal (mean 28 cmol(p+)kg^{-1} soil). The cation exchange capacity of the soils of cotton growing area of Prakasam district was therefore appreciably high which might be due to the dominance of montmorillonitic type of clay with very high cation exchange capacity in addition to appreciable amounts of organic colloids. Similar results were observed by Menon and Mariakulandai (1957) and Roy and Barde (1962).

The results further revealed that Ca^{2+} was the most dominant cation on the exchange complex, ranging from 12.13 to 30 cmol(p+)kg^{-1} soil with a mean value of 21 cmol(p+)kg^{-1} soil. The Ca^{2+} per cent saturation on the exchange complex ranged from 62 to 68 per cent, while Mg^{2+} saturation varied from 14.61 to 15.01 per cent and Na^{+} saturation varied from 10.25 to 11.49 per cent. Similar results were reported by Roy and Barde (1962) for black soils of India and Krishnamurthy and Govinda Rajan (1977) for black soils of Andhra Pradesh. High values of the per cent saturation of the exchange complex by Ca^{2+} and low values of the same by Mg^{+2}, Na^{+} and K^{+} might be due to high calcium carbonate content in these soils and lesser leaching losses of calcium salts on account of lesser solubility of calcium salts than those of magnesium, sodium and potassium salts.

5.1.6 Available nitrogen

The available nitrogen content ranged from 202 to 500 kg ha^{-1} with a mean 347 kg ha^{-1}. The maximum available nitrogen content was recorded in the soils of Inkollu mandal (mean375 kg ha^{-1}), while the minimum was observed in the soils of Naguluppalapadu mandal (mean 309 kg ha^{-1}). Of the total soil samples collected, 84 per cent of the samples were medium in available nitrogen and the remaining 14 per cent of the soils were found to be low in available nitrogen as per the ratings suggested by Ramamurthy and Bajaj (1969). The average nutrient index was 1.84 indicating that the soils of cotton growing areas of Prakasam district were medium in fertility status with respect to available nitrogen. The results of the present investigation were thus in consonance with those of Ramamurthy and Bajaj (1969) who reported that majority of the districts in India were low to medium in fertility status with respect to available nitrogen and a very small area was under high nutrient status. The medium availability nature of soils of cotton growing areas of Prakasam district were due to continuous application of nitrogenous fertilizers, as the cotton crop being an important commercial crop of the area.

5.1.7 Available phosphorus (P_2O_5)

The available phosphorus content ranged from 10.11 to 25.0 kg ha^{-1} with a mean value of 17.4 kg ha^{-1}. The maximum available phosphorus content was recorded in the soils of Inkollu mandal (mean 18.8 kg ha^{-1}) while the least was recorded in the soils of Naguluppalapadu mandal (mean 15.49 kg ha^{-1}). The mean values of available phosphorus content of the remaining Parchur and Karamchedu mandals were found to be 17.0 and 17.9 kg ha^{-1} respectively. Variation in available phosphorus content could be attributed to varying amounts of phosphate application, variation in the native soil phosphorus content and/or the degree of phosphate fixation by calcium carbonate and clay as suggested by Subbaiah (1984).

On the whole, 87 per cent of the soil samples were found to be low and 13 per cent of the soil samples were medium in available phosphorus content as per the ratings proposed by Muhr et al (1965). The average nutrient index was found to be 1.1 indicating that the fertility status of these soils as low with respect to available phosphorus. Similarly Subbaiah and Manickam (1987) also reported low available phosphorus in Vertisols of Andhra Pradesh.

5.1.9 **Available potassium**

Available potassium content of the soils ranged from 319 to 771 kg ha^{-1} with a mean value of 548 kg ha^{-1}. The minimum available potassium content (mean 489 kg ha^{-1}) was recorded in the soils of Naguluppalapadu mandal, while the maximum was recorded in the soils of Inkollu mandal (mean 593 kg ha^{-1}). The mean values of available potassium content in the soils of the remaining Parchur and Karamchedu mandals were found to be 546 to 565 kg ha^{-1} respectively. As per the ratings suggested by Ramamurthy and Bajaj (1969), all the soils in the study area were found to be high in available potassium. The high available potassium in these soils could be due to greater potassium retention on the exchange complex by the high CEC clays and organic colloids. The average nutrient index was 3.00 suggesting that the fertility status of cotton growing areas of Prakasam district was high with regard to available potassium. The higher potassium content of loamy or clayey soils might be attributed to the presence of potassium bearing minerals in heavy textured soils. According to Singh and Benerjee (1984) finer fractions of soils were rich sources of all forms of potassium as they contain more potassium bearing minerals. Earlier Subbaiah and Manickam (1987) reported that black soils of Andhra Pradesh were high in available potassium. The present investigation was in accordance with earlier reports.

5.1.10 Iron

Available iron content of the soils ranged from 3.4 to 8.5 ppm with a mean value of 5.9 ppm. The minimum value was recorded in the soil samples of Naguluppalapadu mandal (mean 5.0 ppm), while the maximum value was observed in the Inkollu mandal (mean 6.4 ppm). In accordance with the critical limits of iron given by ICAR (1988-89), 99 per cent of the soil samples were found to be above critical limit. Subbaiah and Manickam (1987) reported the richness of the available iron content of the Vertisols in dry farming areas of Andhra Pradesh. Narayana Rao et al (1989) reported that the available iron content of the soils of Agricultural College Farm, Bapatla was above critical limit. Gopichand et al (1985) reported that the available iron contents of different broad soil groups of Andhra Pradesh were above the critical limit. The soils of Prakasam district had sufficient iron in available form (Anonymous 1988-89).

5.1.11 **Copper**

The available copper content of the soils ranged from 0.40 to 1.00 ppm with an average value of 0.68 ppm. The highest available copper content was recorded in the soils of Inkollu mandal (mean 0.75 ppm), while the lowest value of the same was observed in the soils of Naguluppalapadu mandal (mean 0.61 ppm). All the samples were found to be above the critical limit of available copper, in accordance with the critical limits given by ICAR (1988-89). Gopichand et al, 1985 also reported of that the available copper content of some soil groups of Andhra Pradesh above the critical limit. The available copper content was above critical limit in Vertisols in dryfarming areas of Andhra Pradesh (Subbaiah and Manickam, 1987). The present investigation was in accordance with the reports of above workers.

5.1.12 Manganese

The available manganese content ranged from 2.0 to 5.0 ppm with an average value of 3.5 ppm. The highest value of available manganese was recorded in the soils of Inkollu mandal (mean 3.77 ppm), while the lowest value of the same was recorded in the soils of Naguluppalapadu mandal (mean 3.07 ppm). All the soil samples were found to be above critical limit, in accordance with critical limits given by ICAR (1988-89). The same trend was reported by Subbaiah and Manickam (1987) in Vertisols of Andhra Pradesh. All the farm soils of Agricultural College, Bapatla were above the critical limit (Narayana Rao et al., 1989).

5.1.13 Zinc

The available zinc content of the soils ranged from 0.8 to 2.0 ppm with a mean value of 1.4 ppm. The lowest available zinc content was recorded in the soils of Naguluppalapadu mandal (mean 1.28 ppm) while the highest value of the same was observed in the soils of Inkollu mandal (mean 1.5 ppm). On the whole, 100 per cent samples were above the critical limit, as per the limits given by ICAR (1988-89).

The zinc deficiency in Prakasam district was observed in the earlier investigations (Anonymus, 1988-89).

The rise in available zinc content over the years might be due to the fact that the soils were continuously being fertilized with zinc containing fertilizers.

