"NITROGEN AVAILABILITY AND FERTILIZER 'N' RECOMMENDATION FOR RICE IN SOILS UNDER SREERAMSAGAR PROJECT COMMAND"

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M.Sc. (Ag.)

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CERTIFICATE

Mr. B.R. BHASKAR RAO,. has satisfactorily prosecuted the Course of the Research and that the Thesis entitled "NITROGEN AVAILABILITY AND FERTILISER 'N' RECOMMENDATION FOR RICE IN SOILS UNDER SRIRAMSAGAR PROJECT COMMAND" submitted is the result of original Research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the Thesis or part thereof has not been previously submitted by him for a Degree of any University.

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No part of the Thesis has been submitted for any other Degree of Diploma. The published part has been fully acknowledged. All the assistance and help received during the course of investigation have been duly acknowledged by the author of the Thesis.

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LIST OF SYMBOLS AND ABBREVIATIONS

N	:	Nitrogen
P	:	Phosphorus
K	:	Potassium
KM-N (or) $KMnO_4$-N	:	Potassium Permanganate Method of Nitrogen
OC	:	Organic Carbon (%)
R^2	:	Coefficient of Predictablity
σ or S.D	:	Standard deviation
R B D	:	Randamized Block Design
S R S P	:	Sreeramsagar Project
Kg ha^{-1} (or) Kg/ha	:	Kilogram per Hectare
NR	:	Nutrient Requirement
CS	:	Contribution from Soil
CF	:	Contribution from Fertilizer
T	:	Target
SN	:	Soil Nitrogen
SP	:	Soil Phosphorus
SK	:	Soil Potassium
Kg/Kg	:	Kilogram/ Kilogram
IRRI	:	International Rice Research Institute
$CaCl_2$	:	Calcium Chloride
$Ca(OH)_2$	:	Calcium Hydroxide
C.V	:	Coefficient of Variation

$CaCO_3$	:	Calcium Carbonate
NaOH	:	Sodium Hydroxide
$NaHCO_3$	:	Sodium bicarbonate
KCl	:	Potassium Chloride
KH_2PO_4	:	Potassium Dihydrogen Orthophosphate
NO_2	:	Nitrite
NO_3	:	Nitrate
NO_3-N	:	Nitrate Nitrogen
NH_4-N	:	Ammonical Nitrogen
HCl	:	Hydrochloric Acid
H_2SO_4	:	Sulphuric Acid
$Ba(OH)_2$	:	Barium Hydroxide
FN	:	Fertilizer Nitrogen
FP (or) FP_2O_5	:	Fertilizer Phosphorus
FK (or) FK_2O	:	Fertilizer Potassium
EC	:	Electrical Conductivity
STV	:	Soil Test Value
STL	:	Soil Testing Laboratory
D	:	Distributory
$dS\,m^{-1}$	:	Desi Siemens per centimeter
$C\,mol(P^+)kg^{-1}$	:	Concentration moles per Kilogram

1 N NH_4OAC	:	Neutral Normal Ammonium Acetate
$K_2Cr_2O_7$	:	Potassium Dichromate
gm	:	Gram
mμ	:	milimicrons
ml	:	millilitre
B	:	Base Value or Blanket Recommendation
Sq.m	:	Square meter
AOAC	:	Association of Official Agricultural Chemists
GY	:	Grain Yield
SY	:	Straw Yield
OC(I)	:	Organic Carbon (Initial)
KM(I)	:	Potassium Permanganate (Initial)
OL(I)	:	Olsen (Initial)
AM(I)	:	Ammonium Acetate (Initial)
KM(PH)	:	Potassium Permanganate (Post Harvest)
OL(PH)	:	Olsen (Post Harvest)
AM(PH)	:	Ammonium Acetate (Post Harvest)
PIOC	:	Organic Carban at Panicle Initiation Stage
PIKM	:	Soil N at Panicle Initiation Stage

PIN	:	Plant N % at Panicle Initiation Stage
L	:	Low
M	:	Medium
H	:	High
CL	:	Clay loam
SCL	:	Sandy clay loam
SL	:	Sandy loam
LS	:	Loamy Sandy
SIL	:	Silt Loam
GR-N	:	Grain Nitrogen
GR-P	:	Grain Phosphorus
GR-K	:	Grain Potassium
ST-N	:	Straw Nitrogen
ST-P	:	Straw Phosphorus
ST-K	:	Straw Potassium
CD	:	Critical Difference
UN	:	Uptake of Nitrogen
UP	:	Uptake of Phosphorus
UK	:	Uptake of Potassium
CA-N	:	Calcium Hydroxide Nitrogen
AM-K	:	Ammonium Acetate Potassium
OC-N	:	Organic Carbon Nitrogen

GRP	:	General Recommended Dose
DMRT	:	Duncan's Multiple Range Test
Fig	:	Figure
PI	:	Panicle Initiation
PH	:	Post Harvest
Rep	:	Replication
RR	:	Response Ratio
DRR	:	Desired Rate of Return
WF	:	Whole Field
YM	:	Yield Maximum
R	:	Cost Benefit Ratio
I.P	:	Irrigation Potential
NI	:	Nutrient Index

A C K N O W L E D G E M E N T S

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Place: Hyderabad.

Date : 16 January 1997

[B. R. BHASKAR RAO]

DECLARATION

I, B.R.BHASKAR RAO, hereby declare that the thesis entitled "NITROGEN AVAILABILITY AND FERTILIZER N RECOMMENDATION FOR RICE IN SOILS UNDER SREERAMSAGAR PROJECT COMMAND" is a result of the original research work done by me. It is further declared that the thesis or any part there of has not been published earlier in any manner.

16.1.1997

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(B.R.BHASKAR RAO)

DISCUSSION

CHAPTER V

DISCUSSION

Dry root rot of mungbean, an important fungal disease causing yield losses upto 25 per cent, became one of the major constraints in mungbean growing tracts of India. The endemic and serious nature of the disease in most of the areas particularly in some districts of Telangana region of Andhra Pradesh prompted taking up investigations on "Biological control of dry root rot of mungbean".

Currently with increasing awareness of possible deleterious effects of fungicides on the ecosystem, growing interest in pesticide free agricultural products and time consuming breeding programmes, the integrated biological control of plant pathogenic fungi have received considerable attention (Baker and Cook, 1974; Henis *et al.* 1978; Elad *et al.* 1980; Chet *et al.* 1982).A major challenge in plant disease management is to introduce or develop new disease strategies as the more traditional controls become obsolete and to do so without greater use of chemicals.

Bilogical control offers many advantages to the growers and to society in general and must be pursued on all fronts. If offers durable, environmentally safe and cost effective alternative to chemicals. Introduction of a proper fungicide tolerant strain of antagonist at a time when the pathogen is more vulnerable, might delay disease development. Potential of such bioagents need to be exploited and utilized as a component in the integrated management of the pathogen. It is now a widely recognised fact that biological control of plant pathogens is a distinct possibility for the future and can be successfully exploited in modern agriculture within the frame work of integrated disease management module. The use of the *Trichoderma* species as a potential biocontrol agent in the integrated biological control of plant pathogens along with other pest management practices has been discussed (Papavizas, 1985; Chet and Henis 1985). Since Trichoderma dominates in soil treated with a sublethal dosage of pesticides, proliferates easily to produce antibiotics, competes for nutrients and acts as a mycoparasite, the role in integrated biological control is of practical significance.

Integrated approach seems to be the only possible solution for effective management of the dry root rot pathogen (Chandra and Kheri, 1996)) due to its extreme prevalence, wide host range and extensive environmental adaptability. Hence, an attempt was made to develop an integrated disease management strategy for dry root rot of mungbean and the results obtained from the present investigations are discussed here under.

5.1 SYMPTOMATOLOGY

In the present investigation, the course of development of symptoms over a crop growth period was studied under field conditions in CV. ML-267. The disease appeared at all stages of crop growth starting from seedling to maturity. At early stages (10 DAS), germination failures, pre- and post-emergence damping off of seedlings and seedling rot (charcoal rot) are the characteristic symptoms observed. Similar type of charcoal rot symptoms due to dry root rot pathogen, *M. phaseolina* has already been reported by Bhargava (1965) in potato, Philip *et al.* (1969) and Scholefield and Griffin (1979) in mungbean and Sharada and Shetty (1987) in urdbean.

Symptoms on grown up plants i.e., (30-45 DAS) manifested as formation of irregular leaf spots with brown margins and greyish centres which expanded and caused necrosis of leaves with or without exhibiting root rot symptoms. Similar type of leaf blight symptoms in mungbean was reported by Philip (1965), Grover and Sakhuja (1981) and by Kumar *et al.* (1969), Vidyasekharan and Arjunan (1978) in urdbean. At advanced stages of infection wilting of the whole plant, yellowing, droopping of leaves, discolouration of basal portion of the stem, rotting of under ground plant parts followed by drying and death of the whole plants. The affected roots were dark, brittle, devoid of lateral and finer roots and decay of the secondary roots and shredding of the cortex of the tap root. When the affected plants were uprooted, the tap root was black and usually remains in the soil. Presence of numerous fungal fruiting bodies viz. sclerotia, pycnidia and mycelium on the affected plant parts are the conspicuous symptoms of dry root rot that are associated with adult plant infection. The present results are inconfirmity with descriptions made by Philip *et al.* (1969) who reported the presence of numerous, minute black sclerotia on infected roots and stem. In the present studies both sclerotia and pycnidia were frequently observed on the affected plant parts. The presence of sclerotia and pycnidia on the affected plant parts is an important feature which could be used as a diagnostic key for identification of the pathogen.

5.2 ISOLATION AND IDENTIFICATION OF THE PATHOGEN

The fungus was isolated from infected plant parts showing dry root rot symptoms and single spore cultures were maintained on PDA. Pathogenicity was established by inoculation and reisolation of the pathogen from infected plant parts.

The fungus produces spherical hyaline colonies which later became fluffy, carbonaceous, brown to black with numerous small black sclerotia on PDA. Mycelia were hyaline to brown, branched, septate and ran parallel to each other. Sclerotia were 67.5 µm in size, minute, black and pycnidia were dark brown with pigmented wall and an apical ostiole. Pycnidiospores from pycnidia were oval, hyaline, non septate and thin walled. The morphology of the pathogen observed was in accordance with the descriptions given by Philip *et al.* (1969) in mungbean and by Jain *et al.* (1973) in urdbean.

5.3 PATHOGENICITY TESTS

Soil and spray inoculation techniques were tried to prove pathogenicity in mungbean CV.ML-267. Out of the two methods, soil inoculation method was found best. Maximum seedling infection of 90 per cent was observed when fresh inoculum of the pathogen grown on PDB was incorporated to the soil. Formation of pycnidial and sclerotial bodies were observed at collar region of the infected plant parts. Similar type of symptoms were observed in mungbean by Grover and Sakhuja (1981) and Hooda and Grover (1983). Plants sprayed with spore suspensions have shown symptoms on leaves as circular brown spots with greyish centres after 48 h of inoculation. Wilting, drying of leaves, complete blightening of the whole plant and seedling death were observed. In spray inoculation technique, 70 per cent of the seedlings exhibited infection. This apparently indicates that the fungus had gained entry into the plant system through natural openings that are present on leaves and stem and became systemic resulting in the death of the whole plants. The results also are in agreement with those of Grover and Sakhuja (1981) in mungbean due to *M. phaseolina*.

5.4 ISOLATION OF RHIZOSPHERE MICROFLORA FROM MUNGBEAN CULTIVARS

The total number of rhizosphere microflora (fungi, bacteria and actinomycetes) were more in the rhizosphere soil of the mungbean cv. ML-267 (70.4 x 10^3/g dry soil) than in Pusa Baisakhi (66.1 x 10^3/g dry soil). The rhizosphere microflora increased with increase in age of the plants. Highest number of microflora from rhizosphere were accounted in both the mungbean cultivars at pod formation stage. Similarly, the lowest number of rhizosphere microflora were observed at seedling stage (Table 19). Fourteen different fungi were isolated at seedling, flowering and pod formation stages from mungbean cvs. ML-267 and Pusa Baisakhi. Ram Singh *et al.* (1993) also made similar observations who isolated 17 rhizosphere microflora at seedling, flowering and pod formation stages from mungbean cultivars SML-32 and ML-5 during spring season in Punjab.

The rhizosphere microflora to a large extent is influenced by the plant species, plant age, the nature of root exudates, nutrient status of the soil and above all the physiology and the type of stress on the host plant. The variations in fungal flora of mungbean cultivars under certain conditions were possibly due to the differences in chemical composition of root exudates. The quanity of root exudates produced is more at flowering stage of the plant (Mall, 1979; Blackman, 1981). Root exudates have a direct influence on rhizosphere microbiota (Sadasivan, 1960; Schroth and Hilderbrand, 1964; Rovira, 1965). Thus, in the present investigation, qualitative and quantitative changes in the rhizosphere microflora could be attributed to the alteration in the pattern of root exudates of the two cultivars.

The metabolic activities of microbes in root region are of vital importance for plant growth and management of soil-borne plant pathogens (Balandreau and Knowles, 1978). The presence of large number of antagonists in the rhizosphere of several crop plants suppressed dry root rot pathogen (Dhingra, 1971; Dhingra and Khare, 1973; Mukhopadhyay, 1977; Singh and Mehrotra, 1980; Gangawane and Salve, 1987; Dubey and Dwivedi, 1988, Kumar and Khare, 1990 and Ram Singh *et al.*, 1993). Thus, it is evident that mungbean plants under the influence of dry root rot pathogen could support a significant increase in the antagonistic rhizosphere microflora. This further suggests that the occurrence of increased populations of beneficial fungal flora in the rhizosphere at later age signifies the role of these organisms in the better management of the disease. Since *Trichoderma harzianum* also occurred in rhizosphere, the scope for increasing its population for biological control of dry root rot of mungbean was exploited in the present investigation.

5.5 INTERACTION OF SOIL MICROFLORA ISOLATES (SMI) WITH M. PHASEOLINA

When soil microflora isolates (SMI) were tested against *M. phaseolina*, four types of interactions were observed, namely, mutual intermingling, over growth of pathogen, over growth of SMI and slight inhibition at a distance (Fig.1). Similar type of interactions between two organisms were reported by other workers. When two or more organisms were grown in close proximity, the interactions could be antagonistic, indifferent or favourable (Smith, 1905), stimulating, inhibiting, over growing and non-influencing (Zeller and Schmitz, 1919). Porter (1924) while studying the characters of non-pathogenic fungi when grown in the presence of other such fungi, could distinguish five types of inhibition, namely, intermingling, over growing with inhibition of slower growing organism, slight inhibition, growth around the contending organism and inhibition at a distance Sharma and Sen (1991) while studying the interaction of SMI with *Fusarium solani*, could distinguish similar types except the fourth type i.e., growth around the contending organism. Interaction of soil micro organisms with a pathogenic fungus, namely *Sclerotium rolfsii* were classified (Ghaffar, 1968) as intermingling, over growing and production of pathogen free zones. Dubey and Dwivedi (1988) observed colony growth inhibition coagulation of cytoplasm, hyphal discolouration and dissolution of the hyphae of *M. phaseolina* by eight antagonistic rhizosphere fungi of soybean due to the secretion of toxin (s), antibiotics and/or cell wall lytic enzymes. The rhizosphere microflora could interact with each other for nutrients, space, air and other resources and play a significant role in the biocontrol of soil-borne plant pathogens (Balandreau and Knowles, 1978). Soil micro organisms interfere with the activity of pathogen, directly by their growth inhibitory products, predation and parasitism and indirectly by competition for nutrients and space. The organism showing type III interaction was classified as potential inhibitor of *M. phaseolina* and this was identified as *Trichoderma harzianum* (H_4) native isolate with the help of microscopic structures (Rifai, 1969; Cook and Baker, 1983). This native isolate agrees with Rifai's (1969) concept of *T. harzianum* aggregate.

The tendency of *Trichoderma* to overgrew and produce volatile and non-volatile compounds as metabolites is well known (Papavizas, 1985; Papavizas and Lewis, 1989) and hence this native SMI may prove to be a promising biocontrol agent of *Macrophomina phaseolina* inciting dry root rot of mungbean. Classification of soil micro organisms into specific interaction groups forms the first essential step in identifying the potential antagonists for all soil-borne pathogens (Sharma and Sen, 1991).

5.6 IN VITRO EFFICACY OF BIOCONTROL AGENTS AGAINST M. PHASEOLINA

Biocontrol through the use of native and exotic antagonists has of late gained importance and is poised for successful application in modern agriculture (Cook, 1985). *Trichoderma* sp. have received considerable attention as possible biocontrol agents of several soil borne pathogens, and their recognized antagonistic potential often has been used as a means of *in vitro* screening for the selection of best biocontrol candidates. Mycoparasitism or hyperparasitism of munbgean dry root rot pathogen by *Trichoderma* and *Gliocladium* sp. has been well documented (Elad *et al.*, 1986; Ikotun and Adenkunle, 1990; Deshmukh and Raut, 1992; Ram Singh *et al.*, 1993).