5.2 CORRELATION STUDIES

5.2.1 MAJOR NUTRIENTS

The available nitrogen was significantly and positively correlated with organic carbon and with all other available nutrients (P, K, Ca, Mg, Fe, Cu, Mn and Zn) and soil characteristics (CEC, Clay and $CaCO_3$).

The available phosphorus had positive and significant correlation with CEC, Clay and organic carbon and negative correlation with pH and $CaCO_3$

The available potassium content was positively and significantly correlated with all other available nutrients (N,P,Ca,Mg,Fe,Cu,Mn and Zn) and soil characteristics (pH, CEC, clay, $CaCO_3$ and OC). All the three major nutrients were in significantly related to EC.

5.2.2 MICRONUTRIENTS

5.2.2.1 Iron

Simple correlation coefficient studies indicated a positive significant correlation between iron and organic carbon. Sakal *et at* (1988) and Singh *et al* (1988) reported a significant positive correlation between organic carbon and available iron. The results further revealed that the available iron was significantly and negatively correlated with the calcium carbonate content. Singh and Dahia (1976) reported that exchangeable and reduceable iron content of soils decreased with an increase in the concentration of calcium carbonate. Simple correlation showed that the available iron was significantly and negatively correlated with pH. The results further revealed that available iron positively and significantly correlated with available zinc, copper and manganese. Similar findings were earlier reported by Singh *et al* (1988). Simple correlation study showed that the available iron was significantly and negatively correlated with CEC and clay. Earlier this trend was reported by Madhavi (1989).

5.2.2.2 Copper

The results revealed that the available copper content of the soils was significantly and positively correlated to with organic carbon. The presence of organic carbon might have promoted the availability of copper, presumbly by supplying complexing and chelating agents as a result of which loss of soluble copper mainly due to fixation and formation of insoluble hydroxides and carbonates was reduced. Similar relationship between available copper and organic carbon was earlier also reported by Sahni et al (1980) and Joshi et al (1983).

Simple correlation showed that the available copper had significant and negative correlation with calcium carbonate. Similar findings were reported by Rawat and Mathpal (1981) and Singh et al (1988). Negative relationship between available copper and calcium carbonate content of soils might be at least in partly be due to the formation of insoluble copper carbonates, as the soils were rich in calcium carbonate.

The available copper content was found to be significantly and positively correlated with the available phosphorus content of the soils. Similar results were reported by Sakal et al (1986) and Sakal et al (1988).

Correlation coefficients revealed that the available copper bore significant and positive correlation with available zinc, manganese and iron. Similar results were reported by Singh et al (1988). Simple correlation revealed that the copper was negatively correlated with CEC and Clay and positively correlated with other available nutrients like, N, K, Ca and Mg.

5.2.2.5 Manganese

Simple correlations revealed that the available manganese was negatively and significantly correlated with soil p^H. The same results were reported earlier by Shukla et al (1975) and Joshi et al (1981).

The available manganese had negative and significant correlation with CEC. The same trend was reported by Patel et al (1972) and Tembhare and Rai (1967). The available manganese content was significantly and negatively correlated with the calcium carbonate content of the soils. Similar findings were earlier reported by Rawat and Mathpal (1981) and Sakal et al (1985). Such negative relationship might be due to the adsorption of manganese on the surface of calcium carbonate particles as suggested by Mulder and Gerretren (1952). The authors further reported that such binding was strong enough and manganese could not be released with neutral normal ammonium acetate solution. Manganese exhibited positive and significant correlation with organic carbon. Sharma and Shinde (1968) observed significant positive correlation between the two variables. Patel et al (1972), Sakal et al (1988) and Tiwari and Mishra (1990) also reported the same trend.

The available manganese content was found to be positive related to available phosphorus. Pathak et al (1972) and Sakal et al (1986) also observed the same trend. Simple correlation further revealed that the available manganese was significantly and positively correlated with available zinc, iron and copper. Singh *et al* (1988) also reported similar relationship between the manganese and other micronutrients. Simple correlation revealed that manganese was negatively and significantly correlated with clay and positively and significantly correlated with other nutrients like N, K, Ca and Mg.

5.2.2.4 Zinc

Simple correlation showed that available zinc had negative and significant correlation with p^H. Similar trend was reported by Ganjir *et al* (1973) and Prasad and Sakal (1988).

Maskin and Randhawa (1980) suggested that the application of organic manure would alleviate zinc deficiency in soils having high p^H. The possibility of adsorption of soluble zinc on calcium carbonate surfaces was further evidenced by the significant negative correlation between available zinc and calcium carbonate content. Sikharulidze *et al* (1973) also reported that zinc was strongly bound by the sites of calcium carbonate in calcareous soils and as a consequence its availability was reduced. Significant negative correlation between available zinc and calcium carbonate was earlier also been reported by Rawat and Mathpal (1981) and Sakal *et al* (1985).

The results of the simple correlation coefficient indicated that available zinc was positively and significantly correlated with available phosphorus. Similar findings were reported by Sakal et al (1986) and Sakal et al (1988).

However, there were some reports on antagonistic effect between zinc and phosphorus, mainly due to the formation of insoluble zinc phosphate in soil resulting in reduced zinc availability (Singh and Singh, 1980; Sakal and Sinha, 1983 and Kamaludin, 1987). Soil processes and mechanisms leading to a significant positive correlation between available zinc and available phosphorus as obtained in the present study, despite the fact that zinc and phosphorus both are being precipitated as insoluble zinc phosphate, need to be explored through further studies.

Zinc was positively and significantly correlated with available iron, manganese and copper. Similar findings were reported by Singh et al (1988). Simple correlations further revealed that the available zinc had negative correlation with CEC, clay and positive correlation with N, K, Ca, Mg. All the four micronutrients had non significant correlation with EC.

5.3 LEAF ANALYSIS

5.3.1 Nitrogen content

The nitrogen content of leaf samples ranged from 3.96 to 5.75 per cent with a mean value of 4.83 per cent. Six per cent of the leaf samples were below the optimum level, while ninety two per cent of leaf samples were optimum level and two per cent of the samples above optimum level. On the whole, the leaf samples recorded the nitrogen in optimum level as per the critical limits given by Subbarao (1975). Earlier reports by Venkateswara Reddy et al (1979) revealed that the nitrogen content of the leaf samples during 1974-75 were below optimum level, while during 1976-77 they were in optimum level. So the present investigation was in accordance with the above findings.

5.3.2 Phosphorus content

The phosphorus content of leaf samples ranged from 0.10 to 0.40 per cent with a mean value of 0.24 per cent. Seventy five per cent of the leaf samples were below optimum level, while twenty five per cent samples were optimum level as per the limits given by Subbarao (1975). On the whole, three fourth of the samples were below optimum level while remaining one fourth of the samples recorded above optimum level. Venkateswara Reddy et al (1979) reported the deficiency of phosphorus in the leaf samples. The present findings were in accordance with the above findings.

5.3.3 **Potassium content**

The potassium content of the leaf samples ranged from 1.21 to 3.0 per cent with a mean value of 2.1 per cent. Almost all leaf samples were found to be above optimum level as per the limits given by Subbarao (1975). The present findings were similar to those of Venkateswara Reddy et al (1979).

5.3.4 **Calcium content**

The calcium content of the leaf samples ranged from 1.66 to 4.0 per cent with a mean value of 2.8 per cent. Out of 100 leaf samples 82 per cent samples were above optimum level and remaining 18 per cent of the leaf samples were in optimum level as per the critical limits given by Subbarao (1975). There was no deficiency of calcium in the leaf samples collected during 1974-75 to 76-77 as reported by Venkateswara Reddy et al (1979).

5.3.5 **Magnesium content**

The magnesium content of the leaf samples ranged from 0.24 to 0.6 per cent with a mean value of 0.40 per cent. Out of 100 leaf samples collected, 96 per cent of the samples were above optimum level and remaining 4 per cent of samples were in optimum level as per the limits given by Subbarao (1975).

There was no deficiency of magnesium in the leaf samples of Prakasam district during 1974-75 to 76-77 ad reported by Venkateswara Reddy et al (1979).

5.3.6 MICRONUTRIENTS

The iron content of the leaf samples ranged from 80 to 200 ppm with a mean 139 ppm. All the leaf samples in all mandals were sufficient in iron as per the limits given by Venkateswarlu (1975). The copper content of the leaf samples ranged from 11.23 to 16.0 ppm with a mean value of 13.56 ppm. Almost all the leaf samples were sufficient in copper content.

The manganese content of the leaf samples ranged from 40 to 100 ppm with a mean value of 69 ppm. All the leaf samples in all mandals were found to be sufficient in manganese content. The zinc content of the leaf samples ranged from 24 to 60 ppm with a mean value of 41 ppm. All the leaf samples in all mandals were found to be at sufficient level in zinc content.

5.3.7 CORRELATION STUDIES

5.3.7.1 MAJOR NUTRIENTS

The nitrogen content in the leaf samples had positive and significant correlation with organic carbon and with all other nutrients such as P, K, Ca, Mg, Fe, Cu, Mn, Zn and the soil characteristics like CEC, Clay, p^H and $CaCO_3$. The phosphorus content in the leaf samples had positive and significant correlation with other nutrients like N, K, Ca, Mg, Fe, Cu, Mn, Zn and soil characteristics like organic carbon, CEC, clay and negatively and significantly correlated with p^H and calcium carbonate. The potassium content in the leaf samples had positive and significant correlation with all the nutrients like N, P, Ca, Mg, Fe, Cu, Mn, Zn and soil characteristics like p^H, CEC, clay and $CaCO_3$.

The calcium content in the leaf samples bore positive and significant correlation with all other nutrients like N, P, K, Mg, Fe, Cu, Mn, Zn and soil characteristics like CEC, p^H, clay, $CaCO_3$ and organic carbon. The magnesium content in the leaf samples was positively and significantly correlated with other nutrients like N, P, K, Ca, Fe, Cu, Mn, Zn and soil characteristics like p^H, CEC, Clay and OC. All the major nutrients were in significant correlation with EC.

5.3.7.2 **MICRONUTRIENTS**

The iron content in the leaf samples had negative and significant correlation with CEC, clay, p^H and $CaCO_3$. It was positively and significantly correlated with the other nutrients like N, P, K, Ca, Mg, Cu, Mn, Zn, organic carbon and p^H. The copper content in the leaf samples had negative and significant correlation with CEC, clay and $CaCO_3$. It was positively and significantly correlated with other nutrients (N, P, K Ca, Mg, Cu, Mn, Zn) and soil characteristics (organic carbon and p^H). The manganese content in the leaf samples had negative and significant correlation with CEC, clay, p^H, $CaCO_3$ and organic carbon, while it was positively and significantly correlated with the other nutrients like N, P, K, Ca, Mg, Fe, Cu, and Zn. The zinc content in the leaf samples had negative and significant correlation with CEC, clay p^H, $CaCO_3$ while it was positively and significantly correlated with the other nutrients like N, P, K, Ca, Mg, Fe, Cu, Mn and organic carbon. All the four micronutrients had non-significant correlation with EC.

Yield of seed cotton

The yield of seed cotton in the survey area widely varied from 1062 to 2625 kg ha^{-1} with a mean value of 1818 kg ha^{-1}.

Among the four varieties (H-44, shobha, MCU-5, LKA-861), Hybrid-44 gave the highest mean seed cotton yield of 2248 kg ha^{-1} followed by Shobha (1821). Both the varieties LKA-861 and MCU-5 yielded comparatively lesser, i.e, 1723 and 1470 kg ha^{-1} respectively than the other two varieties. hybrids recorded higher seed cotton yield than the other two varieties because of their higher yield potential.

STATISTICAL ANALYSIS

From the correlation matrix given in the Appendix-II it was found that the seed cotton yield had shown the highest positive correlation to the extent of 95.6 per cent with the leaf iron followed by soil K 94.5 per cent. The least positive non significant correlation was found with organic carbon content in soil (27.8%).

The general MLR equation is given by

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12} + b_{13}X_{13} + b_{14}X_{14} + b_{15}X_{15} + b_{16}X_{16} + b_{17}X_{17} + b_{18}X_{18} + b_{19}X_{19} + b_{20}X_{20} + b_{21}X_{21} + b_{22}X_{22} + b_{23}X_{23} + b_{24}X_{24} + b_{25}X_{25} + b_{26}X_{26}$$

The fitted MLR equation is given by

$$Y = -1125.88 - 4.87x_1^{*} - 77.05x_2 + 12.87x_3 - 347.70x_4 + 0.21x_5^{*} - 43.46x_6 - 8.85x_7 + 623.81x_8 + 3.20x_9 + 621/25\ x_{10}^{*} + 56.07x_{11} + 7.51x_{12}^{*} + 3582.29x_{13} - 156.06x_{14} + 91.47x_{15} - 0.32x_{16} - 2057.57x_{17} + 19.19x_{18}2 + 34.78x_{19} + 197.43x_{20} - 22.33x_{21} + 2.59x_{22} + 180.33x_{23} + 507.33x_{24} - 60.42_{25}^{*} - 2.61X_{26}$$

x_1 = Soil nitrogen

x_5 = Soil potassium

x_{10} = Leaf magnesium

x_{12} = Leaf iron

x_{25} = OC

Though, the MLR consisted of twenty six (26) independent variables, only five (5) viz., soil nitrogen, soil potassium, leaf magnesium, leaf iron, organic carbon could bring significant variation in yield.

Further, the value of coefficient of multiple determination (R^2) was found to be 0.9673 which was significant. This indicated that twenty six (26) explanatory variables brought out the variation in Y (yield) to the extent of 96.73 per cent combinedly. As the per cent of error was only 3.3, the estimated MLR was a good fit to the data.

From the partial regression coefficients and coefficient of determination values given in Appendix-II, it was evident that Hybrid-44 showed highest R^2 values of 0.9999 and 0.9742 for macro and micronutrients respectively. The R^2 values for Shobha were 0.9147 and 0.9185; for MCU-5 were 0.8492 and 0.7946; for LKA-861 were 0.7114 and 0.8329 for macro and micronutrients respectively. When varieties were compared, it was obvious that Hybrid-44 performed better and was a responsive variety for soil nutrients and the varieties under investigation were in the order of HY-44 > Shobha > LKA-861 > MCU-5. As regards micronutrients, the trend was similar to macronutrients. This was supported very much by yield data i.e., 2243 (HY-44) > 1821 (Shobha) > 1723 (LKA-861) > 1470 (MCU-5) kg ha^{-1} respectively. Thus it can be concluded that overall varietal performance was in the order of Hybrid-44 > Shobha > LKA-861 > MCU-5.

SUMMARY

SUMMARY

Cotton (*Gossypium herbaceum*) is one of the most important cash crops grown in Prakasam district of Andhra Pradesh for many years. Of late, there has been some stray reports indicating the deficiency of plant available nutrients to be a constraining factor in the realisation of optimum yields of cotton. Accordingly, an investigation entitled "study of nutrient status of cotton growing areas in Prakasam district" was under taken. The salient features of the results of this investigation are summarised below.