In dual culture technique, among all the species of *Trichoderma* and *Gliocladium* screened, the native *T. harzianum* (H_3) isolate was found superior in completely overgrowing the pathogen within 4 days followed by *T. viride* (V_2) and *G. virens* (G_2) while *T. pseudokoningii* (TPK), *T. hamatum* (TH), *T. harzianum* (H_1), *T. viride* (V_1), *T. longibrachiatum* (TL), *T. harzianum* (H_3), (H_2), (H_4), *G. virens* (G_1) and *T. koningii* (K) took 5 days to overgrow the pathogen. (Table 20, Fig.2). *Trichoderma* and *Gliocladium* are known to be mycoparasitic over a range of fungi. Hyper parasitism between bioagents and *M. phaseolina* has been reported by several workers while working with *T. harzianum*.

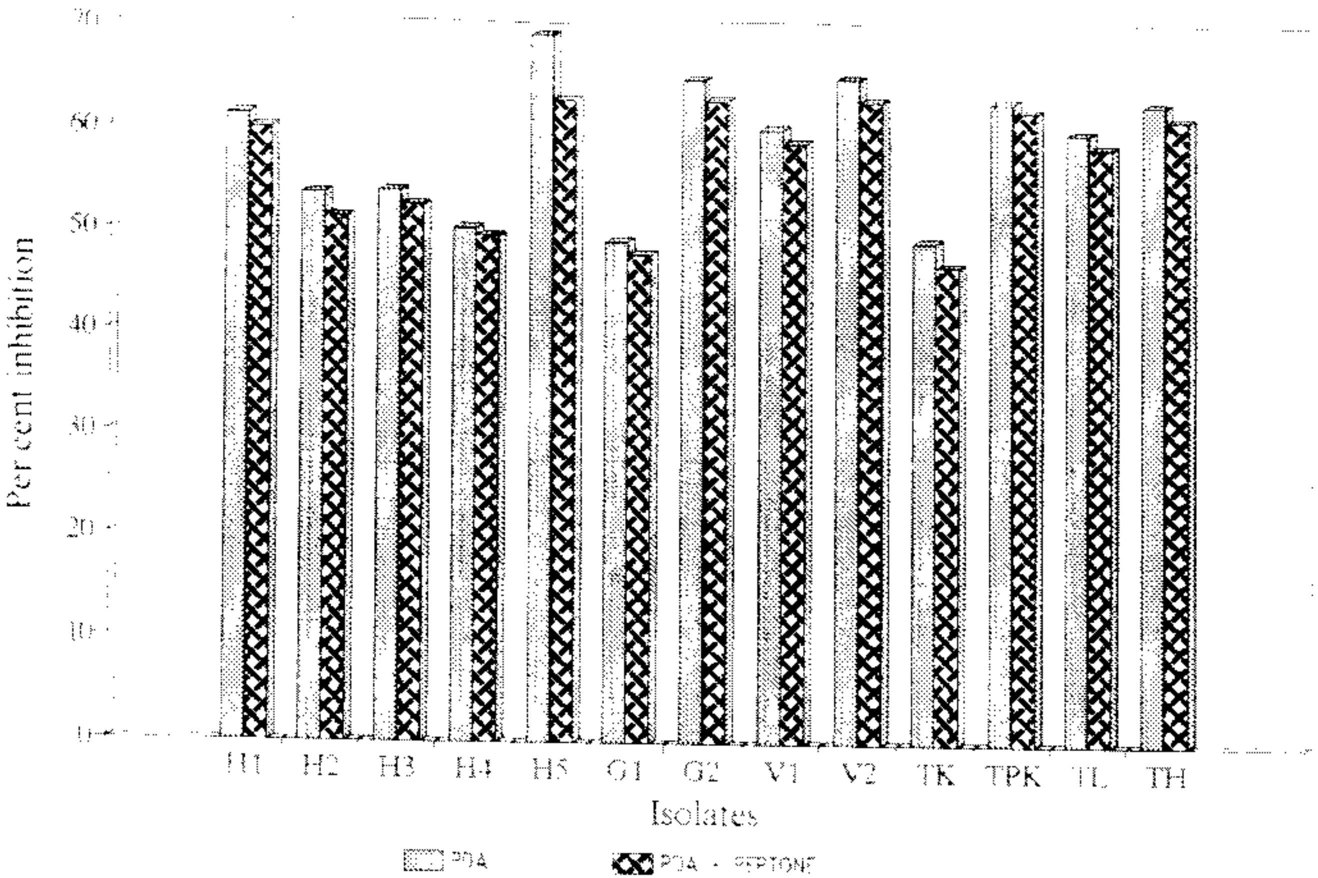


Fig.2 Effect of bioagents in inhibiting the linear growth of *M. phaseolina*

Trichoderma and *Gliocladium* are known to be mycoparasitic over a range of fungi. Hyper parasitism between bioagents and *M. phaseolina* has been reported by several workers while working with *T. harzianum* (Weindling 1932., 1934; Elad *et al.*, 1986; Ikotun and Adenkunle, 1990 and Deshmukh and Raut, 1992), *T. viride* (Vasudeva and Sikka, 1941) and *T. hamatum* (Rukmani and Mariappan, 1994) against *M. phaseolina* was reported. In dual culture technique, *T. harzianum* (H_6) native isolate, *T.viride* (V_2) and *G. virens* (G_3) showed a strong hyperparasitic potential than other isolates. This type of variation in hyper parasitic potential within *Trichoderma* sp. has already been well established (Dennis and Webster, 1971 b)

The features of mycoparasitism observed were tight appression, coiling, penetration of *M. phaseolina* hyphae by *Trichoderma* hyphae, penetration of conidia of *Trichoderma* into mycelium of *M. phaseolina*, sclerotial parasitization and dissolution and disintegration of pathogen mycelium. These observations are in accordance with earlier reports (Norton, 1954, Elad *et al.*, 1986; Ramsingh *et al.*, 1993). The morphological disturbances observed such as dissolution and disintegration of *M. phaseolina* hyphae on interaction with *T. harzianum* are indications of the production of cell wall lytic enzymes and involutions leading to the utilization of cell contents. These results are in accordance with Ghaffar (1968) who reported that the hyphae of *T. lignorum* and *T. viride* parasitized and coiled around *M. phaseolina* resulting in coagulation of protoplasmic contents of the hyphal cells followed by cell wall dissolution.

The bioagent *T. harzianum* (H_4) native isolate showed effective coiling and penetration into *M. phaseolina* hyphae compared to other two isolates. *T. harzianum*, was more effective in parasitizing the hyphae of *M. phaseolina* compared to *T. viride* (V_2) and *G. virens* (G_2) and exhibited greater hyper parasitic potential.

Inhibition zones were observed between the two test fungi after 5 days of incubation in dual culture plates (Table 20). Among them, the native *T. harzianum* (H_4) isolate exhibited maximum zone (4 mm) of inhibition as compared to other antagonist isolates. Campbell (1989) opined that such an inhibition zone could be taken as a clue for the production of antibiotics and thereby screening and selecting antagonists. Similar observations on inhibition zone were made by Sankar and Jeyarajan (1996) while studying with *G. virens* and *M. phaseolina*. *T. viride* and *T. hamatum* strongly inhibited *M. phaseolina* (Rukmani and Mariappan, 1994). Majumdhar *et al* (1995) reported that *T. harzianum* and *T. viride* showed strong antagonism against *M. phaseolina*.

All species of *Trichoderma* and *Gliocladium* used in the present studies inhibited *M. phaseolina* by direct parasitism with minor inhibition by antibiosis. Different mechanisms of *Trichoderma* have been well documented (Ayers and Adams, 1981; Cook and Baker, 1983). However, it is rare to find a single isolate exhibiting all the mechanisms. Because of such aggressive nature of this native isolate of *T. harzianum*, it was chosen for biocontrol of *M. phaseolina* along with other two exotic bioagents namely *T. viride* and *G. virens* for glass house experiments.

Culture filtrates of *T. harzianum* had significantly higher toxic effect on the radial growth of *M. phaseolina*. Incorporation of different concentrations of filtrates into PDA medium exhibited varying degrees of colony inhibition of *M. phaseolina*. There was a positive correlation between the amount of cell-free culture filtrate and growth inhibition of *M. phaseolina*. Inhibition of 15 to 100 per cent growth was obtained using 5 to 40 per cent culture filtrate. The extent of growth inhibition of the pathogen depends on the relative volume of filtrate and their concentration gradients (Dennis and Webster, 1971a). Culture filtrates of *Trichoderma* and *Gliocladium* spp. showing antibiosis against *M. phaseolina* was reported by several workers with *T. lignorum* (Vasudeva and Sikka, 1941), *T. viride* (Dubey and Dwivedi, 1981; Pande, 1985), *T. harzianum* (Elad *et al.*, 1986), *T. hamatum* and *T. pseudokoningii* (Rukmani and Mariappan, 1994). In the present studies (Table 21; Fig. 3) radial growth inhibition (15 to 100 per cent) and loss in mycelial dry weight (178.75 to 53.1 mg) of the pathogen with increasing volumes of culture filtrates (5 to 40 per cent) might be attributed to the production of toxins, antibiotics and cell wall degrading enzymes, indicating the strongest antibiotic potential of *T. harzianum* (H_5), as suggested by Dubey and Dwivedi (1988). The culture filtrates of bioagent produces certain metabolites which are pernicious to *M. phaseolina*. This provides a superfluous chemical weapon to the bioagent to suppress the pathogen (Kumar and Mukhopadhyay, 1994). The present study also revealed that the antifugal activity could be due to the antibiotics diffusible in solid agar and produced extracellularly in liquid media indicating that *T.harzianum* holds great promise in the biocontrol of *M. phaseolina*.

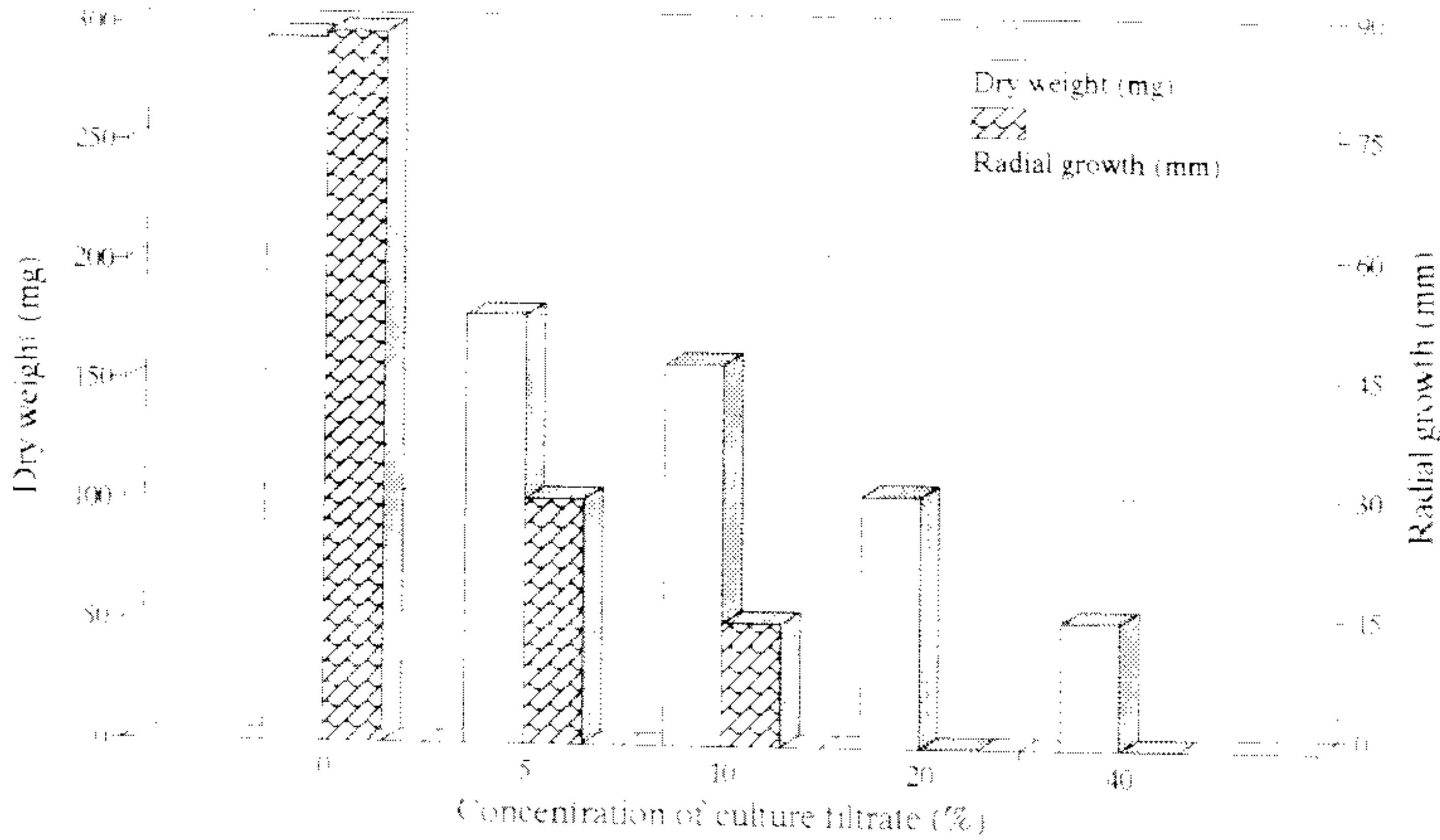


Fig 3 Effect of culture filtrate of *T. harzianum* on growth of *M. phaseolina*

5.7 EFFECT OF pH ON GROWTH OF PATHOGEN AND BIOAGENTS

It is a well-known fact that hydrogen ion concentration of the medium has a profound influence on the growth of fungi. As per Lilly and Barnett (1951), fungi in general tolerate acidic than an alkaline reaction. This experiment was designed to study the range and optimum pH for growth of the pathogen and bioagents.

All the isolates of selected bioagents and pathogen, showed maximum growth at pH 5.5 to 6.5. The growth of the pathogen and bioagents was poor at high acidic and alkaline pH than at slightly acidic values to moderately acidic values of pH (6.5 - 5.5). The bioagents and pathogen could grow over a wide range of pH (4.5 - 8.5) with the optimum at 6.5. At pH 2 and below and pH 8 and above, there was considerable decline in growth (Table 22; Fig. 4) Chet and Baker (1981), Aslmol *et al.* (1992) and Gupta *et al.* (1995) reported that growth of *Trichoderma* and *Gliocladium* spp. occured at pH 5.5. Philip (1963) and Singh and Chohan (1982) reported 5 to 6 as optimum pH for pathogen growth.

5.8 EFFECT OF TEMPERATURE AND WATER POTENTIALS ON THE GROWTH OF PATHOGEN AND BIOAGENTS

In plant disease development, temperature and water potential interaction has been considered to be one of the most important factor influencing growth and reproduction of all pathogens. All the isolates of bioagents and pathogen showed ideal growth at temperature range of 25 to

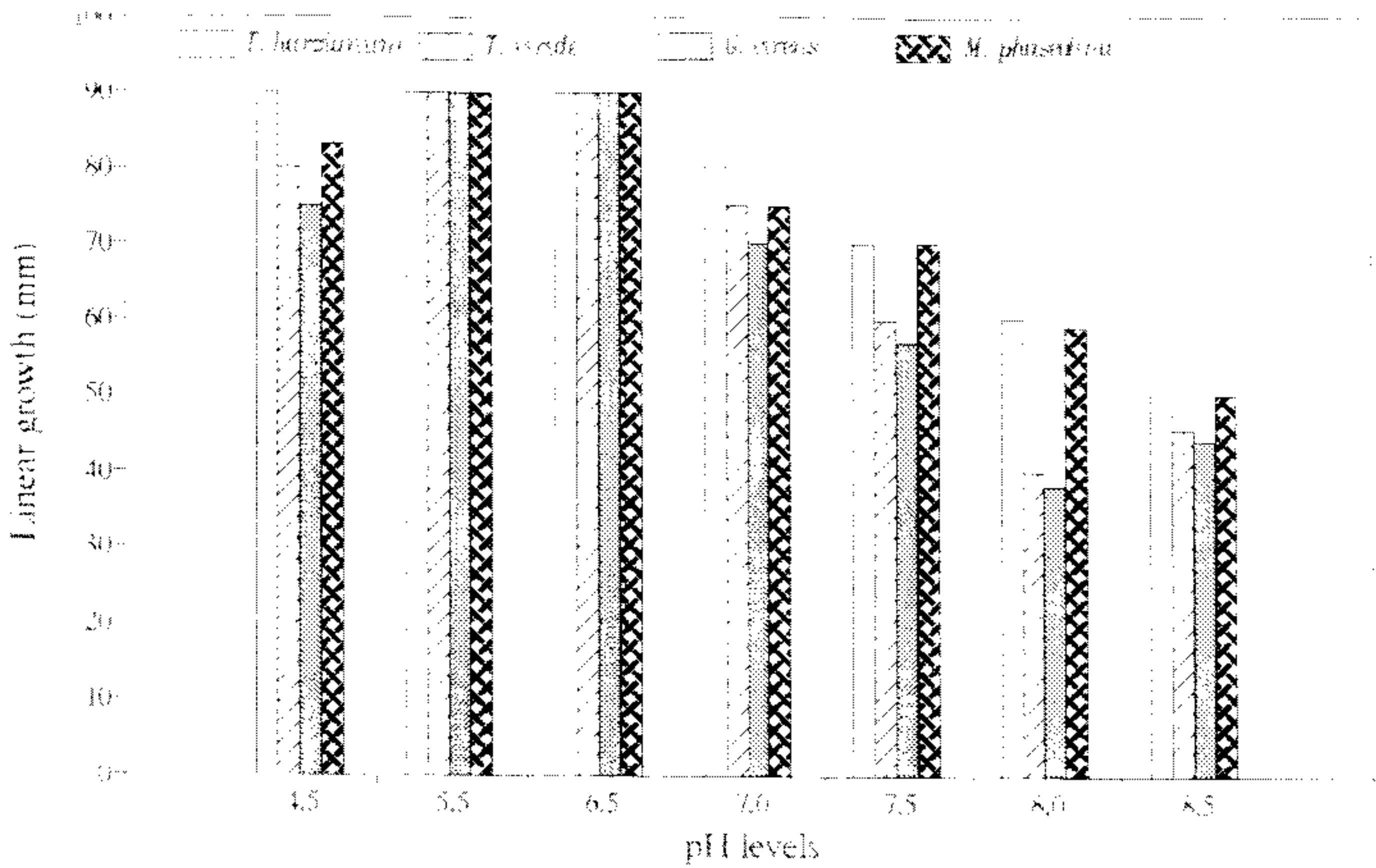


Fig.4 Effect of pH on the linear growth of bioagents and pathogen.