1. All the soil samples collected from all the four mandals representing the major cotton growing areas of the Prakasam district were found to be neutral to slightly alkaline in reaction, non saline and medium in organic carbon.

2. The available nitrogen content of the soil samples was medium, while in plant samples it was at optimum level. Available phosphorus content of both the soil and leaf samples was low. The potassium content was high in both soil and leaf samples.

3. The cation exchange capacity and calcium carbonate content of the soils were found to be high, indicating a fine texture and or high organic carbon content, and high sorption capacity of the soils, respectively. Calcium was found to be the most dominant exchangeable cation followed by magnesium, sodium and potassium. However calcium alone accounted for 62 to 68 per cent of exchange capacity of the soils.

4. The soil and leaf samples were analysed for Fe, Cu, Mn and Zn. The critical limits for the available Fe, Cu, Zn, Mn in soil proposed by ICAR (1988-89) were adopted. For leaf samples the critical limits proposed by Venkateswarlu (1975) were adopted to categorise leaf samples with regard to their micronutrient status. All the four micro nutrients both in soil and leaf samples in all the four mandals were found to be at sufficient level and no deficiency symptoms were recorded for these micro nutrients.

5. Correlation studies indicated that the nitrogen in both soil and plant had positive and significant correlation with other nutrients and soil characteristics . Phosphorus, potassium, calcium and manganese had positive and significant correlation with one another and micro nutri-

ents. They have negative and significant correlations with soil characteristics. The micro nutrients had positive and significant correlations with one another and with major nutrients. They had negative and significant correlations with soil characteristics and negative and non-significant correlation with EC.

6. In MLR the R^2 (coefficient of multiple determination) value explained the variation of independent variables in 'y' to the extent of 96.73 per cent. So the estimated MLR equation is good fit for the data.

7. Among the four varieties compared, H-44 performed well.

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APPENDIX

INDEX

S.No. = Sample Number

Variety

Yield

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1. Available nitrogen (kg ha^{-1})
2. Leaf nitrogen (%)
3. Available phosphorus (kg ha^{-1})
4. Leaf phosphorus (%)
5. Available potassium (kg ha^{-1})
6. Leaf potassium (%)
7. Available calcium (kg ha^{-1})
8. Leaf calcium (%)
9. Available magnesium (kg ha^{-1})
10. Leaf magnesium (%)
11. Available iron (kg ha^{-1})
12. Leaf iron (%)
13. Available copper (kg ha^{-1})
14. Leaf copper (%)
15. Available manganese (kg ha^{-1})
16. Leaf manganese (%)
17. Available zinc (kg ha^{-1})
18. Leaf zinc (%)
19. Exchangeable potassium (cmol(p+)kg^{-1} soil)
20. Exchangeable sodium (cmol(p+)kg^{-1} soil)
21. CEC (cmol(p+)kg^{-1} soil)
22. Clay content (%)
23. Silt (%)
24. Sand (%)
25. Bulk density (Mg m^{-3})
26. pH
27. Electrical conductivity (dS m^{-1})
28. Organic carbon (%)
29. Calcium carbonate (%)

Appendix - 1 : Analytical results pertaining to the individual soil and leaf samples