30 °C and water potential range of -80 to -100 bars. Decline in growth of all isolates occured at a temperature range of 15 to 20 °C and water potential range of -60 to -70 bars (Table 23; Fig 5). Hadar *et al.* (1984) and Aslmol *et al* (1992) reported the optimum temperature for the growth of *Trichoderma* sp as 25 to 30 °C. Maximum vegetative growth of bioagents occurred at -80 to -100 bars (Chet, 1987).

Similar observations about the temperature requirements of the pathogen was made by Philip (1963) and Grover and Sakhuja (1981) who reported best growth at 30 to 35 °C. The water potential requirement for maximum vegetative growth of the pathogen varied between -13 to -40 bars. In contrary, in the present study, the pathogen produced maximum vegetative growth at -80 to -100 bars. This could be due to variation in pathogenic behaviour at different environments.

5.9 EFFICACY OF FUNGICIDES ON THE GROWTH OF THE PATHOGEN AND BIOAGENTS

Most crop diseases have been commonly controlled by the application of chemical compounds. However, recently new approaches are being attempted as an alternative or supplementary to pesticides to avoid or minimise the crop diseases. In this context, biological control is of significance. Therefore, it has been contemplated to evaluate the efficacy of fungicides against pathogen as well as its bioagents with a view to formulate an integrated approach. The results in this direction obtained in the present investigations are discussed hereunder.

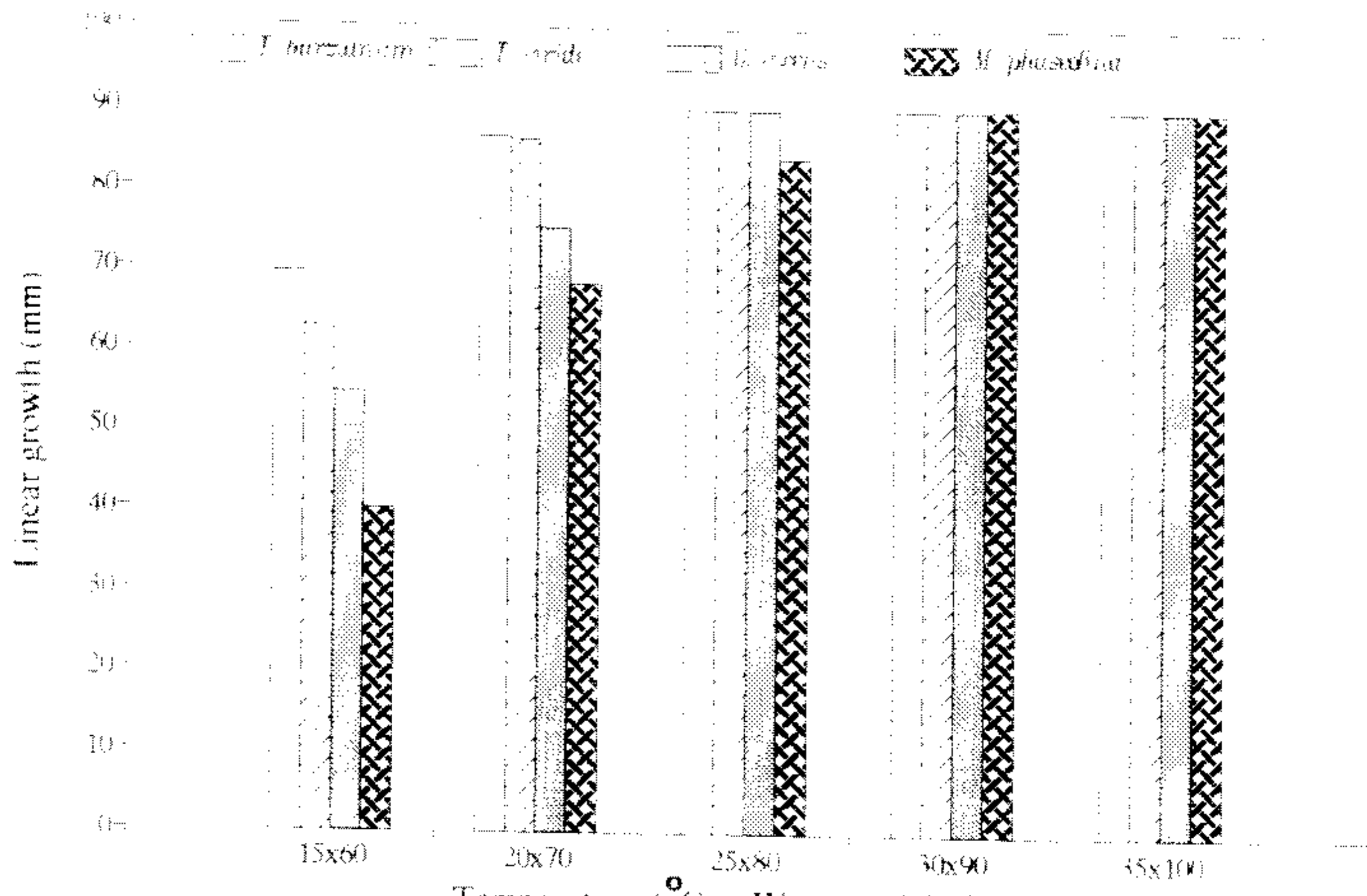


Fig.5 Interaction of temperature and water potentials on the linear growth of bioagents and pathogen.

Significant differences among the test fungicides were established in inhibiting the mycelial growth of the pathogen. Carbendazim was found to be highly effective (100 per cent inhibition) even at lowest concentration (25 μg ml $^{-1}$). Thiophanate methyl at 75 μg ml $^{-1}$ also resulted in 100 per cent inhibition of the pathogen. The effectiveness of benzimidazoles in inhibiting the mycelial growth was reported by several workers. While Sinha and Khare (1977) established the sensitivity of carbendazim at 625 μg ml $^{-1}$ against *M. phaseolina,* dry root rot of cowpea, Taneja and Grover (1982) reported the effectiveness of carbendazim and thiophanate methyl at EC 0.01 and 5.9 μ M ml $^{-1}$) respectively against the same fungus on mungbean. The present findings clearly revealed the superiority of the carbendazim even at 25 μg ml $^{-1}$ against dry root rot of mungbean. Hooda and Grover (1983) demonstrated the efficacy of the carbendazim at 300 μg ml $^{-1}$ in complete inhibition of the dry root rot pathogen of mungbean. Kirkpatrick and Sinclair (1973) showed that carbendazim and thiophanate methyl were found effective at 50 μg ml $^{-1}$ against *M. phaseolina.* Ilyas *et al.* (1975) reported that thiophanate methyl was more effective in inhibiting the colony diameter as well as mycelial growth of *M. phaseolina* at 50 μg ml $^{-1}$

Among the non systemic fungicides, thiram (100 per cent), mancozeb (81 per cent), captan (80.1 per cent) and captafol (75.13 per cent) were in order of merit in checking the growth. Sinha and Khare (1977) found that thiram and captan at 300 μg ml $^{-1}$ and captafol at 500 μg ml $^{-1}$ inhibited the dry root rot pathogen of cowpea to an extent of 100 per cent. In contrast, relatively high per cent inhibition of pathogen was obtained with thiram (100 per cent), mancozeb (81 per cent), captan (80.1 per cent) and captafol (75.13 per cent) in the present study, which can be attributed to the differences in the dosages used (Table 24; Fig. 6). Peshney *et al.* (1992) observed that

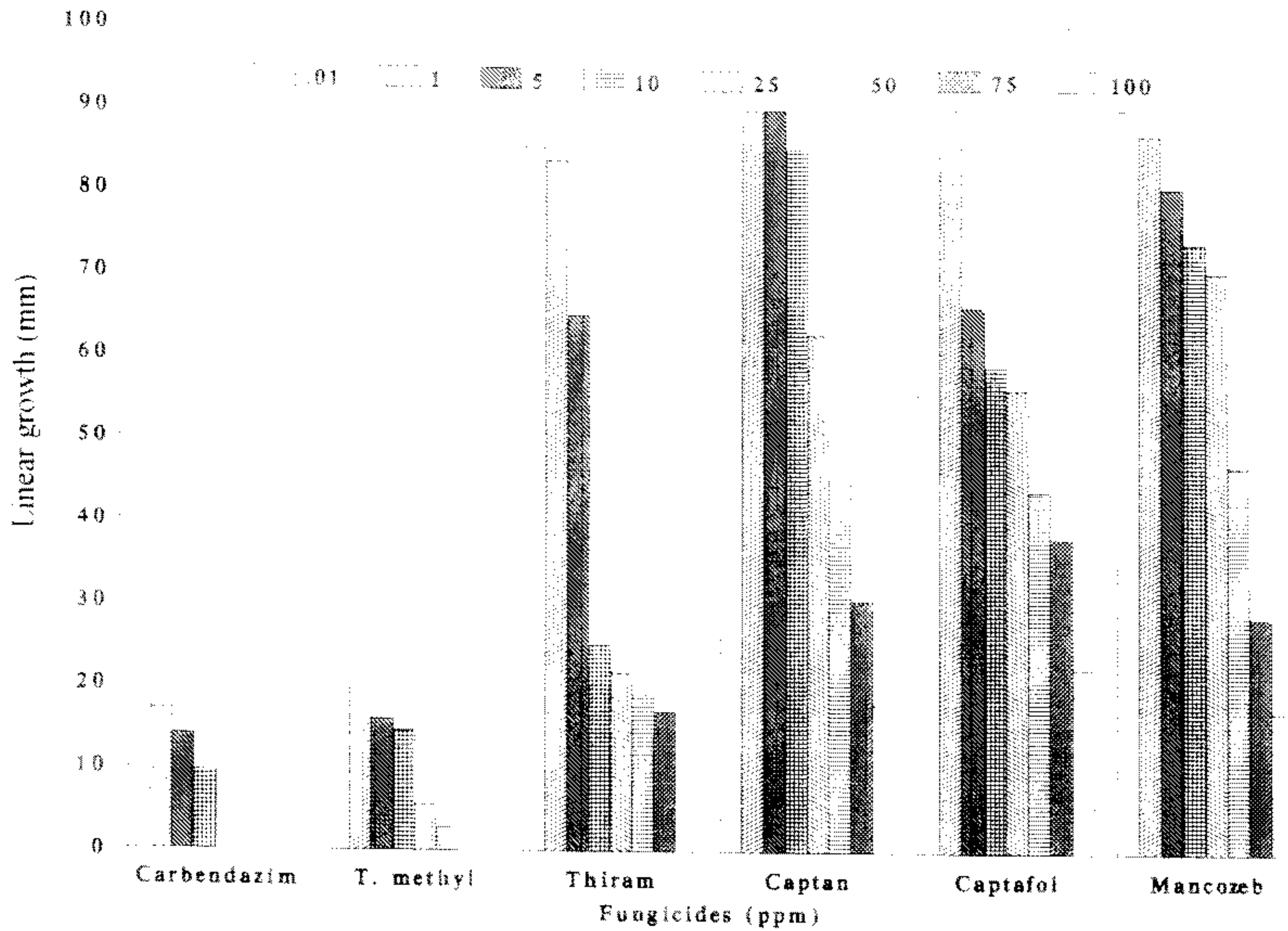


Fig.6. *In vitro* efficacy of fungicides against *M. phaseolina*

mancozeb, thiram and captan were effective in inhibiting the growth of *M. phaseolina* at 200 μg ml $^{-1}$.

In the present study, 2 systemics and 4 non systemic fungicides were evaluated for their inhibitory effects on the mycelial growth of *T. harzianum*. Carbendazim (50 μg ml $^{-1}$) and thiophanate methyl (75 μg ml $^{-1}$) completely inhibited the mycelial growth of *T. harzianum*. Thiram and Captan, non-systemic fungicides, at 100 μg ml $^{-1}$ inhibited the mycelial growth to an extent of 74.22 and 76.88 per cent respectively. On the other hand, captafol and mancozeb were found to be compatible with *T. harzianum* at all the concentrations tested (0.1 to 100 μg ml $^{-1}$) (Table 25, Fig.7).

These findings are in corroboration with the observations of Kuruvilla Jacob (1989) who reported the complete inhibition of *T. harzianum* with carbendazim at 50 μg ml $^{-1}$. Papavizas and Lewis (1983) observed that wild strain of *T. viride* was sensitive to thiophanate methyl at 50 μg ml $^{-1}$.

Kay and Stewart (1994) observed that *T. harzianum*, *T. viride* and *Trichoderma* spp. were insensitive to thiram. In contrast, the present study results showed that thiram was found toxic to the mycelial growth of *T. harzianum*. Singh *et al.* (1995) also reported the toxicity of thiram which inhibited the mycelial growth of 77.7 per cent at 100 μg ml $^{-1}$. While captan and mancozeb (500 μg ml $^{-1}$) showed 63.3 and 94.4 per cent reduction respectively. Sharma *et al.* (1995) showed that captafol caused little inhibition of mycelial growth of *T. harzianum*. However, in the present study, *T. harzianum* was insensitive to captafol at all the concentrations tested (0.1 to 100 μg ml $^{-1}$).

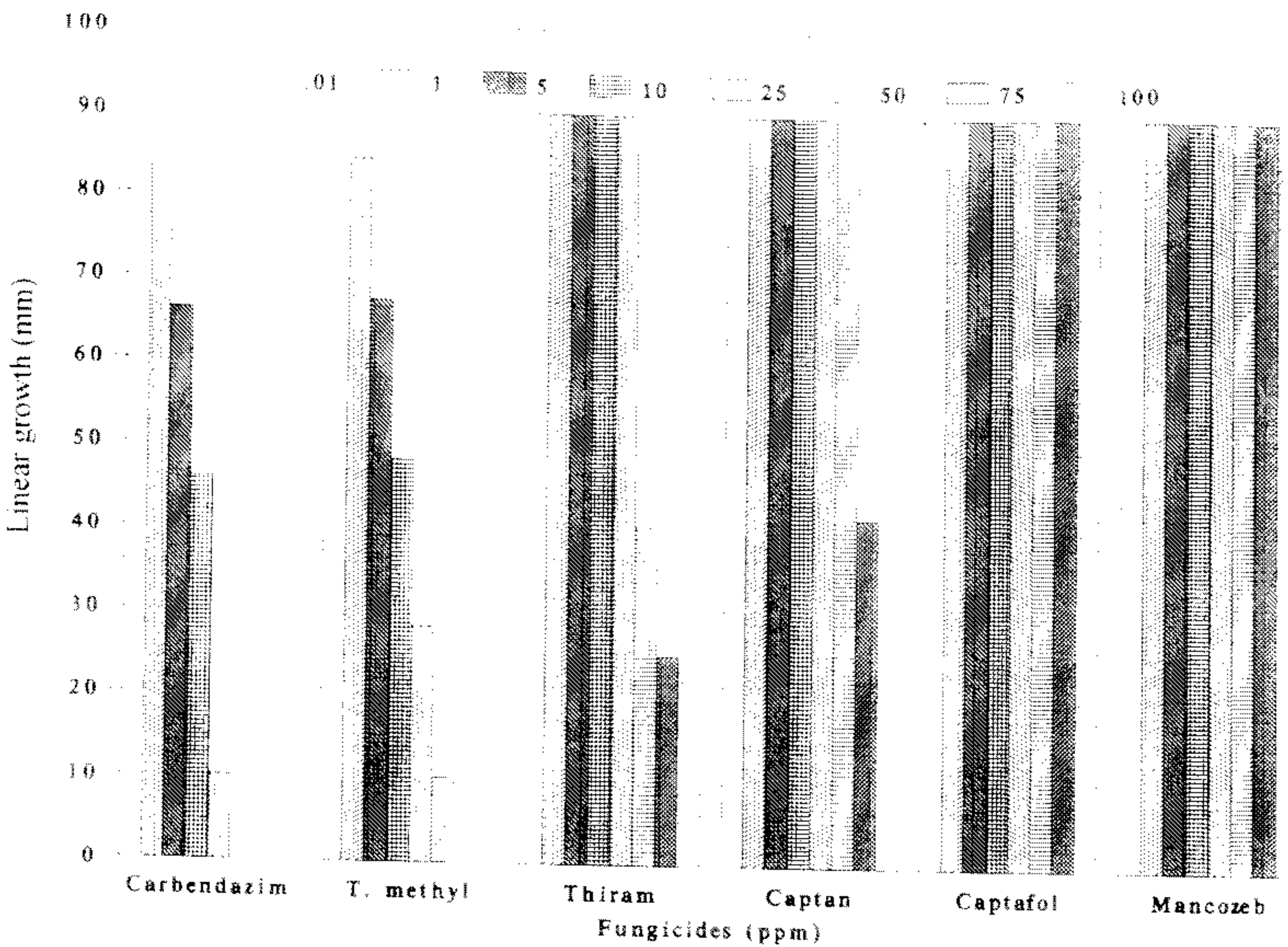


Fig.7. *In vitro* evaluation of fungicides on *T. harzianum*

5.10 DEVELOPMENT OF FUNGICIDE TOLERANT STRAINS OF *T. HARZIANUM* TO CARBENDAZIM AND THIOPHANATE METHYL

An attempt was made to induce new isolates of *T. harzianum* tolerant to carbendazim and thiophanate methyl, using prolonged and repeated exposure to increasing concentrations of the fungicides and to evaluate their ability to control dry root rot of mungbean incited by *M. phaseolina*.

The native isolate of *T. harzianum* was acquired 8 - fold (25-100 $\mu g\ ml^{-1}$) tolerance to carbendazim and 2 - fold tolerance to thiophanate methyl (50-100 $\mu g\ ml^{-1}$) (Table 27, 28). New biotypes of *T. harzianum* tolerant to fungicides such as, chlorothalonil, procymidone, iprodione and vinclozolin have been developed by Abd El Moity *et al.* (1982). Exposing conidia to increasing concentrations of the fungicides in culture media during subsequent subculturings resulted in the stability of some of them. Carbendazim tolerant strains of *T. harzianum* and *T. viride* (Vyas and Khare, 1986) was developed which possess enhanced biocontrol capabilities than their wild types.

Some changes in morphological and cultural characters were observed during the process of successive subculturings. In some experiments conidia were confined to the inoculation zone and periphery of the plate. Abd-El-Moity *et al.* (1982) also noticed that continuous exposure of wild strains of *T. harzianum* to fungicides resulted in some morphological changes in colony characters.

The native isolates of *T. harzianum* tolerant to carbendazim at 200 $\mu g\ ml^{-1}$ (equivalent to 0.04% Bavistin 50 WP) was evaluated for its antagonistic and biocontrol properties under glasshouse and field conditions in combination with carbendazim @ 0.02 per cent against dry root rot of mungbean. Integrating bioagents with sublethal doses of fungicides not only improves the efficiency but also reduces the dependence on chemicals (Mukhopadhyay, 1995). There are few reports available where purposeful tolerance was developed in bioagents and used along with fungicides for the biocontrol of plant diseases. Papavizas *et al.* (1982) developed for the first time purposeful tolerance by UV irradiation of *T. harzianum* to benomyl (100 μg ml^{-1}) and used for the control of *R. solani*. Carbendazim tolerant strains of *T. viride* and *T. harzianum* were developed by Vyas and Khare (1986) by serially transferring the antagonists from sublethal to high concentration and used along with carbendazim for control of dry root rot of soybean incited by *M. phaseolina*. Abd El Moity *et al.* (1982) developed integrated disease management by combining small amounts of chemicals with a biocontrol agents tolerant to fungicides which effectively controlled white rot of onion than either was used alone.

5.11 EFFICACY OF *T.HARZIANUM*, *T. VIRIDE* and *G. VIRENS* on DRY ROOT ROT OF MUNGBEAN BY SOIL APPLICATION UNDER GLASS HOUSE CONDITIONS

In vitro screening is not always reliable as there often exists no correlation between performance in *in vitro* and disease control potential in glass house (Lewis and Papavizas, 1985). There is no general, rapid and reliable test, and considering the variability in pathogens, soils and temperatures, the ultimate tests are still those using 'test plants' (Chet, 1987). In the present investigation, three isolates were selected based on their *in vitro* performance to test their efficacy under glass house conditions @ 10 g/kg soil in combination with *M. phaseolina* resulted in significant improvement in disease control. *T. harzianum* native isolate showed the maximum disease reduction (82.76%) over control which was followed by *T. viride* (63.14%), and *G. virens* (48.32%) (Table29; Fig.8). This reduction in disease in the sterilized soil at maturity stage of mungbean plants could be attributed to the suppression of the activity of the pathogen by the antagonists and possibly the absence of interference of the indigenous microflora in the sterilized soil which allowed a full expression of the pathogen and bioagent. This protection of mungbean plants from infection of *M. phaseolina* throughout the crop growth period by *T. harzianum, T. viride* and *G. virens* clearly indicated the longer viability and effectivity of *Trichoderma* propagules in the soil.

The efficay of *Trichoderma* species incontrolling soil borne pathogens of many crops has been well documented. Hadar *et al.* (1979 a) reported that *T. harzianum* effectively controlled damping off of bean, tomato and egg plant seedlings caused by *R. solani* but not *S. rolfsii* by soil application. Chet *et al.* (1979) found a more efficient isolate, capable of decreasing the incidence of plant diseases caused by *S. rolfsii* and *R. solani* in naturally infected soils. Henis *et al.* (1978) found that successive radish plantings induced soil suppressiveness to *R. solani*. Liu and Baker (1980), working with a similar system found that *T. harzianum* population increased with the increase in suppressiveness.

Treating pea and radish seeds with *T. harzianum* conidia in a methocel slurry protected seeds and seedlings from *Pythium* spp. and *R. solani*, respectively,nearly as effectively as fungicides treatments. *T. hamatum* propagules increased approximately 100 - fold in soils planted with *T. harzianum*

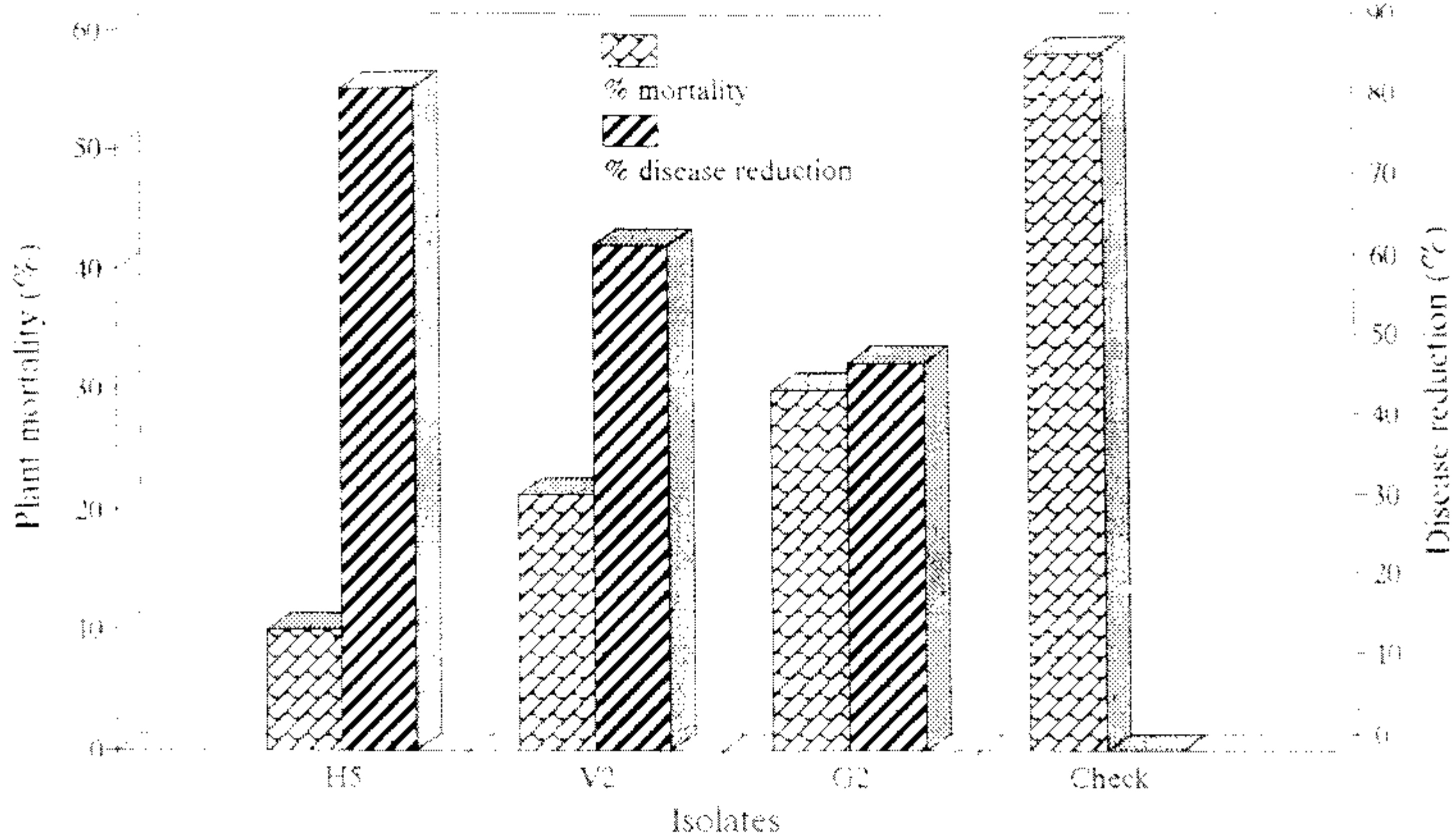


Fig.8. Effect of *T. harzianum* (H_5), *T. viride* (V_2) and *G. virens* (G_2) on dry root rot of mungbean.

treated seeds (Harman *et al.* 1980). *R. solani* and *Pythium* densities were lower in soils containing *T. hamatum* than in soils without this antagonist. Sivan and Chet (1982) found that a preparation of *T. hamatum* based on the wheat-bran/peat mixture controlled *P. aphanidermatum* in pea, cucumber, tomato, pepper and gypsophila and *R. solani* and *S. rolfsii* in beans. Coating pea and cucumber seeds with *T. hamatum* conidia suspension reduced *Pythium* disease incidence by 67-88 per cent and increased the level of *Trichoderma* population in the soil from 1.5 to 4.7 times.

A new isolate of *T. harzianum*, capable of controlling *P.aphanidermatum* better than *T. hamatum* at higher temperatures, was also found. This led to the idea that a mixture of several isolates should be prepared in order to achieve activity at a wide temperature or pH range (Sivan *et al.* 1984). Sivan and Chet (1985) found a new isolate of *T. harzianum* and applied it, either as conidial seed coating or a bran: Peat (1:1) preparation, to naturally infested soil. The isolate significantly reduced disease incidence caused by *Fusarium oxysporum f. sp. melonis* in melons, *F. oxysporum f.sp vasinfectum* in cotton and *F. culmorum* in wheat. It was also effective against *R. solani* and *S. rolfsii* attacking seedlings. *T. harzianum* as peat bran preparation reduced the incidence of *Macrophomina* root rot of beans by 37 to 74 per cent (Elad *et al.* 1986). Parakhia and Vaishnav (1986) found that *T. harzianum* when applied as seed treatment, soil drenching and wheat husk bran culture reduced dry root rot in chickpea to an extent of 18, 28 and 14 per cent as compared to 70 per cent in the check. The introduction of *Trichoderma* with different methods of application reduced disease to an appreciable level compared with checks.

Sivan and Chet (1987) observed that the incidence of crown rot of tomatoes reduced by upto 80 per cent after 75 days of sowing when *T. harzianum* was applied either as seed coating or wheat bran peat preparation Maiti *et al.* (1991) found that wheat bran culture of *T. harzianum*, *T. viride* reduced betelvine stem rot effectively when applied at low doses (5g/kg soil)

Kheri and Chandra (1991) reported that *T. viride* when applied as seed coating reduced mortality due to *M. phaseolina* from 19 to 8 per cent in mungbean varieties T 44 and from 19 to 10 per cent in Pusa Baisaki in unsterilized soil. The biocontrol efficacy of the antagonist showed an improvement in sterilized soil. Soil amendment with *T. harzianum* and *T. viride* reduces *M. phaseolina* in urdbean (Kousalya and Jeyarajan, 1991). The isolates *T. viride* and *T. harzianum* reduced dry root rot of urdbean to an extent of 3.2 and 2.8% as against 24% in control (Rukmani and Mariappan, 1994). Dinakaran *et al.* (1995) found that treatment of sesamum with antagonists viz., *Trichoderma harzianum*, *T. viride* and *B. subtilis* was significantly reduced *M. phaseolina*. Among them, *T. viride* was most effective (21.9%) followed by *B. subtilis* (24.7%) and *T. harzianum* (25.3%).

5.12 EFFICACY OF *T. HARZIANUM*, *T. VIRIDE* AND *G. VIRENS* ON GROWTH PARAMETERS OF THE HOST PLANT UNDER GLASS HOUSE CONDITIONS.

The selected three bioagents *T. harzianum*, *T. viride* and *G. virens* either alone or in combination with pathogen gave better germination and protection of mungbean seedlings and adult plants from rotting. The plant height and dry weight also increased in these treatments compared to inoculated and

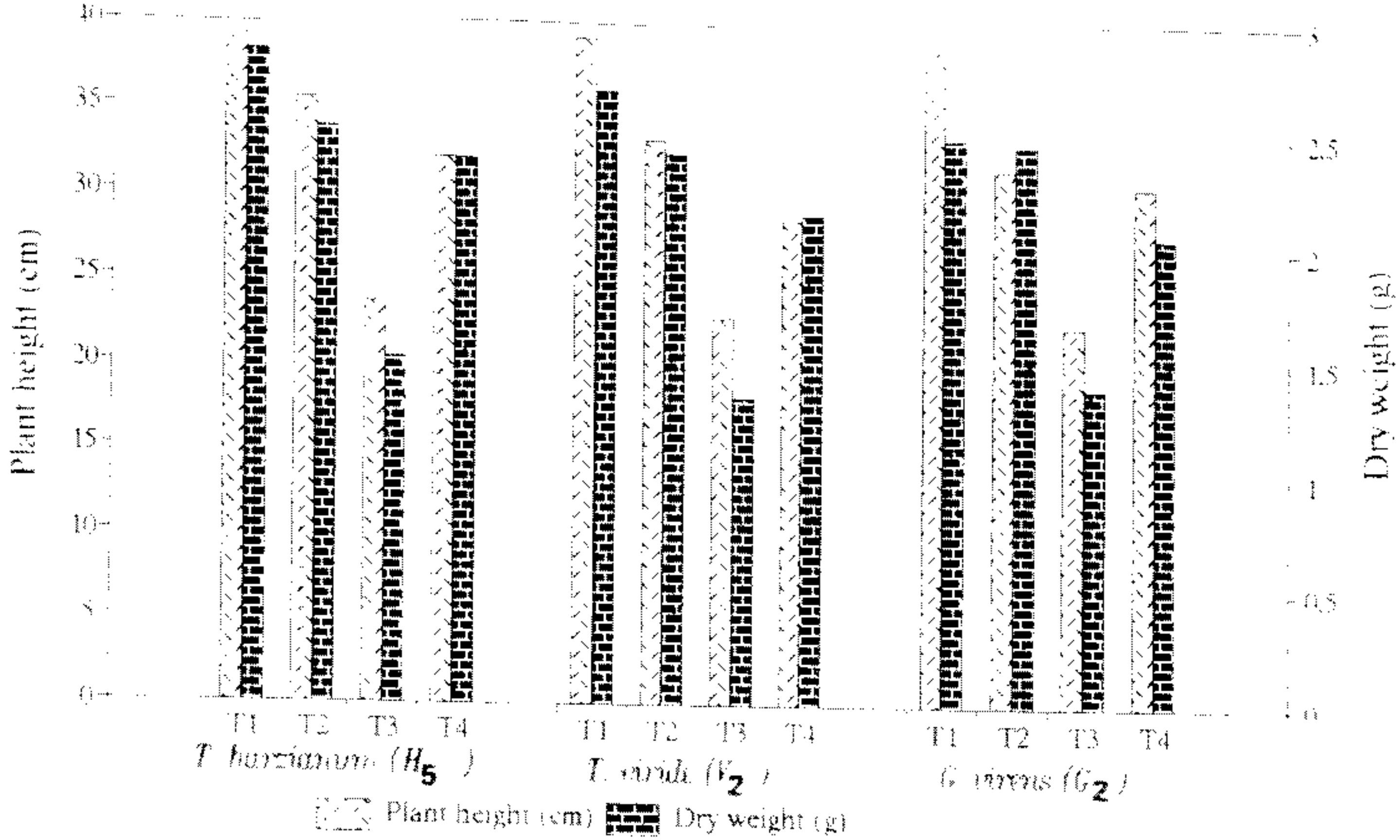


Fig 9. Effect of *T. harzianum* (H_5), *T. viride* (V_2) and *G. virens* (G_2) on growth parameters of mungbean.