S. No.	Variety	Yield	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1.	MCU-5	1500	285	3.71	14.28	0.28	451	1.71	17.14	2.28	3.42	0.34	4.85	114	0.57	12.57	2.85	57	1.14	34	0.34	2.85	26.00	30.50	14.28	55.22	2.0	7.10	0.45	0.57	9.00
2.	MCU-5	1375	261	3.57	13.09	0.26	413	1.57	15.71	2.09	3.14	0.31	4.45	104	0.52	12.19	2.61	52	1.04	31	0.31	2.61	24.00	30.00	13.09	56.91	2.0	8.20	0.41	0.52	10.0
3.	MCU-5	1562	297	3.78	14.87	0.29	470	1.78	17.85	2.38	3.57	0.35	5.05	119	0.59	12.76	2.97	59	1.19	35	0.35	2.97	26.00	31.50	14.87	53.63	1.9	8.10	0.47	0.59	9.00
4.	MCU-5	1875	357	4.14	17.85	0.35	564	2.14	21.42	2.85	4.28	0.42	6.07	142	0.71	12.71	3.57	71	1.42	42	0.42	3.57	30.50	33.00	17.85	49.14	1.9	7.80	0.57	0.71	8.50
5.	MCU-5	1525	290	3.74	14.52	0.29	450	1.74	17.42	2.32	3.48	0.34	4.93	116	0.58	12.64	2.90	58	1.16	34	0.34	2.90	25.25	29.50	14.52	55.97	2.0	7.90	0.46	0.58	9.00
6.	MCU-5	1562	297	3.78	14.87	0.29	458	1.78	17.42	2.38	3.57	0.35	5.05	119	0.59	12.76	2.97	59	1.19	35	0.35	2.97	26.91	31.00	14.87	54.12	2.0	7.60	0.47	0.59	8.50
7.	MCU-5	1687	266	3.60	13.33	0.26	421	1.60	16.00	2.13	3.70	0.32	4.53	106	0.53	12.76	2.66	53	1.06	32	0.30	3.21	25.50	28.00	16.06	55.93	2.0	7.70	0.51	0.64	8.00
8.	MCU-5	1400	321	3.92	16.60	0.32	507	1.92	19.28	2.57	3.85	0.38	5.46	128	0.63	13.14	3.21	64	1.28	38	0.32	2.66	28.90	30.50	13.33	56.16	2.1	7.80	0.42	0.53	9.00
9.	MCU-5	1425	271	3.62	13.57	0.27	428	1.62	16.28	2.17	3.25	0.32	4.61	108	0.54	12.34	2.71	54	1.08	32	0.32	2.71	25.00	29.00	13.57	57.42	2.1	7.70	0.43	0.54	8.50
10.	MCU-5	1387	264	3.58	13.20	0.26	417	1.58	15.85	2.11	3.17	0.31	4.49	105	0.52	12.22	2.64	52	1.05	31	0.31	2.64	23.50	26.00	13.20	60.72	2.0	8.00	0.42	0.52	10.0
11.	H-44	2250	420	4.57	21.42	0.42	677	2.57	25.71	3.42	5.14	0.51	7.28	171	0.85	14.85	4.28	85	1.71	51	0.51	4.28	36.50	42.00	22.01	41.98	1.8	7.60	0.68	0.85	6.00
12.	H-44	1750	333	4.00	16.66	0.33	526	2.00	20.00	2.66	4.00	0.40	5.66	133	0.66	13.33	3.33	66	1.35	40	0.58	4.80	42.50	47.00	21.42	39.09	1.9	7.20	0.78	0.97	6.50
13.	H-44	2375	452	4.71	22.61	0.45	714	2.71	27.14	3.61	5.42	0.54	7.69	180	0.90	15.23	4.52	90	1.80	54	0.54	4.52	40.00	44.00	19.04	40.95	2.0	7.30	0.72	0.90	6.50
14.	LKA-861	2312	440	4.64	22.00	0.44	695	2.64	26.42	3.52	5.28	0.52	7.48	180	0.88	15.04	4.40	88	1.76	52	0.52	4.40	38.00	42.00	22.61	34.39	1.8	7.90	0.70	0.88	7.00
15.	LKA-861	2300	438	4.62	21.90	0.43	692	2.62	26.28	3.51	5.25	0.52	7.44	175	0.87	15.00	4.38	87	1.75	52	0.52	4.39	39.00	43.00	23.20	32.99	1.9	7.60	0.70	0.87	6.50
16.	Shobha	1750	333	4.00	16.66	0.33	526	2.00	20.00	2.66	4.00	0.40	5.66	133	0.66	13.33	3.33	66	1.33	40	0.40	3.30	30.00	35.00	15.47	53.52	2.0	7.60	0.53	0.66	9.50
17.	Shobha	1687	321	3.92	16.06	0.32	507	1.92	19.28	2.57	3.85	0.38	5.46	128	0.64	13.14	3.21	64	1.28	38	0.38	3.21	29.00	34.00	14.87	56.12	2.0	7.60	0.51	0.64	9.00
18.	Shobha	1625	309	3.85	15.47	0.30	489	1.85	18.57	2.47	3.71	0.37	5.42	123	0.61	12.95	3.09	61	1.23	37	0.37	3.09	27.00	32.00	16.06	49.93	2.1	7.60	0.49	0.61	9.00
19.	Shobha	1562	297	3.78	14.87	0.29	470	2.49	24.99	2.38	3.57	0.35	5.05	119	0.59	12.76	2.97	59	1.19	35	0.35	2.97	33.00	30.00	15.47	52.52	2.0	7.90	0.47	0.59	10.0
20.	Shobha	1625	309	3.85	15.47	0.30	489	1.85	18.57	2.47	3.71	0.37	5.42	123	0.61	12.95	3.09	61	1.23	37	0.37	3.09	27.00	32.00	16.66	48.33	1.8	7.40	0.49	0.61	10.0
21.	H-44	1750	333	4.00	16.66	0.33	526	2.00	27.85	2.66	4.00	0.40	5.66	133	0.66	13.33	3.33	66	1.33	40	0.40	3.33	41.00	34.00	22.61	33.38	1.8	6.50	0.53	0.66	9.00
22.	H-44	1750	333	4.00	16.66	0.33	526	2.00	30.00	2.66	4.00	0.40	5.66	133	0.66	13.33	3.33	66	1.33	40	0.40	3.33	41.00	34.00	22.01	34.18	1.9	7.40	0.53	0.66	7.50
23.	H-44	2625	500	5.00	25.00	0.50	790	3.00	20.00	4.00	6.00	0.60	8.50	200	1.00	16.00	5.00	100	2.0	60	0.60	5.00	33.00	46.00	20.23	39.76	1.8	7.00	0.79	1.00	6.00
24.	MCU-5	1525	290	3.74	14.52	0.19	458	1.74	17.42	2.32	3.48	0.34	4.93	116	0.58	12.64	2.90	58	1.16	34	0.34	2.90	25.50	31.00	14.52	54.42	2.1	7.60	0.46	0.58	9.50
25.	MCU-5	1562	297	3.78	14.87	0.29	470	1.78	17.85	2.38	3.57	0.35	5.05	119	0.59	12.76	2.92	59	1.19	35	0.35	2.97	25.00	29.00	14.87	56.72	2.0	7.90	0.47	0.59	8.00
26.	LKA-861	1437	273	3.64	13.68	0.27	432	1.64	16.42	2.18	3.28	0.32	4.65	109	0.54	12.37	2.73	54	1.09	32	0.32	2.73	26.00	29.00	13.68	57.31	2.0	7.60	0.64	0.54	8.50
27.	LKA-861	1500	285	3.71	14.28	0.28	451	1.71	17.14	2.28	3.42	0.34	4.85	114	0.57	12.57	2.85	57	1.14	34	0.34	2.85	27.00	32.00	14.28	53.71	2.0	8.00	0.43	0.57	9.00
28.	LKA-861	2000	380	4.28	19.04	0.38	601	2.28	22.85	3.04	4.57	0.45	6.47	152	0.76	14.09	3.80	26	1.52	45	0.45	3.80	34.00	39.00	19.04	42.96	1.9	7.60	0.45	0.76	8.50
29.	LKA-861	2000	380	4.28	19.04	0.38	601	2.28	22.85	3.04	4.57	0.45	6.47	152	0.76	14.09	3.80	26	1.52	45	0.45	3.80	33.50	38.00	19.04	41.95	1.8	7.20	0.60	0.76	9.00
30.	Shobha	2125	404	4.42	20.23	0.40	639	2.22	24.28	3.23	4.85	0.48	6.88	161	0.80	14.47	4.04	80	1.61	48	0.48	4.04	35.00	40.00	16.66	48.33	2.0	7.80	0.64	0.80	8.50
31.	Shobha	2000	380	4.28	19.04	0.38	601	2.28	22.85	3.04	4.57	0.45	6.47	152	0.76	14.09	3.80	76	1.52	45	0.45	3.80	33.00	39.00	20.29	39.76	2.0	7.90	0.60	0.76	8.00

Contd........