This positive effect of the bioagent on plant growth could serve as a valuable factor in using *Trichoderma* as a biocontrol agent for effective management of dry root rot. *T. harzianum* was the best antagonist in suppressing the dry root rot in glass house. Based on this observation, it was finally selected for further studies under glass house and field conditions. The results further indicate that correlation exists between performance of an antagonist in dual culture and ability to control the disease in glass house. The selected antagonist *T. harzianum* did not have any adverse effect on growth parameters of mungbean thus making it suitable as a biocontrol agent for management of dry root rot disease.

5.13 TESTING THE EFFICACY OF *T. HARZIANUM* IN CONTROLLING DRY ROOT ROT OF MUNGBEAN BY SOIL APPLICATION AND SEED TREATMENT

T. harzianum applied to soil at 1, 2.5, 5 and 10g/pot and as seed treatment at 10^7, 10^8, 10^9 c/ml/10 g seed provided final seedling stands of (92.9, 97.03, 98.14 and 90 per cent) and 74, 77.7, 55 per cent) respectively over control. *T. harzianum* @ 5 g/kg in sterilized soil provided 97 per cent protection in glass house. Such a high degree of disease control with such a low dose of antagonist conclusively proves that *T. harzianum* is a biological control agent of very high potential. Similar type of protection was achieved by simply coating seeds with conidial suspension of *T. harzianum* (10^8 c/ml/10 g seed). It is interesting to note that there exists a negative correlation between the concentration of conidia and degree of protection (Table 31; Fig 10). This may be due to the phenomenon of self inhibition (Harman *et al.*, 1981). Hence an optimum dose of 10^8c/ml was selected as seed treatment since the quantity of

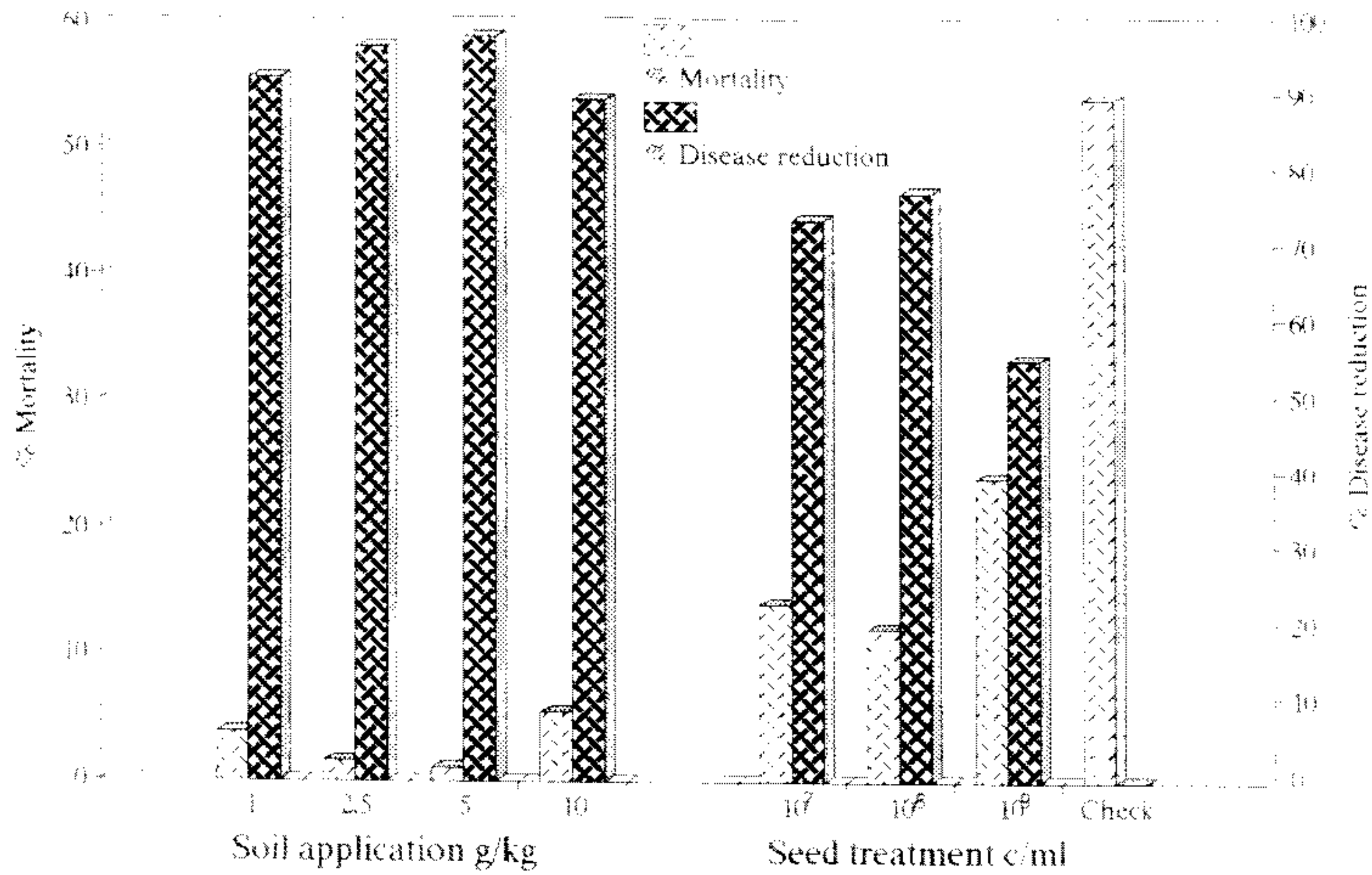


Fig 10 Efficacy of *T. harzianum* as soil and seed treatments on dry root rot of mungbean.

antagonist required is very less and can be easily adopted for large scale field applications.

Comparison between soil or seed treatments as mode of treatment indicated a better response with soil application. Similar observations were obtained in chickpea (Parakhia and Vaishnav, 1986), and mungbean (Samiyappan *et al* 1987). Parakhia and Vaishnav (1986) found that *T. harzianum*, when applied as seed pelleting, soil drenching with a spore suspension and application as wheat husk bran culture superior to other methods for chickpea root rot caused by *M. phaseolina*. *T. harzianum* and *T. viride* as seed treatment was inferior to soil application (Samiyappan *et al.*, 1987) in controlling dry root rot of mungbean.

In the present investigation, soil application @ 5 g/ kg soil and seed treatment @ (10^8C/ml) of *T. harzianum* provided better control of the disease under glass house conditions.

For seed treatment with antagonists, various stickers like carboxy methyl cellulose (CMC), methocil, pelgel and gum arabica have been used previously (Krishnamoorthy, 1987). In the present study, CMC gave good response, as the surface of mungbean seed is smooth in texture, the spores stick well to the seed coat and improved the disease control.

5.14 INTEGRATED CHEMICAL AND BIOLOGICAL CONTROL OF DRY ROOT ROT OF MUNGBEAN UNDER GLASS CONDITIONS

Integration of biological control with other control methods may be required to increase yield and quality and to minimise environmental hazards. Efficacy of a biological control system can be improved by utilizing the antagonist as a component of integrated disease management system. Integrating bioagents with sublethal doses of fungicide not only improves the efficiency but also reduces dependence on agrochemicals (Mukhopadhyay, 1995). In the present study carbendazim was highly effective against test pathogen, compared to all other fungicides tested in the laboratory. As *T. harzianum* was sensitive to carbendazim, fungicide tolerant strains of *T. harzianum* was developed and used in integrated control trial under glass house conditions.

Application of *T. harzianum* to soil (5 g/pot) and seed (10^8 c/ml) in combination with sublethal doses of carbendazim (0.02%) recorded less mortality and gave significant improvement in the protection of mungbean against *M. phaseolina* than soil application or seed treatment alone (Table 32, Fig.11). Integration of biological and chemical control seems to be very promising way of controlling pathogens with minimal interference with the biological equilibrium (Papavizas, 1973). Similar results on integration of *Trichoderma* with chemicals was reported by several workers.

Curl *et al.* (1977) obtained a slight additive benefit to biological control of the antagonist towards *R. solani* in cotton by addition of PCNB at 2 and 10 μg/g soil, together with *Trichoderma* sp. Integrating low doses of PCNB (0.1 to 4 g kg^{-1}) and *T. harzianum* reduced the inoculum potential of *R. solani* and increased disease control in radish (Henis *et al.*, 1978). Chet *et al.* (1979) reported a synergistic effect resulting from the interaction of *T. harzianum* and sublethal doses of PCNB when applied against *R. solani* in beans. Hadar *et al.* (1979) observed that PCNB (1-2 μg kg^{-1} soil) together with *T. harzianum*

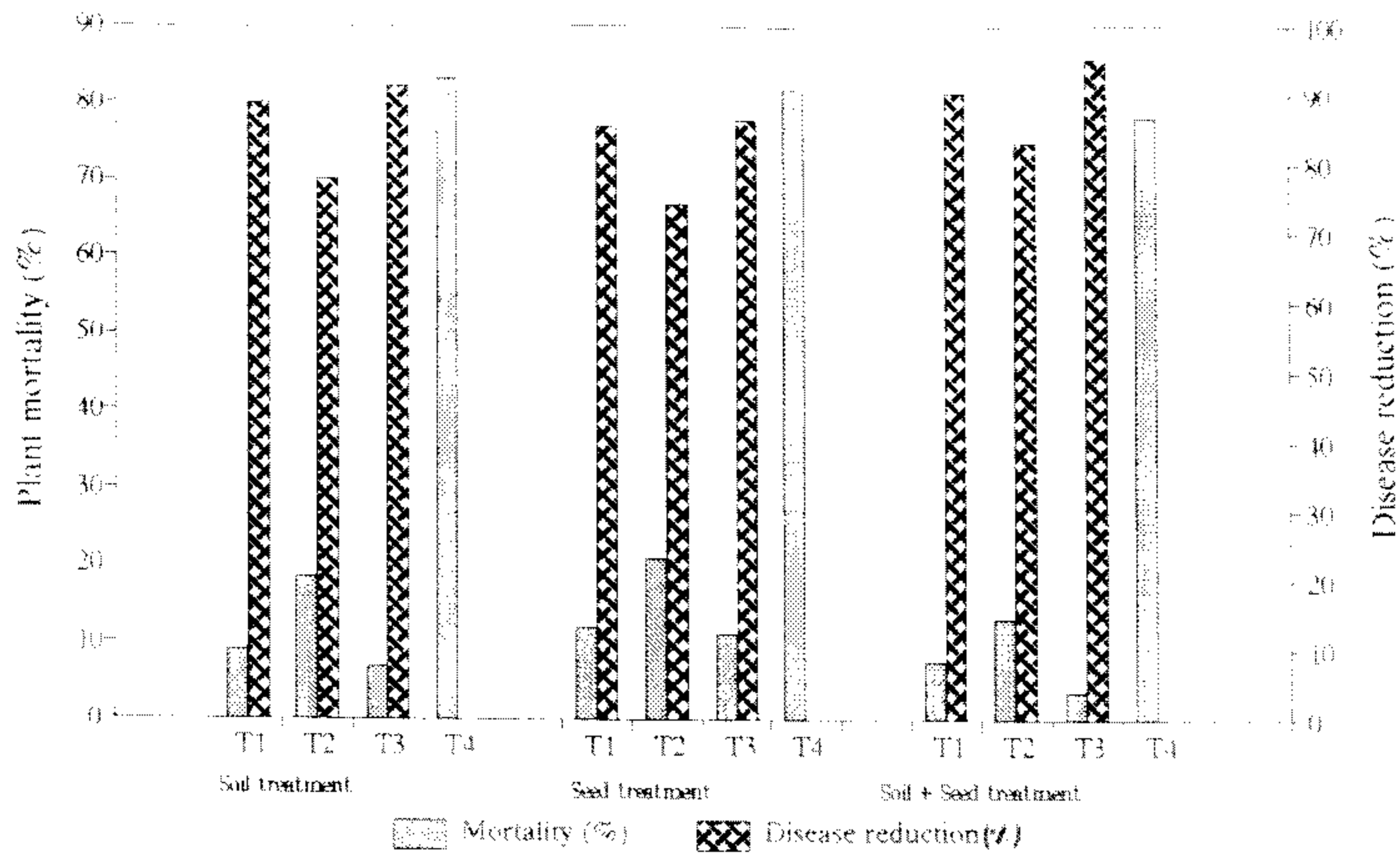


Fig 11. Effect of integration of control methods on dry root rot of mungbean.

interacts synergistically with sublethal doses of fungicides and controlled *R. solani* in egg plant than either was applied alone. Application of fungicide tolerant strain of *T. harzianum* to carbendazim (100-500 µg ml^{-1}) in combination with carbendazim effectively controlled *R. solani* in cotton and radish (Papavizas *et al.* 1982). Papavizas and Lewis (1983) found that *T. viride* and carbendazim (100 ppm) controlled *S. rolfsii* in beans. Lewis and Papavizas (1984) also reported similar phenomenon that in the approach of an integrated control the pathogen was first weakened by the chemical was subsequently controlled for longer periods by *Trichoderma*. Elad *et al.* (1986) reported that *T. harzianum* was as effective as the chemical and combination of bioagent and low doses of PCNB (25 µg g^{-1} soil) slightly enhanced disease control in beans and melons from *M. phaseolina*. Integration of PCNB (5 mg kg^{-1} soil) with sorghum culture of *T. harzianum* (6 g kg^{-1} soil) reduced *S. rolfsii* in sugarbeet and ultimately increased the growth parameters of the host plant (Upadhyay and Mukhopadhyay, 1986).

Alagarsamy and Sivaprakasam (1988) observed that seed pelleting with carbendazim in combination with *T. viride* reduced the seedling mortality in cowpea from *M. phaseolina* besides enhancing growth characters like shoot length, root length and dry matter production. *T. harzianum* and *T. viride* in combination with thiram reduced the incidence of seed borne fungi in clusterbean (Shivanna and Shetty, 1989). Rukmani and Mariappan (1994) found that *T. harzianum* + carbendazim recorded the least disease incidence (2.38 per cent) of dry root in urdbean as against the control which recorded 32.07 per cent.

5.15 A MACROPHOMINA SICK PLOT

The poison distribution has been shown to be an approximate model for binary data when n is much larger than mean. This is especially an approximate model for random pattern of fungal propagules in sampling units. Madden *et al.* (1995) have conclusively shown that the poison distribution forms an appropriate model for binary data when n is much larger than mean. The distribution is approximate for count data that had no upper bound or one which is much larger than observed data. The results of the present investigation also confirm the same pattern of distribution of the fungal propagules in the soil.

5.15 B INTEGRATED CONTROL OF DRY ROOT ROT OF MUNGBEAN UNDER FIELD CONDITIONS

An "**Integrated Disease Management Strategy**" was developed for effective management of dry root rot of mungbean using carbendazim tolerant isolate of *T. harzianum*, sublethal doses of carbendazim, neem cake and soil solarization as components. During *kharif* 1994, carbendazim - tolerant isolate of *T. harzianum* was used as a component of IDM strategy while in *rabi* 1995, the carbendazim - tolerant isolate of *T. harzianum* was used with wild introduced isolates of *T. viride* and *G. virens* as a mixture with carbendazim.

Under field conditions, a maximum disease reduction of 67.09 and 62.15 per cent dry root rot and 68.79 and 69.90 per cent leaf blight, respectively were achieved by integrated application of soil solarization, *T. harzianum* and carbendazim during *kharif* 1994 and combination of three bioagents with carbendazim in *rabi* 1995 (Table 33, 34; Fig. 12, 13). The combination of bioagent with pathogen, solarization, carbendazim, neem cake, with other bioagents viz., *T. virde* and *G. virens* were found significantly superior over check and on par with each other in reducing the disease in both the crop seasons. The plant height and biomass increased substantially over checks in all the treatments involving bioagent alone and in combination with other treatments

T. harzianum alone and in integration with soil solarization, carbendazim, neem cake and other bioagents gave significantly higher yields over checks in both the crop seasons. Maximum yields of 6.55 and 5.99 q ha^{-1} respectively were recorded in the treatments involving bioagent + soil solarization + carbendazim, combination of three bioagents and carbendazim during *kharif* 1994 and *rabi* 1995 respectively .

Although it is well established that certain diseases can be controlled either completely or partially by the use of biocontrol agents. It is understood that the best method to control diseases is through integrated disease management wherein a biocontrol component would be significant. In the past, biocontrol agents have been used alone to control diseases, their integrated use with other management practices has been inadequately studied and practiced. The results of the present investigation revealed that IDM strategy is greatly promising in the management of dry root rot of mungbean which is not possible with either of the existing management practices alone.

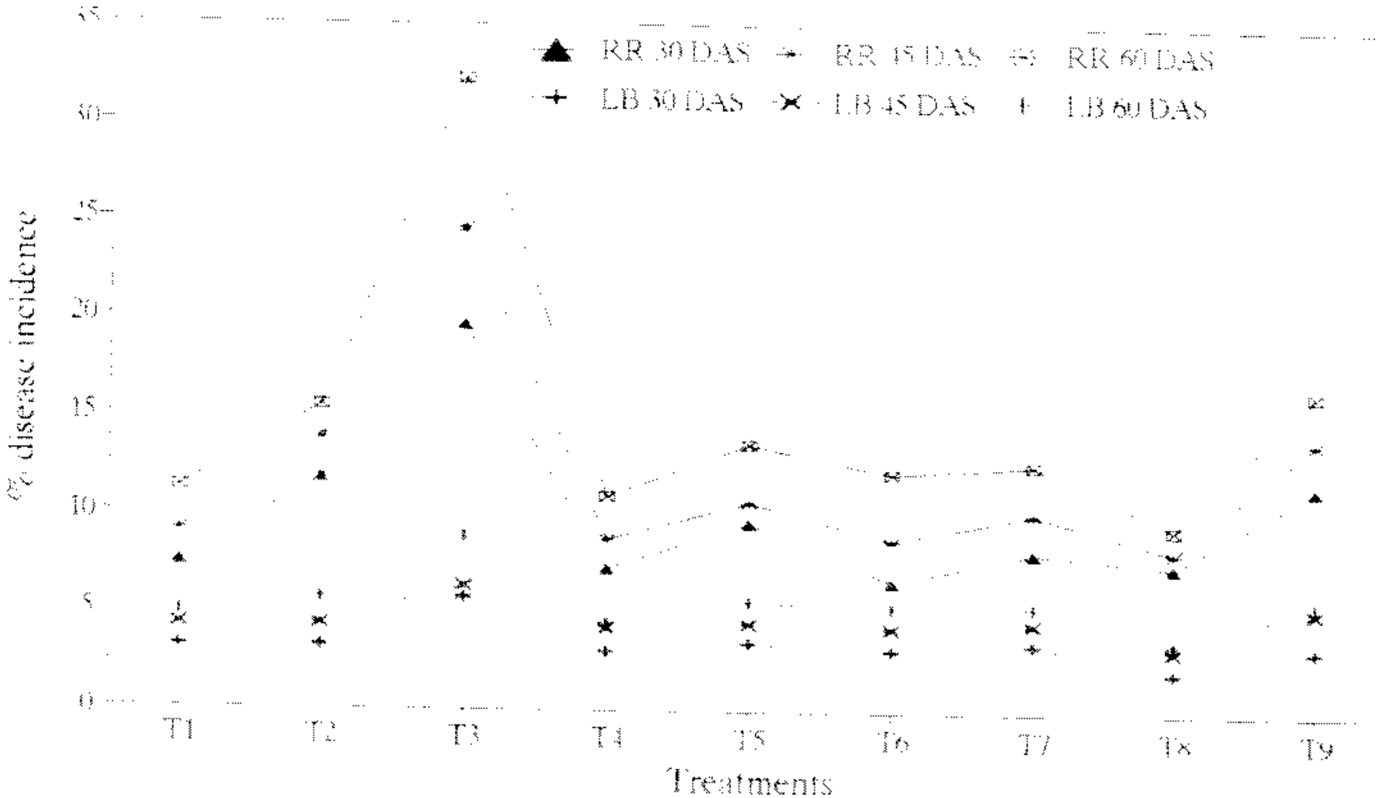


Fig. 12 Effect of *T. harzianum* in combination with other treatments on dry root rot (RR) and leaf blight (LB) of mungbean during *kharif* 1994.

The integrated biological control of plant pathogens has been discussed by several workers (Baker and Cook, 1974; Elad *et al.* 1980; Klassen, 1981; Chet *et al.* 1982; Cook and Baker, 1983; Sivan *et al.* 1984; Strashnov *et al.* 1985; Sawant and Mukhopadhyay, 1990, Upadhyay and Mukhopadhyay, 1986, Vyas and Khare, 1986; Kaur and Mukhopadhyay, 1992; Vyas, 1994; Jayraj and Rambadran, 1996).

The use of *Trichoderma* sp. as a potential biocontrol agent in the integrated biological control of plant pathogens along with other disease management practices has been discussed by Chet and Henis (1985) and Papavizas (1985). It has been pointed out that since *Trichoderma* dominates in soil treated with a sublethal dosage of pesticides, proliferates easily to produce antibiotics, competes for nutrients, and acts as a mycoparasite, its role in integrated biological control may be of practical significance.

Disease management practices used jointly with biocontrol agents includes the use of fungicides and resistant varieties as well as other cultural methods (Klassen, 1981) including solarization (Katan, 1981; Chet *et al.* 1982). Integrating biological and chemical control seems a very promising way of controlling pathogens with minimal interference with biological equilibrium (Papavizas, 1973; Henis and Chet, 1975; Baker and Cook, 1982).

Important pathogens have been successfully controlled by an integrated approach using biocontrol agents and fungicides. These include *Armillaria mellea* on citrus by *Trichoderma* + methyl bromide (Ohr *et al.* 1973), *S. rolfsii*

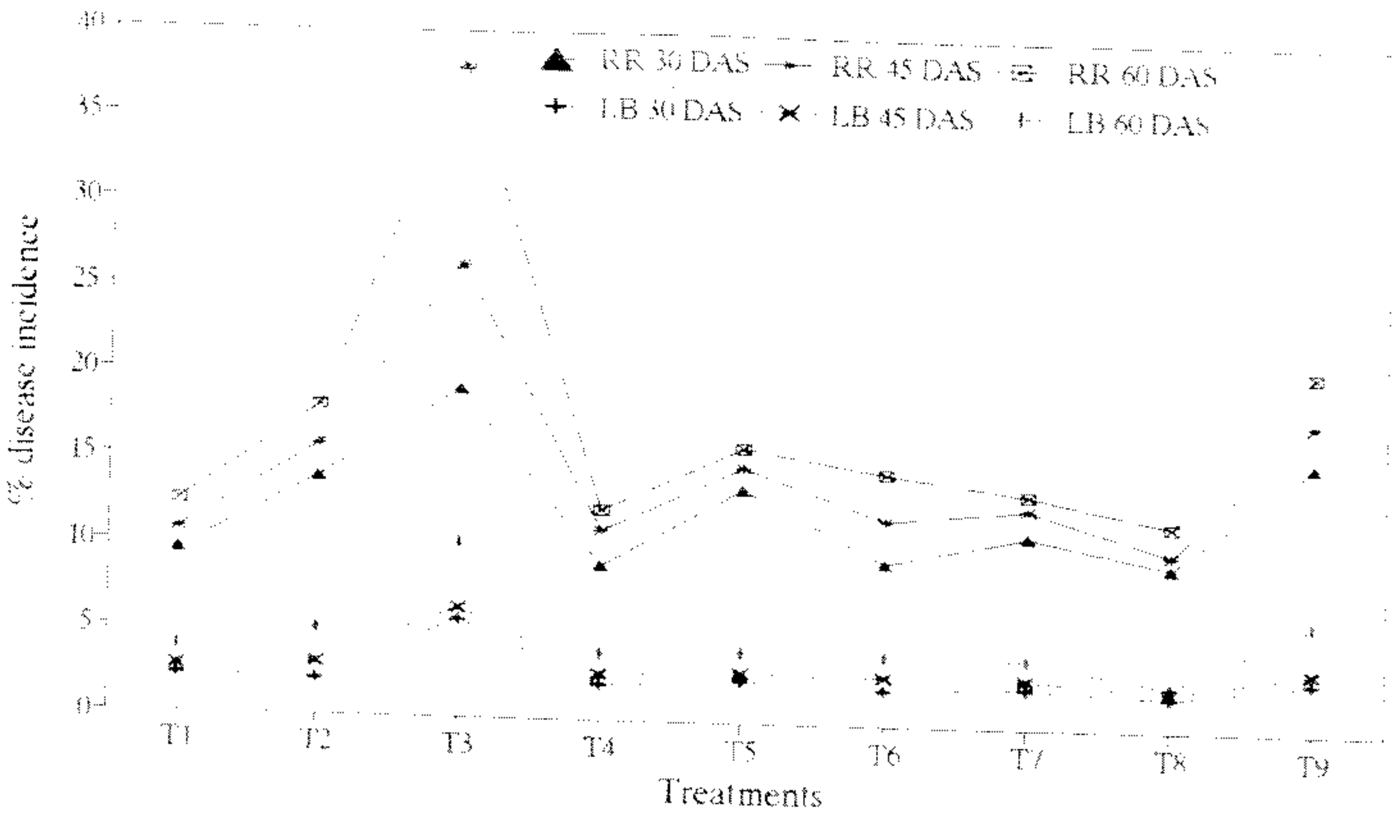


Fig. 13 Effect of *T. harzianum* in combination with other treatments on dry root rot (RR) and leaf blight (LB) incidence of mungbean during *rabi* 1995.

and *R. solani* in beans and carnation by *T. harzianum* + PCNB (Elad *et al.*, 1980., 1981), *R. solani* on radish by *T. harzianum* + PCNB (Harman *et al* 1981), *R. solani* in strawberry by *T. harzianum* + methyl bromide (Munneecke *et al.* 1981), *R. solani* and *S. rolfsii* in groundnut by *T. harzianum* and methyl bromide (Elad *et al.* 1982), *Phytophthora capsici* on pepper by *T. harzianum* + metalaxyl (Papavizas and Lewis, 1981), *S. cepivorum* in onion by *T. harzianum* + Ipro dione (Abd-El-Moity *et al.* 1982), *Pythium ultimum* in pea by *T. harzianum* + metalaxyl (Kraft and Papavizas, 1983), *Pythium* in gypsophilla cuttings by *T. harzianum* + prothiocarb (Sivan *et al.*, 1984), *R. solani* in beans by *T. harzianum* + methyl bromide (Strashnov *et al.* 1985), *Pythium aphanidematum* in sugarbeet by *T. harzianum* + metalaxyl (Mukhopadhyay and Chandra, 1986), *S. roflsii* in sugarbeet by *T. harzianum* + PCNB (Upadhyay and Mukhopadhyay, 1986), *M. phaseolina* in soybean by *T. harzianum*, *T. virde* + carbendazim (Vyas and Khare, 1986), *P. aphanidermatum* in cauliflower by *T. harzianum* + metalaxyl or thiram (Mukherjee *et al.* 1989), *V. dhaliae* in potato by *T. harzianum* + captan (Ordentlich *et al.* 1990), *P. phanidermatum* in sugarbeet by *T. harzianum* + metalaxyl (Sawant and Mukhopadhyay, 1990), *Fusarium oxysporum* fsp. *ciceri* *R. solani* and *S. roflsii* in chickpea by *T. harzianum* + vitavax 200 (Kaur and Mukhopadhyay, 1992), *Pythium* in tomato by *G. virens* + thiram and Cobox L (Kumar and Mukhopadhyay, 1994), *M. phaseolina* in soybean by *T. virde*, *T. harzianum* + carbendazim (Vyas, 1994), *M. phaseolina* in mungbean by *T. harzianum* + carbendazim (Jayraj and Rambadran, 1996), *S. rolfsii* in groundnut (Muthamilan and Jeyarajan, 1996). In the present studies successful control of dry root rot of mungbean was achieved by integratation of *T. harzianum* with carbendazim.

Carbendazim tolerant strain of *T. harzianum* was developed and was blended with carbendazim in the development of IDM strategy for management of dry root rot of mungbean under field conditions.

For enhanced control of soil-borne diseases by blending technology using *Trichoderma* sp. and fungicides, the biocontrol agent should be compatible with such fungicides and possess the required tolerance. *Trichoderma* sp. are known to have greater tolerance for broad spectrum fungicides than many other soil biota and to colonize the treated soils more rapidly than other soil competitors (Munnecke, 1973). *Trichoderma* was predominant in the soil after treatment with the biocides, but also persisted for more than half an year. Induced mutation is is one of the most commonly used practice to modify the genetic composition of microorganisms including antagonistic fungi (Alikhanian, 1962; Ball, 1980; Papavizas, 1981). Purposeful induction of tolerance to fungicides in *Trichoderma* species and the selection of stable biotypes for use in combination with fungicides is one of the several options available for establishing an effective management system. These tolerant strains possess enhanced biocontrol capabilities than their respective wild types.

Different fungicides and soil fumigants are widely used for controlling soil-borne diseases. Because of the concern regarding the toxicity of these compounds, there is a general trend to reduce the amounts applied to soil. In the present study, carbendazim was used at sublethal doses (0.02%) for developing an IDM strategy. One of the most attractive ways of reducing the amounts of fungicides is the integration of sublethal doses of chemicals with *Trichoderma* sp. which is resistant to relatively high doses of methyl bromide (Munnecke, 1973) and PCNB (Elad *et al.*, 1981). Davet *et al.* (1981) found that benomyl inhibited *Trichoderma* growth while thiram enhanced it. Papavizas *et al.* (1982) found mutants resistant to benomyl. These indicate the possibility of combining some appropriate chemicals with this biocontrol agent.

Many workers have obtained successful control of soil-borne diseases in various crops by integrating bioagents with sublethal doses of fungicides. Introduction of *Trichoderma* with sublethal doses of fumigant such as methyl bromide has shown better results than use of *Trichoderma* alone for management of soil borne pathogens (Strashnov *et al.*, 1985). This has been attributed to higher tolerance of *Trichoderma* to sublethal doses of fumigant, which kills most of the other soil microorganisms leaving *Trichoderma* to fluorish with minimal competition (Munnecke, 1973; Ohr *et al.*, 1973). Sawant and Mukhopadhyay (1990) obtained good control of *Pythium* damping off in sugarbeet by the addition of *T. harzianum* and metalaxyl at low doses, which were less effective individually, but when used in combination, they had an additive effect providing 84-100 per cent disease control. Vyas (1994) reported that simultaneous application of *T. harzianum* or *T. viride* with carbendazim as soil drench (125 ppm) reduced dry root rot of soybean effectively under field conditions. Dry root rot of mungbean was also effectively controlled by fungicide tolerant strain of *Trichoderma* and 500 ppm of carbendazim (Jayraj and Rambadran (1966).

The common control treatment of *R. solani* in strawberry is soil fumigation of nurseries and fruiting fields with methyl bromide (Wilhelm and Poulus, 1980). However, because planting material is usually taken from last year's fields, a build-up of the pathogen population in fields and the strawberry plants themselves can result a phenomenon which can enhance adverse soil reinfestation. Successful application of *Trichoderma* in commercial nurseries and fields (Elad *et al.* 1981) revealed the possibility of using this biocontrol agent for reducing such reinfestation. Indeed, *Trichoderma* spp. is the most common antagonist to reappear after soil fumigation, since they have few competitors and can reproduce rapidly (Munnecke *et al.*, 1981). Application of *T. harzianum* after soil fumigation with methyl bromide improved the control of both *S. rolfsii* and *R. solani* in a peanut field. Although soil fumigation controlled the diseases caused by these pathogens, rapid reinfestation followed. *T. harzianum* prevented reinfestation of the fumigated soil (88 per cent reduction both in a controlled environment and under field conditions). The combined treatment, fumigation and application of *T. harzianum* caused almost total mortality of sclerotia in the soil. Transplanting of tomato plants treated with *T. harzianum* into soil fumigated with methyl bromide reduced disease incidence caused by *S. rolfsii* and *R. solani* by 93 per cent and increased yield by 160 per cent (Elad *et al.*, 1982). A combination of *T. harzianum* and a reduced dose of methyl bromide (200 kg/ha) gave a significant synergistic effect in carrot seedlings against damping-off caused by *R. solani* and had a similar effect on growth, yield and diseases control as that of the recommended dose (Strashnov *et al.* 1985).