S. No.	Variety	Yield	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
32.	Shobha	2187	416	4.49	20.82	0.41	658	1.78	17.85	3.33	4.99	0.49	7.08	166	0.83	14.66	4.16	83	1.66	49	0.49	4.16	30.00	38.00	19.04	41.95	1.9	7.90	0.66	0.83	8.50
33.	Shobha	1562	297	3.78	14.81	0.29	470	1.28	17.85	2.38	3.57	0.35	5.05	119	0.59	12.76	2.97	59	1.19	35	0.35	2.97	25.00	29.00	20.82	41.17	1.8	8.30	0.47	0.59	9.50
34.	Shobha	2025	385	4.31	19.28	0.38	609	2.31	23.14	3.08	4.62	0.46	6.55	154	0.77	14.17	3.85	77	1.54	46	0.46	3.85	33.00	37.00	16.66	47.33	1.9	7.90	0.61	0.77	8.00
35.	Shobha	1750	333	4.00	16.66	0.33	526	2.00	20.00	2.66	4.00	0.40	5.66	133	0.66	13.33	3.33	66	1.33	40	0.40	3.33	30.00	36.00	14.87	55.12	2.0	7.40	0.53	0.66	9.50
36.	Shobha	1687	321	3.92	16.06	0.32	507	1.98	19.28	2.57	3.85	0.38	5.46	128	0.64	13.14	3.21	64	1.28	38	0.38	3.21	28.00	38.00	19.28	43.71	2.0	8.00	0.51	0.64	9.50
37.	Shobha	1750	333	4.00	16.66	0.33	526	2.00	20.00	2.66	4.00	0.40	5.66	133	0.66	13.33	3.33	66	1.33	40	0.40	3.33	30.30	35.00	16.06	49.93	1.9	7.80	0.53	0.66	9.00
38.	Shobha	1562	297	3.78	14.87	0.29	470	1.78	26.00	2.38	3.57	0.35	5.05	119	0.59	12.76	2.97	59	1.19	35	0.35	2.97	33.00	32.00	15.47	52.52	2.0	7.40	0.47	0.59	10.0
39.	Shobha	1750	333	4.00	16.66	0.33	526	2.00	20.00	2.66	4.00	0.40	5.66	133	0.66	13.33	3.33	66	1.33	40	0.40	3.33	31.00	36.00	14.87	53.12	2.1	7.10	0.53	0.66	9.50
40.	Shobha	2275	433	4.60	21.66	0.43	684	2.60	17.89	3.46	5.20	0.52	7.36	173	0.86	14.93	4.33	86	1.73	52	0.52	4.33	29.00	42.00	16.66	47.37	2.0	7.00	0.69	0.86	8.00
41.	Shobha	1687	392	4.35	19.63	0.39	620	2.45	23.56	3.14	4.71	0.38	6.67	157	0.78	14.28	3.92	78	1.57	47	0.47	3.92	30.00	37.00	19.63	43.36	1.8	7.80	0.62	6.64	7.50
42.	Shobha	2187	416	4.49	20.82	0.41	658	2.39	24.99	3.33	4.99	0.40	7.08	166	0.83	14.66	4.16	83	1.66	49	0.49	4.16	35.00	40.00	16.06	41.90	2.0	7.90	0.66	0.83	6.50
43.	Shobha	1750	333	4.00	16.66	0.33	526	2.00	20.00	2.66	4.00	0.49	5.66	133	0.66	13.33	3.33	66	1.33	40	0.40	3.33	31.00	30.00	20.82	39.17	1.9	7.60	0.53	0.66	7.50
44.	MCU-5	1562	297	3.57	14.87	0.29	470	1.78	17.85	2.38	3.57	0.35	5.05	119	0.59	12.76	2.92	59	1.19	35	0.35	2.97	25.00	29.00	14.87	57.12	2.0	7.90	0.47	0.59	9.50
45.	MCU-5	1375	261	3.78	13.09	0.26	413	1.57	15.71	2.09	3.14	0.31	4.45	104	0.52	12.19	2.61	52	1.04	31	0.31	2.61	23.00	29.00	13.09	57.90	2.0	7.91	0.41	0.52	9.50
46.	MCU-5	1375	261	3.57	13.09	0.26	413	1.57	15.71	2.09	3.14	0.28	4.45	104	0.47	12.19	2.61	52	0.95	31	0.31	2.61	25.00	29.00	13.09	57.90	2.0	7.80	0.41	0.52	10.0
47.	MCU-5	1250	238	3.42	11.90	0.23	376	1.42	14.28	1.90	2.85	0.31	4.04	95	0.52	13.80	2.38	47	1.04	28	0.28	2.38	23.00	28.00	11.90	60.09	2.0	7.90	0.38	0.47	10.0
48.	MCU-5	1250	238	3.42	13.09	0.23	376	1.57	14.28	1.90	2.85	0.28	4.04	95	0.47	11.80	2.38	47	0.75	28	0.28	2.38	22.50	27.00	19.04	41.95	1.8	7.60	0.38	0.47	27.0
49.	MCU-5	1375	261	3.57	11.90	0.26	413	1.42	15.71	2.09	3.14	0.31	4.45	104	0.52	12.19	2.61	52	1.04	31	0.31	2.61	24.00	29.00	13.09	57.90	2.1	7.60	0.41	0.52	9.00
50.	MCU-5	1375	261	3.57	13.09	0.26	413	1.57	15.71	2.09	3.14	0.34	4.45	104	0.52	12.19	2.61	52	1.04	31	0.31	2.61	23.50	29.00	13.09	57.90	2.0	7.90	0.41	0.52	9.00
51.	MCU-5	1312	249	3.49	12.49	0.34	394	1.48	14.99	1.99	2.99	0.29	4.24	114	0.49	11.99	2.49	49	0.99	29	0.29	2.40	22.00	25.00	12.49	62.50	2.1	8.10	0.39	0.49	10.0
52.	MCU-5	1500	285	3.71	14.28	0.28	451	1.71	17.42	2.28	3.42	0.34	4.85	99	0.57	12.57	2.97	57	1.14	34	0.34	2.85	24.50	26.60	14.28	59.01	2.0	7.60	0.45	0.57	8.50
53.	MCU-5	1562	297	3.78	14.87	0.29	470	1.78	17.14	2.38	3.57	0.35	5.05	119	0.59	12.76	2.85	59	1.19	35	0.35	2.97	24.50	25.00	14.87	60.13	1.9	7.90	0.47	0.59	9.00
54.	LKA-861	1250	238	3.42	11.90	0.23	376	1.42	14.28	1.90	2.85	0.28	4.04	95	0.47	11.80	2.38	47	0.95	28	0.28	2.38	22.00	26.00	11.90	62.09	2.1	8.00	0.47	0.47	10.0
55.	LKA-861	1312	249	3.49	12.49	0.24	394	1.49	14.99	1.99	2.99	0.29	4.24	99	0.49	11.99	2.49	49	0.99	29	0.29	2.49	21.00	25.00	12.49	62.50	2.1	8.20	0.38	0.49	10.0
56.	LKA-861	1500	202	3.21	10.11	0.20	319	1.21	12.13	1.61	2.42	0.24	3.43	114	0.40	11.23	2.02	40	0.80	24	0.34	2.85	19.50	19.50	14.28	61.70	2.1	7.80	0.39	0.57	9.50
57.	LKA-861	1062	285	3.71	14.28	0.28	451	1.71	17.14	2.28	3.42	0.34	4.80	80	0.57	12.53	2.87	57	1.14	34	0.24	2.02	23.50	27.00	10.11	62.88	2.1	8.00	0.45	0.40	10.0
58.	LKA-861	1562	297	3.78	14.87	0.29	470	1.78	17.85	2.38	3.57	0.35	5.05	114	0.59	12.76	2.97	59	1.19	35	0.35	2.97	24.00	28.00	14.87	57.12	2.0	7.80	0.32	0.59	9.00
59.	LKA-861	1500	285	3.71	14.28	0.28	451	1.71	17.14	2.28	3.42	0.34	4.85	119	0.57	12.57	2.85	57	1.14	34	0.34	2.85	25.00	29.00	14.28	56.71	2.0	7.80	0.47	0.57	9.00
60.	LKA-861	2125	404	4.42	20.23	0.40	639	2.42	24.28	3.23	4.85	0.80	6.88	161	0.80	14.47	4.04	80	1.61	48	0.48	4.04	35.00	40.00	20.23	39.76	1.8	7.40	0.45	0.80	6.00
61.	LKA-861	2375	452	4.71	22.61	0.45	714	2.71	25.14	3.61	5.42	0.54	7.69	180	0.90	15.23	4.52	90	1.80	54	0.54	4.52	36.00	40.00	16.06	50.93	1.9	7.60	0.72	0.90	6.00
62.	Shobha	2250	428	4.57	21.42	0.42	677	2.00	27.14	3.42	5.14	0.51	7.28	171	0.85	14.85	4.28	85	1.71	51	0.40	3.33	37.00	35.00	16.66	49.34	3.0	7.80	0.68	0.66	9.00
63.	Shobha	1750	333	4.00	16.66	0.33	526	2.57	20.00	2.66	4.00	0.40	5.66	133	0.66	13.33	3.33	66	1.33	40	0.35	2.97	25.00	29.00	21.42	38.57	1.8	7.70	0.53	0.59	8.00
64.	Shobha	1625	309	3.85	15.47	0.30	489	1.67	27.14	2.47	3.71	0.37	5.26	123	0.61	12.95	3.09	61	1.23	37	0.37	3.09	34.00	33.00	16.66	48.33	1.9	7.60	0.49	0.61	9.00

Contd.......

S. No.	Variety	Yield	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
65.	Shobha	1687	321	3.92	16.06	0.32	507	1.98	26.42	2.57	2.85	0.38	5.46	128	0.64	13.14	3.21	64	1.28	38	0.38	3.21	34.00	32.00	15.47	51.52	2.1	7.50	0.51	0.64	9.50
66.	Shobha	1625	309	3.85	15.47	0.30	489	1.85	18.57	2.47	3.71	0.37	5.76	123	0.61	12.95	3.09	61	1.23	37	0.37	3.09	26.00	31.00	16.06	51.93	2.0	7.40	0.49	0.61	8.50
67.	H-44	2312	440	4.64	22.00	0.44	695	2.64	26.42	3.52	5.28	0.52	7.48	176	0.88	15.04	4.40	88	1.76	52	0.52	4.40	38.00	43.00	22.61	35.38	1.8	7.00	0.70	0.88	6.00
68.	H-44	2125	404	4.42	20.23	0.40	639	2.42	24.28	3.23	4.85	0.48	6.88	161	0.80	14.41	4.04	80	1.61	48	0.48	4.04	35.00	40.00	21.90	35.07	1.9	7.40	0.64	0.88	7.00
69.	H-44	2062	392	4.35	19.63	0.39	620	2.35	23.56	3.14	4.71	0.47	6.67	157	0.78	14.28	3.92	78	1.57	47	0.47	3.92	33.00	37.00	21.42	37.57	1.8	7.00	0.62	0.78	6.50
70.	H-44	2300	380	4.28	19.04	0.43	691	2.28	22.85	3.04	4.57	0.45	6.47	175	0.76	14.09	3.08	76	1.52	45	0.52	4.38	33.00	38.00	22.61	35.38	1.8	7.10	0.70	0.87	6.00
71.	H-44	2312	440	4.64	22.00	0.44	695	2.64	26.42	3.52	5.28	0.52	7.48	176	0.88	15.04	4.40	88	1.76	52	0.52	4.40	37.50	36.00	22.01	35.98	1.8	7.60	0.70	0.88	6.00
72.	H-44	2250	428	4.57	21.42	0.42	677	2.57	25.71	3.42	5.14	0.51	7.28	171	0.85	14.85	4.28	85	1.71	51	0.51	4.28	30.00	39.50	21.90	35.89	1.9	7.30	0.68	0.85	7.00
73.	H-44	2000	438	4.62	21.90	0.38	601	2.62	26.28	3.51	5.25	0.52	7.44	152	0.87	15.00	4.38	87	1.75	52	0.45	3.80	37.50	40.00	22.01	33.98	1.9	7.00	0.60	0.76	7.50
74.	H-44	2375	452	4.71	22.61	0.45	714	2.71	27.14	3.61	5.42	0.54	7.69	180	0.90	15.23	4.52	90	1.80	54	0.54	4.52	39.50	42.00	22.01	35.99	1.9	7.60	0.72	0.90	6.00
75.	H-44	2300	438	4.62	21.90	0.43	692	2.62	26.28	3.51	5.25	0.52	7.44	175	0.87	15.00	4.38	87	1.75	52	0.52	4.38	38.00	43.00	19.63	38.37	1.9	7.60	0.70	0.87	6.50
76.	H-44	2250	428	4.57	21.42	0.42	677	2.57	25.71	3.42	5.14	0.51	7.28	171	0.85	14.85	4.28	85	1.71	51	0.51	4.28	37.00	41.00	22.61	37.28	1.8	7.70	0.68	0.85	6.50
77.	LKA-861	2375	452	4.71	22.61	0.45	714	2.71	18.57	3.61	5.42	0.54	7.69	176	0.90	15.23	4.52	90	1.80	54	0.54	4.52	31.00	42.00	22.61	37.38	1.8	7.40	0.72	0.90	6.00
78.	LKA-861	2312	440	4.64	22.00	0.44	695	2.64	19.28	3.52	5.28	0.52	7.48	176	0.80	15.04	4.40	88	1.76	52	0.52	4.40	32.00	44.00	19.63	58.36	2.0	7.60	0.70	0.88	6.50
79.	LKA-861	2312	440	4.64	22.00	0.44	695	2.64	26.42	3.52	5.28	0.52	7.48	176	0.88	15.04	4.40	88	1.76	52	0.52	4.40	39.00	42.00	19.63	43.36	2.0	7.40	0.70	0.88	6.00
80.	LKA-861	2062	392	4.35	19.63	0.39	620	2.35	23.56	3.14	4.71	0.47	6.67	157	0.78	14.28	3.92	78	1.57	47	0.47	3.92	39.00	42.00	16.66	48.33	1.8	7.30	0.62	0.78	6.50
81.	LKA-861	1500	285	3.71	14.28	0.28	451	1.71	17.14	2.28	3.42	0.34	4.85	114	0.57	12.57	2.85	57	1.14	34	0.34	2.85	25.00	39.00	14.28	46.71	2.0	7.60	0.45	0.57	6.50
82.	LKA-861	1625	309	3.85	15.47	0.30	489	1.85	18.57	2.47	3.71	0.37	5.26	123	0.61	12.97	3.09	69	1.23	37	0.37	3.09	27.00	40.00	15.47	44.52	2.1	7.60	0.49	0.61	9.50
83.	LKA-861	1937	368	4.21	18.44	0.36	582	2.21	22.13	2.95	4.42	0.44	6.27	147	0.73	13.90	3.68	73	1.47	44	0.44	3.68	33.00	38.00	18.44	43.55	1.9	7.40	0.59	0.73	6.50
84.	LKA-861	1750	333	4.00	16.66	0.33	526	2.00	20.00	2.66	4.00	0.40	5.66	133	0.66	13.33	3.33	66	1.33	40	0.40	3.33	30.00	33.00	16.66	58.33	2.0	7.90	0.53	0.66	9.50
85.	LKA-861	1687	321	3.92	16.06	0.32	507	1.92	19.28	2.57	3.85	0.38	5.46	128	0.64	13.14	3.21	64	1.28	38	0.38	3.21	30.00	35.00	16.06	48.93	1.9	7.80	0.51	0.64	7.50
86.	LKA-861	1607	321	3.92	16.06	0.32	507	1.92	19.28	2.57	3.85	0.38	5.46	128	0.64	13.14	3.21	64	1.28	38	0.38	3.21	29.00	33.00	16.06	58.93	2.0	8.10	0.51	0.64	9.50
87.	LKA-861	1750	333	4.00	16.66	0.33	526	2.00	20.00	2.66	4.00	0.40	4.85	133	0.66	12.57	2.85	66	1.33	34	0.40	3.33	30.00	34.00	16.66	49.33	1.8	7.50	0.53	0.66	8.00
88.	LKA-861	1500	392	4.35	19.63	0.39	620	2.35	23.56	3.14	4.71	0.47	6.67	157	0.78	14.28	3.92	78	1.57	47	0.34	2.85	33.50	37.00	14.28	48.71	2.0	7.30	0.45	0.57	9.00
89.	H-44	2375	452	4.71	22.61	0.45	714	2.71	19.28	3.61	5.42	0.54	7.69	180	0.90	15.23	4.52	90	1.80	54	0.54	4.52	32.00	43.00	16.66	58.33	1.8	7.50	0.72	0.90	6.00
90.	H-44	2437	464	4.76	23.20	0.46	733	2.78	20.08	3.71	5.57	0.55	7.89	185	0.92	15.42	4.64	92	1.88	55	0.55	4.64	32.00	44.00	25.00	29.00	1.9	7.30	0.74	0.92	6.50
91.	H-44	2062	285	3.71	14.28	0.28	451	1.71	17.14	2.28	3.42	0.34	5.66	114	0.57	13.33	3.33	57	1.14	40	0.47	3.97	25.00	30.00	24.40	28.60	1.8	6.80	0.62	0.78	7.00
92.	H-44	2062	392	4.35	19.63	0.39	620	2.35	23.56	3.14	4.71	0.47	6.67	157	0.78	14.28	3.92	78	1.57	47	0.47	3.92	32.00	37.00	21.42	36.57	1.9	7.40	0.62	0.78	7.00
93.	H-44	1750	333	4.00	16.66	0.33	526	2.00	20.00	2.66	4.00	0.40	5.66	133	0.66	13.33	3.33	66	1.33	40	0.40	3.33	31.00	35.00	22.01	36.98	1.8	7.80	0.53	0.66	9.00
94.	H-44	1687	321	3.92	16.06	0.32	507	1.92	22.14	2.57	3.85	0.38	5.46	128	0.64	13.14	3.21	64	1.28	38	0.38	3.21	37.00	33.00	21.42	36.57	1.8	7.50	0.51	0.64	9.50
95.	H-44	1750	333	4.00	16.66	0.33	526	2.00	27.85	2.66	4.00	0.40	5.66	133	0.66	13.33	3.33	66	1.33	40	0.40	3.33	41.00	34.00	16.66	48.33	1.9	6.50	0.53	0.66	9.00
96.	H-44	1750	333	4.00	16.66	0.33	526	2.00	30.00	2.66	4.00	0.40	5.66	133	0.66	13.33	3.33	66	1.33	40	0.40	3.33	43.50	33.00	22.61	33.38	1.8	7.40	0.53	0.66	7.50
97.	H-44	2625	500	5.00	25.00	0.50	790	3.00	20.00	4.00	6.00	0.60	8.50	200	1.00	16.00	5.00	100	2.0	60	0.60	5.00	33.00	46.00	22.01	34.18	1.9	7.00	0.79	1.00	6.00
98.	H-44	2562	488	4.92	24.40	0.48	771	2.91	29.28	3.90	5.85	0.58	8.29	195	0.97	15.80	4.88	97	1.95	58	0.40	3.33	30.00	35.00	20.23	39.76	1.8	6.90	0.53	0.66	8.50
99.	H-44	2250	428	4.57	21.42	0.42	677	2.57	25.71	3.42	5.14	0.51	7.28	171	0.85	14.85	4.28	85	1.71	51	0.51	4.28	37.00	42.00	19.63	43.36	1.9	7.40	0.68	0.85	7.00
100.	H-44	2312	440	4.64	22.00	0.44	695	2.64	26.42	3.52	5.28	0.52	7.48	176	0.88	15.04	4.40	88	1.76	52	0.52	4.40	37.50	41.00	21.90	43.00	1.8	7.30	0.70	0.88	6.50