The positive effect of integrated control was also observed with *Pythium*. Application of *T. harzianum* preparation combined with the fungicide prothiocarb to a rooting mixture infected with *P. aphanidermatum* resulted in a synergistic effect, reducing disease incidence in gypsophilla cuttings better than either treatment alone (Sivan *et al.*, 1984). Integration of dexon with seed coating of *T. harzianum* reduced the percentage of diseased cucumber plants from 53 to 9, results superior to those of each treatment alone (Elad *et al.*, 1983).

Data from most experiments (Grinstein *et al.*, 1979) indicated that integration of low doses of fungicides with *Trichoderma* improves control of soil-borne diseases.

Enhanced control of several soil-borne diseases by the integrated use of the *Trichoderma* species and soil solarization has been demonstrated (Chet *et al.*, 1982; Elad *et al.*, 1980; Katan, 1985). These workers have observed an enhanced control of the diseases caused by *R. solani* and *S. rolfsii* by a combination of *T. harzianum* and solarization. The solarization technique has a great potential in biological control particularly when used in conjunction with the biocontrol tactics (Katan, 1981., 1985). In this process the pathogens are weakened or killed by a synergistic effect of the two components. The solarization, which involves solar heating (a physical phenomenon), makes the pathogens more vulnerable to antagonism by the biocontrol agents. Another practical application of this technique is that at times the population level of the resident antagonist is augmented by natural solarization and therefore, by using this technique, using alien antagonists which are not generally acceptable to the new habit can be avoided. Thus, the results of the present study clearly brought out that the native isolate of *T. harzianum* was more effective in inhibiting the growth of *R. bataticola in vitro* and reducing the mortality of mungbean plants under glass house conditions compared to the isolates of *T. harzianum*, *T. viride* and *G. virens* obtained from Pantnagar, Coimbatore and Rajahmundry.

Due to solarization, the average soil temperatures under polythene mulching exceeded 55 °C, which is in the lethal range of many soil borne pathogens. The increase in soil temperatures during solarization has been considered as the major driving force for various biological changes in the soil (Katan, 1981). Accumulated hours of high temperature was considered to be primarily responsible for sclerotial mortality under moist conditions. This was found to be coupled with annulment of fungistasis at high temperatures leading to germination of sclerotia. Germinated sclerotia are more prone to attack by antagonists and also to high temperatures (Lodha, 1989). Solar heating of the soil may involve both physical and biological methods of control of soil-borne pathogens (Elad *et al.*, 1980). Populations of *Trichoderma* increased with increasing time and maximum population of 34 x 10^3 and 28 x 10^3 cfu/g soil was

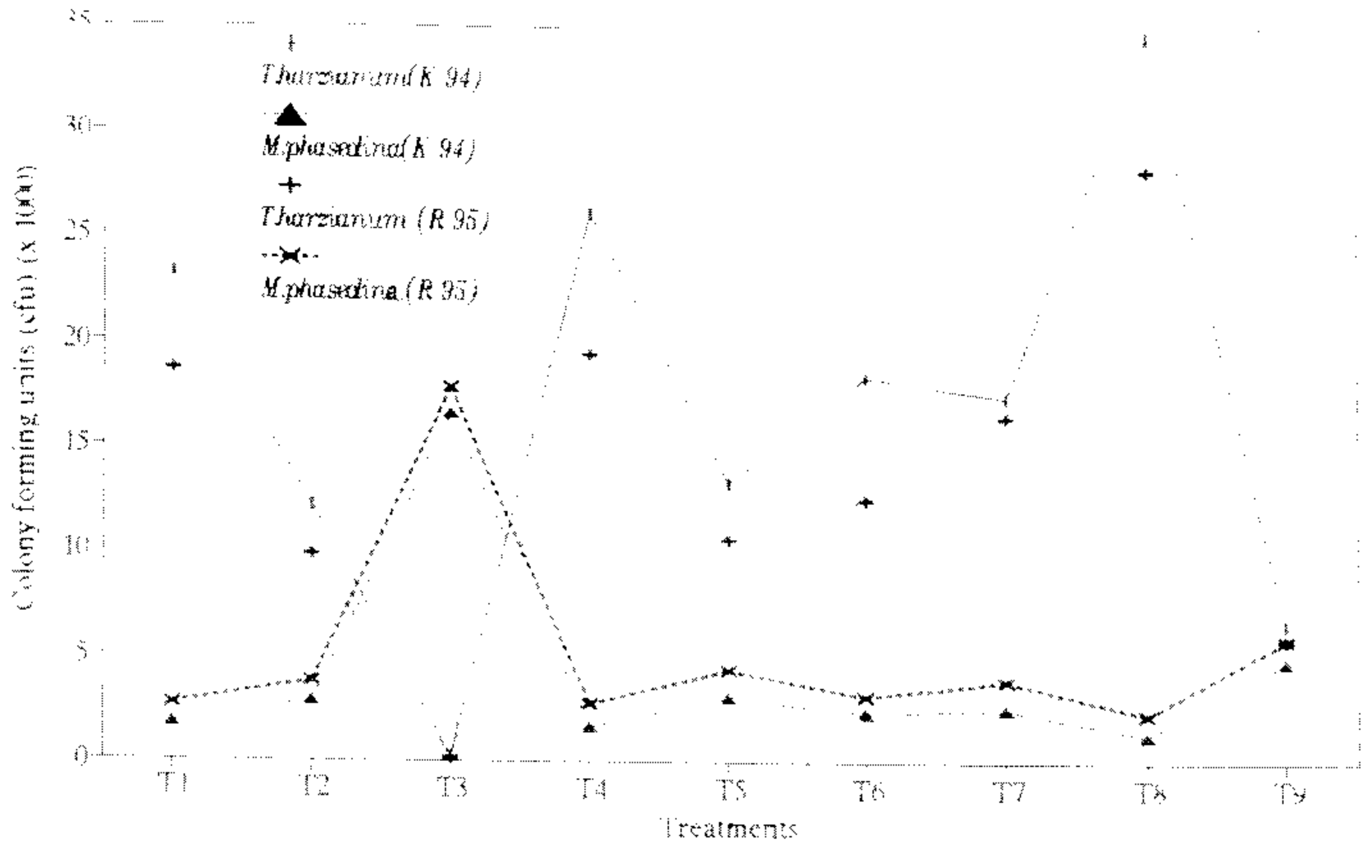


Fig. 14. Colony forming units (cfu) of *Macrophomina* and *Trichoderma* per g of soil during *kharif* 1994 and *rabi* 1995.

recorded in the plots with a combination of bioagent + soil solarization + fungicides in *kharif* and combination of three bioagents with fungicides in *rabi* 1995. Minimum *Trichoderma* population of 0.2×10^3 and 0.16×10^3 was observed in pathogen checks during two seasons, respectively (Table 36, 37, Fig. 14). Conversely, the decline in the population of *M. phaseolina* from 16.56×10^3 and 17.83×10^3, respectively, in pathogen checks during *kharif* 1994 and *rabi* 1995 to 1.26×10^3 and 2.26×10^3 in plots with a combination of bioagent + solarization + fungicide in *kharif*, combination of three bioagents with fungicide in *rabi* which could be attributed to the enhanced antagonistic activity of the bioagent (Raghuchander *et al.*, 1993; Theradimani and Marimuthu, 1993; Muthamilan and Jeyarajan, 1996). Sheikh and Ghaffar (1984) also reported successful control of *M. phaseolina* by soil solarization.

The integrated use of *Trichoderma*, neem cake and carbendazim reduced pathogen survivability, favoured the proliferation of native isolate of the bioagent and ultimately reduced the disease incidence. These results are in agreement with the findings of Arjunan *et al.* (1987), Raghuchander *et al* (1993), Ratnoo and Bhatnagar (1993) and Theradimani and Marimuthu (1993).

There was a remarkable improvement in the accumulation of dry matter and plant height in all the treatments involving bioagent combinations over uninoculated and pathogen checks (Table 33, 34; Fig. 15). Similar increases in total plant height and dry matter production was observed by using bioagents and other methods in beans (Elad *et al.* 1980), sugarbeet (Upadhyay and Mukhopadhyay, 1986), mungbean (Raghuchander *et al.* 1993; Jayaraj and Ramabadran, 1996) and cucumber (Chattopadhyay and Sen, 1996).

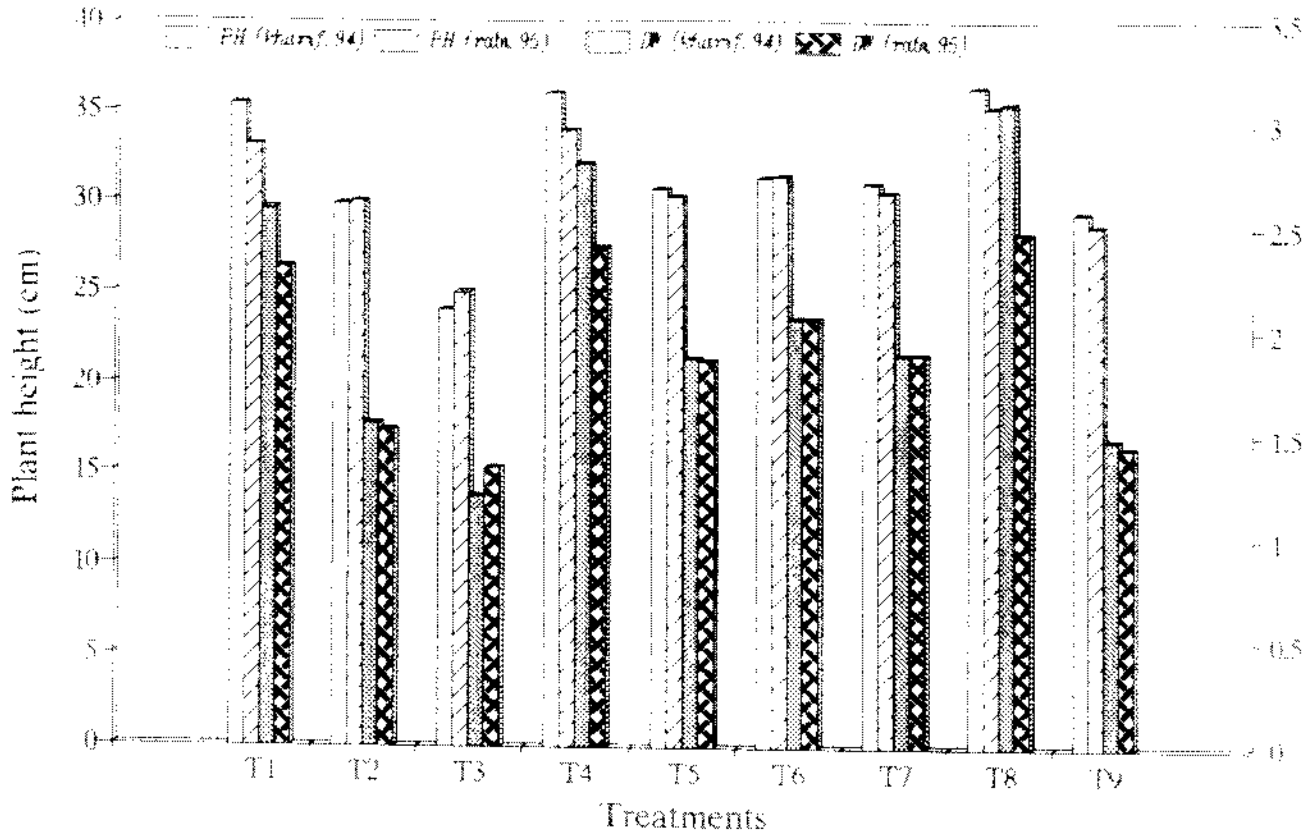


Fig.15 Effect of integration of bioagent *T. harzianum* with other treatments on plant height and dry weight of mungbean during *kharif* 94 and *rabi* 95

The bioagent combinations increased yield of mungbean in both the seasons (Table 33, 34; Fig. 16). Similar yield increases with bioagent combinations have been reported earlier in different hosts (Elad *et al.*, 1980; 1986; Kraft and Papavizas, 1983; Upadhyay and Mukhopadhyay, 1986; Ordentlick *et al.*, 1990; Kumar and Mukhopadhyay, 1994; Jayaraj and Ramabhadran, 1996).

It is evident from the results discussed that the integrated use of biocontrol agents with other diseases control practices is a better strategy than either was used alone. Because of this, in recent years there has been much emphasis placed on the integrated biological control of plant pathogens using different useful components. This approach may prove more effective where no single component is effective in controlling soil-borne diseases such as dry root of mungbean. As stated by Klassen (1981), "high priority should be given in systems research to optimize the joint use of biocontrol agents with other control methods in integrated pest management for insect pests, plant pathogens, nematodes and weeds'

Although successful management of dry root rot of mungbean has been demonstrated in the present investigation by developing an IDM strategy by blending a carbendazim tolerant strain of native isolate of *T. harzianum* proved to be more effective than alien species, sublethal dose of carbendazim and soilsolarization, such as empirical approach needs further refinement to be very promising for agricultural application. There is need to induce stable mutants of *T. harzianum* tolerant to carbendazim. It is at once fairly obvious that the prospects for blending such isolates in IDM strategy would be very promising for agricultural application.

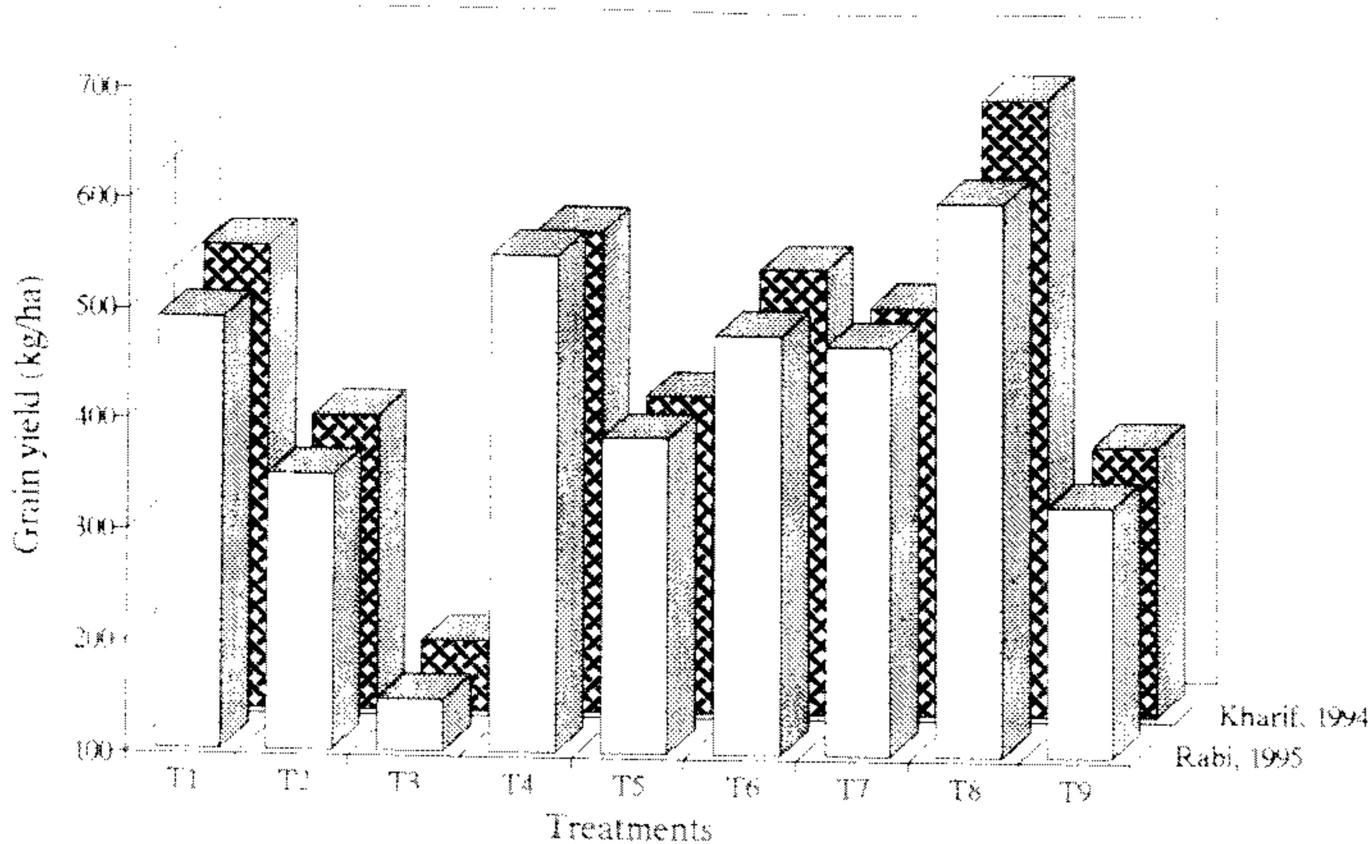


Fig 16 Effect of integration of bioagent *T. harzianum* with other treatments on grain yield of mungbean during *kharif* 94 and *rabi* 95.