Appendix - II : Correlation matrix of independent variables

Yield	1	2	3	4	5	6	7	8	9	10	11	12	13
1.000	0.938	0.936	0.936	0.926	0.945	0.873	0.938	0.938	0.932	0.851	0.944	0.956	0.938
	1.000	0.997	0.999	0.975	0.993	0.941	1.000	1.000	0.993	0.886	0.995	0.975	0.999
		1.000	0.996	0.973	0.991	0.939	0.997	0.997	0.990	0.884	0.992	0.972	0.996
			1.000	0.973	0.992	0.942	0.998	0.999	0.992	0.885	0.994	0.974	0.997
				1.000	0.981	0.918	0.975	0.975	0.968	0.864	0.970	0.971	0.973
					1.000	0.934	0.993	0.993	0.986	0.880	0.988	0.982	0.992
						1.000	0.941	0.941	0.933	0.832	0.936	0.917	0.939
							1.000	1.000	0.993	0.896	0.995	0.974	0.998
								1.000	0.993	0.885	0.995	0.975	0.999
									1.000	0.890	0.988	0.968	0.991
										1.000	0.881	0.863	0.885
											1.000	0.971	0.994
												1.000	0.974
													1.000

14	15	16	17	18	19	20	21	22	23	24	25	26
0.924	0.930	0.827	0.936	0.943	0.930	0.929	0.883	0.828	0.640	0.376	0.178	-0.583
0.975	0.990	0.886	0.999	0.994	0.889	0.887	0.917	0.859	0.606	0.356	0.265	0.559
0.972	0.987	0.884	0.996	0.992	0.888	0.885	0.915	0.860	0.608	0.354	0.265	0.561
0.974	0.988	0.885	0.998	0.993	0.887	0.884	0.916	0.858	-0.607	0.353	0.265	-0.533
0.950	0.957	0.859	0.973	0.969	0.881	0.876	0.897	0.837	-0.588	0.346	0.265	-0.560
0.968	0.974	0.880	0.992	0.988	0.896	0.894	0.910	0.856	0.599	0.363	0.267	0.565
0.916	0.930	0.832	0.940	0.937	0.844	0.842	0.863	0.809	0.548	0.301	0.277	0.523
0.975	0.990	0.886	0.999	0.994	0.890	0.887	0.917	0.861	0.609	0.355	0.265	0.560
0.975	0.990	0.886	0.999	0.994	0.889	0.887	0.917	0.859	0.608	0.355	0.266	0.560
0.968	0.982	0.879	0.992	0.988	0.884	0.881	0.911	0.856	0.607	0.350	0.265	-0.560
0.869	0.877	0.786	0.886	0.882	0.792	0.789	0.836	0.796	0.459	0.289	0.144	-0.530
0.979	0.994	0.882	0.994	0.999	0.896	0.894	-0.910	-0.855	-0.614	0.161	0.266	-0.563
0.950	0.955	0.863	0.974	0.969	0.907	0.904	-0.899	-0.839	-0.591	0.155	0.278	-0.563
0.980	0.988	0.883	1.000	0.993	0.889	0.887	-0.915	-0.859	0.609	0.155	0.265	-0.562
1.000	0.974	0.863	0.980	0.979	0.875	0.873	-0.896	-0.845	0.627	0.142	0.262	-0.556
	1.000	0.876	0.988	0.994	0.981	0.878	-0.906	-0.850	-0.613	0.147	-0.264	-0.551
		1.000	0.885	0.883	0.786	0.781	-0.801	-0.752	-0.449	0.102	-0.241	-0.525
			1.000	0.993	0.889	0.887	-0.917	-0.860	-0.605	0.156	0.266	-0.560
				1.000	0.897	0.894	-0.912	-0.858	-0.612	0.163	0.271	-0.565
					1.000	0.999	0.931	0.877	0.596	0.225	0.296	-0.611
						1.000	0.930	0.873	0.598	0.226	0.293	-0.609
							1.000	0.942	0.596	0.286	0.207	-0.566
								1.000	0.554	0.223	0.238	-0.543
									1.000	0.240	0.037	-0.239
										1.000	0.272	-0.575
											1.000	-0.176
												1.000

'r' table value for 99df = 0.197 at 5% level

Appendix - III : Partial Regression Coefficients (PRC) and coefficient of determination (R^2) values of different varieties

(a) **Macronutrients**

PRC	H-44	Shobha	MCU-5	LKA-861
X_1	-12.65	192.196	-14.72	161.76
X_2	2834.69	-14464.31	-85.79	-11534.94
X_3	684.37*	-736.60	-470.80*	14893.46
X_4	596.54*	-16168.09	186.168	5403.28
X_5	2.96*	-149.187	0.374	-130.90
X_6	-882.17	14.47	3915.65*	22552.22
X_7	-301.32*	2784.97	3.544	-10447.92
X_8	663.82	2345.24	-3549.13	-5903.07
X_9	-1651.05*	53.07	3933.67	-7773.44
X_{10}	-683.00*	2107.85*	432	341.57
R^2 value	0.9999	0.9147	0.8492	0.7114

* Significant at 5% level

(b) **Micronutrients**

PRC	H-44	Shobha	LKA-861	MCU-5
X_1	264.58	-70.35	2934.085	-937.87
X_2	12.27*	-495.33	10.17	0.632
X_3	-5685.60	11790.18	-3200.60	20104.39*
X_4	-56.36	-3539.43	-2089.49	3006.11
X_5	-34.39	18669.06	7475.18	-314.03
X_6	51.81	-110.61	-1.06	-167.32
X_7	-1058	40589.69*	359.12	-10482.67*
X_8	18.58	-82.45	33.30	93.17
R^2 value	0.9742	0.9195	0.8329	0.7946

* Significant at 5% level