5.16 INFLUENCE OF WEATHER FACTORS ON THE INCIDENCE OF THE DISEASE

Environmental factors have profound influence on the development of the disease in mungbean crop. Dry root rot disease increased gradually and reached maximum at the time of harvest during both the seasons of *kharif* 1994 and *rabi* 1995. The spread of the disease was found maximum when the temperatures varied from 29.4 to 30°C with relative humidity between 83 to 90 per cent accompanied by low rainfall (0 to 40 mm) resulting in maximum disease intensity i.e. 25.4, 6.94 and 27.82, 7.41 per cent root rot and leaf blight, respectively during the two crop seasons. High temperatures prevailing during the crop growth period probably caused withering of the mungbean crop in control plots. Rainfall at different time intervals of dry spells favoured the germination of sclerotia which might have infected the pre-disposed susceptible roots of the host plants. The present findings indicate that relatively high ambient temperatures and low relative humidity accompanied with low rainfall contributed to soil moisture/water deficit edaphic factors and resulted in high incidence of the disease in control plots. Environmental factors attributing to soil moisture stress are known to be congenial for development of *Macrophomina* blight (Dhingra and Sinclair, 1978). Grover and Sakhuja (1981) reported that foliage blight of mungbean was favoured at 30 -35 °C with 90 per cent relative humidity levels. The observations regarding the role of high ambient temperatures and low relative humidity and low rainfall on the development of dry root rot of mungbean are in accordance with the present findings.

The results of the present study indicated the need for future research in directions as suggested below:

- Mass multiplication of the bioagents has to be standardised.
- Commercialization of the product formulation of the bioagent by incorporating slowly utilizable nutrient source to permit long duration survival and proliferation in storage has to be exploited
- Concerted efforts are needed to develop effective fungicide tolerant strains through genomic modification.
- Efforts should be made to utilise all feasible components of disease management viz., chemical, physical, cultural, biological and resistant varieties to develop an IDM strategy.
- Efficacy of bacterial and actinomycete antagonists in combating the dry root rot pathogen can be explored.
- None target effects of *T. harzianum* on other soil borne pathogens can also be studied.

INTRODUCTION

CHAPTER I

INTRODUCTION

By the turn of the century, India's population is likely to cross the one billion mark. More than 220 million tons of food grains are required to be produced for meeting the food needs of the ever increasing population by then. At the current level of production of around 190 m.tonnes the country is expected to push up its food production by more than six million tonnes annually to meet the target of 220 m.tonnes by 2001. Keeping in view the past achievements on the food front this phenomenal growth in food production is not beyond reach. With the scope for expansion of cultivated area further being a very much limited, the need of the hour is to optimise productivity of crops particularly in the well endowed irrigated areas where high yielding varieties of crops with better biological yield potential have been successfully introduced and popularised along with the other management practices, for obtaining higher yields of crops.

According to Brown and Roy (1982), fertilisers contributed upto 50 % rise in crop yields. More recently, Randhawa (1992) credited fertiliser to be responsible for 60 % of the increased yield output. Despite 175 fold rise in fertiliser use since Independence (FAI statistics) soil fertility management continues to be the important agenda for scientists and farmers. Wherever irrigation water has been available improper and even excessive fertilisation is a common practice which is causing concern.

It is estimated that the target to produce 220 million tons of foodgrains and other non-food crops by the year 2001 will mean an expense of 28.8 million tons of major plant nutrients viz., nitrogen, phosphorus and potassium. Among the three nutrients, nitrogen use itself accounts for a lion's share of about 18 m.tonnes.

Consequent upon green revolution, the importance of fertilisers for increased crop production was well recognised by the Indian Farmer. In the fertiliser dependent agriculture, nutrient use efficiency has to be addressed with both the short term goal of increasing yield and economic return and the long term need to sustain and improve the productivity of the most basic resource - the soil. Rice yields have increased dramatically since 1966, with the start of the green revolution. Most of the gain in yields can be attributed to two factors viz., improved varieties and increased use of nitrogen fertiliser. In India, with the growing popularity of improved high yielding varieties of crops, a phenomenal increase in the fertiliser consumption is evident.

Nitrogen fertilisers account for the major portion among the fertilisers used because most Indian soils are impoverished particularly with respect to N and P.

Farmers have been using disproportionately large quantities of fertiliser N compared to that of P and K. Therefore, any reduction in the cost on manuring necessitates among others, more rational use of nitrogenous fertilisers. To evolve proper nitrogen fertilisation schedules for different crops, a precise estimate of native (soil) nitrogen availability has to be worked out.

There is a need for a more rational approach to fertiliser N recommendation. Fertiliser N use practices are influenced primarily by such considerations as crop response to N rate, expected crop yields, cost of fertilisers and their availability. The amount of mineralisable (available) native soil N and residual fertiliser N also contribute significantly towards meeting the N requirement of crops. But these aspects are largely ignored in formulating fertiliser N recommendations.

A rational approach to more a meaningful N fertiliser recommendation requires a knowledge of three criteria viz., N requirement of crops for a particular targetted yield, potential of the soil to supply N in mineralised or available form and the amount of residual fertiliser N available from previous application. An estimate of the efficiency of N use for a specific set of crop, soil, climate and management conditions is also essential.

Scientists have long recognised the need for a method that would provide a reliable index of soil N availability, an estimate which would allow for an accurate prediction of the amount of fertiliser N necessary to produce the desired yield levels. The suitability of a soil test procedure in general is judged by obtaining the correlation coefficient between the soil test values and yield/nutrient uptake and response to added fertiliser nutrients. With the price of N fertiliser closely related to the rising cost of of energy, the development of reliable soil test for nitrogen has a lot of relevance. Review of the many suggested N availability indices indicate that there is no universally accepted method which can be adopted for various situations. The necessity for conducting systematic research on soil testing was fully recognised when the All India Coordinated Research Project on Soil Test Crop Response (STCR) Correlation was initiated in the year 1967. Since then, a number of studies have been conducted by the network of research programmes under the project at the different locations of the country. The main purpose of these studies was to screen and select the most appropriate soil test procedure and to calibrate location specific fertiliser recommendations for different crops for yield optimisation and rationalisation of fertilisation. A basis was also developed to evolve soil-test based fertiliser recommendations for targetted yields as early as 1967, by Ramamoorthy et al (1967). However, there is a continuing need to revise fertiliser recommendations for increased crop yields because of the changing scenario of cropping, cropping intensity and fertilisation practices adopted by the farmers throughout the length and breadth of the country. Velayutham et al (1985) have identified a number of research gaps in the STCR correlation studies.

In Andhra Pradesh, STCR experiments have been conducted in farmers fields in the districts of Hyderabad, Guntur, Nizamabad, Khammam, Medak and Kurnool. In order to improve fertiliser use efficiency, similar soil test calibrations need to be developed for different soils, crops and cropping systems in the state. The need for such studies is all the more appropriate in large irrigation commands for optimising crop yields and to prevent imbalanced fertilisation practices. If excessive fertilisation is adopted, which is common in large irrigation project commands, the practice, in addition to being economically wasteful is also ecologically unsustainable causing large scale pollution of water bodies and soil degradation. If the fertilisers are not used to the desired extent, the yield potential of crops remains unexploited. To evolve appropriate fertilisation practices, targetting the individual commands are more appropriate. With these aspects in view, the studies have been conducted with the following objectives :

1. To conduct a survey of rice soils in Sreeramsagar Project for determining fertility status and classify soils into different fertility groups.
2. To evaluate the utility of currently adopted N availability indices in soil testing laboratories in Andhra Pradesh for recommending N fertilisation to rice.
3. To assess the yield response of rice to N applications in soils with varying native nitrogen availability status.
4. To develop a realistic approach for recommending N fertiliser application based on native soil fertility status, crop requirements of N and targetted yield of rice.

It is presumed hopefully that from the studies carried out it would be possible to recommend an appropriate soil testing procedure for adoption by the State Soil Testing Laboratories to determine the N availability indices. Based on this indices N fertilisation schedules can be recommended for rice crop in the Sreeramsagar Project command which is one of the largest irrigation projects in the state. The project has in its command 3.97 lakh ha spread over four districts in the state. The results of these investigations are presented and discussed in the thesis.

REVIEW OF LITERATURE

CHAPTER II

2. REVIEW OF LITERATURE

Nitrogen as a plant nutrient is considered as one of the major requirements to realise the yield potential of high yielding genotypes of crops. Most of the rice soils in the world are recognised as deficient in N (Patnaik, 1978) and in India about 67 per cent of rice soils are estimated to be deficient in Nitrogen (N) (Mahapatra et al. 1985). Enhancing the fertiliser use efficiency is essential not only for increasing the agricultural production but also for realising the maximum returns from the investment on fertilizers at individual farmer's level. Fertilizers are becoming expensive and account for a major portion of cultivation costs. Advice to the farming community on the quantity of fertilizers to be applied is normally generated from field trials using different levels of fertilizer nutrients and deriving a mean optimum dose as a general recommendation from the soil test-crop response correlation in a given agro-climatic region. Recommendation based on local soil test crop response relationship data commonly provides the site specific fertiliser requirements for crops.

With the objective of evaluating utility of currently adopted N availability indices in soil testing laboratories in Andhra Pradesh and derive a basis for recommending N fertilizer based on native soil fertility status, N uptake and yield of rice under Sreeramsagar Project Command Area, the present study was undertaken. The relevant literature has been reviewed here under two separate heads namely :

i) Soil test methods ; and

ii) Response of rice to N fertilization.

As the present studies relate to Soil Test Crop Response Programme, the relevant data generated under the All India Coordinated Soil Test Crop Response Correlation Project is also reviewed here.

2.1. SOIL TEST METHODS

On a global basis, the total N content of soils range from 0.02 percent in tropical soils to more than 2.5 percent in soils of temperate regions. The surface layers of most cultivated soils contain total N ranging between 0.06 and 0.5 percent. The total reserve of N in soil is almost entirely restricted (about 95 %) to organically combined form (Bremner 1965).

Indian soils have very low N content because of tropical climate. The low level of nitrogen in Indian soils is attributed primarily to climate and secondarily to cropping (Jenny and Roya Chaudhury 1960).

A sound soil test methodology is essential for recommending dependable fertiliser use. Soils all over the world would probably more often be deficient in N than any other nutrient and yet there is no universally accepted laboratory method to test soils for available N. This is reflected in part on the fact that 97 to 99 per cent N in soils is present in complex organic matter and conversion to organic compounds that are not available to plants. Thus, N slowly becomes available to plant through microbial decomposition of the organic matter and conversion to available inorganic form of N.

Three important steps in soil test methods are

i) Selecting an extractant

ii) Correlating the amount of nutrient extracted (test value) with the amount taken up by the plant and

iii) Calibrating the test value in terms of its effect on some desirable crop characteristics, usually yield of marketable product (Coney, 1987). A measurement qualifies to be termed a soil test for a particular nutrient if and only if, it provides information on the fertilizer requirement of a crop for that nutrient (Colwell, 1967).

The fertilizer requirement of a crop is not a static one but changes depending upon the marginal rate of return expected by the farmer on the investment made on fertilizer. Soil testing may therefore, be defined as a tool for rapid soil chemical analysis to assess the available nutrient status of a soil, interpretation of the test results and making fertilizer recommendations based on crop responses and economic considerations. For this, the soil tests have to be calibrated. The process of evolving the relationships between soil test and crop yields is commonly referred as calibration of soil test values. A calibrated soil test value for a particular nutrient will indicate the degree of deficiency of that nutrient to achieve a desired yield goal and the amount of the nutrient needed as a fertilizer to correct that deficiency depending upon the expected marginal ratio of return.

2.1.1. SOIL TEST METHODS FOR NITROGEN

It is essential to know the N supplying capacity of paddy soils for judicious and efficient use of fertilizer nitrogen. Many biological and chemical laboratory methods of testing soil for available N have been proposed for predicting soil N availability (Bremner, 1965, Chang, 1978, and Sahrawat 1983).

It is important to evaluate nitrogen soil tests for selecting the best method which can be used in soil fertility evaluation programme for deriving optimal benefits from nitrogen fertilizers (Dubey et al, 1972). Most of the Indian soils have been categorised as low to medium with respect to available N content.

The chemical indices include simple methods such as measurement of organic carbon and total nitrogen content of soils. The logic behind using organic carbon as an index of soil N availability is that the availabile N pool in soil ultimately comes from organic matter through the process of mineralisation. Soil testing laboratories in India use organic carbon content as an index of nitrogen availability to rice (Sahrawat, 1983, and Minhas and Bora 1982). Other methods include Total N (Sahrawat,1980), mineral N (Bajaj and Singh, 1980), alkaline potassium permanganate digestion (Subbiah and Asija, 1956), Acid $KMnO_4$ extraction (Sahrawat, 1978), Hydrogen peroxide oxidation (Sahrawat, 1980), acid dichromate extraction (Sahrawat, 1978), Autoclave method

(Sarma and Pomaraes, 1992), extraction with dilute sulphuric acid (Sahrawat, 1982), boiling $CaCl_2$ (0.01 N) extraction (Dolomat et al, 1980), alkali hydrolysis with $Ca(OH)_2$, or NaOH (Prasad, 1965), sodium pyrophosphate 0.5 N extraction (Dolmat et al., 1980), boiling H_2O (Ghosh, 1980), and $NaHCO_3$ (Ghosh, 1970).

Biological indices include incubation of soils with out and under submergence at different ambient temperatures (30°, 35° and 40° C) for varying periods of time ranging from 6 to 14 days and in some cases for as much as 12 weeks. Aerobic (submerged) incubation methods are at 30° C for 1-2 weeks (Sahrawat, 1983). Simple methods of N supplying of soils capacity based on biological and chemical indices were also proposed (IRRI 1965). The A-values determined using N^{15} labelled fertilizers could also be used to determine the N-supplying capacity of the soils (Fried and Dean, 1952). The recent techniques on Electro-Ultra-Filtration (EUF) facilitates extraction of nitrogen from soils with varying voltages and temperature (Nemeth, 1979). Plant analysis is yet another accepted method of determining nitrogen supplying capacity of soils for diagnosing and correcting nutrient deficiencies based on critical nutrient values (Chapman, 1971).

Subbiah and Asija (1956) observed a significant correlation between $KMnO_4$ oxidisable N and yield responses of paddy and wheat. Bajaj et al.(1967) found that alkaline $KMnO_4$ method was correlating significantly with percent yields of wheat and paddy. They also observed that for the surface soil, the NO_3 potential gave significant and positive correlation (0.856 **) with the yield of rice (IR-8).

Prasad (1965) estimated potentially available N in soil using $Ca(OH)_2$ for hydrolysis and obtained significant correlation with N uptake by millet grown on sandy and silt loam soils under green house conditions and N mineralised on incubation for 6-weeks. The correlation coefficient values (R-values) for these relationships were 0.717 and 0.610 respectively. Results obtained from the All India Coordinated Soil Test Crop Response Correlation Project (1968) have, however, indicated that the method did not correlate significantly with percent yield of wheat and paddy grown on heavy black soils of Jabalpur, where as the alkaline $KMnO_4$ method correlated significantly with percent yield of wheat and paddy. It was further reported that the $Ca(OH)_2$ method correlated significantly with percent yield of wheat cultivated on an alluvial soil of Delhi.

Keeney and Bremner (1966) used a chemical extraction procedure with Iowa soils, involving extraction of soil N with boiling water and potassium sulphate solution and found that they were closely related to N uptake by ryegrass and indicated that this procedure deserves consideration as a routine method of obtaining an index of soil N availability. Ghosh (1966) observed that the total nitrogen uptake of wheat linearly related to the amount of applied nitrogen in the range of 0 to 134 kg N/ha. He used three chemical tests for available soil nitrogen using the "N value" as a standard of comparison.

Sims et al. (1967) predicted nitrogen availability to rice by laboratory measurement of N availability. Seven different methods were employed and it was concluded that correlations were better with clayey soils than silt loam soil. Organic matter content as a measure of total N in soil were having poor prediction of N availability in rice.

Colwell (1967) calibrated soil tests for estimating fertilizer requirement using statistical models to describe the relationship between yield of crop, fertilizer application rate and soil tests and found only non-significant relationships ($P>0.05$) with N soil test. Bajaj et al. (1967) evaluated methods of determining available N and found that alkaline $KMnO_4$ gave the best correlation of N uptake in wheat and rice with soil available N status.

Robinson (1968) determined simple available soil nitrogen index in cultivated East African soils employing laboratory and green house studies and concluded that mineralisable N was correlated more with total N than organic N. Subbiah and Bajaj (1968) reported that paddy yields were highly correlated with organic matter content of soils inspite of varying conditions of crop growth. Jenkinson (1968) found that the amount of organic matter extracted by $Ba(OH)_2$ might serve as an index of potentially available N in soils.

Ghosh (1970) reviewed the evaluation of chemical soil tests for nitrogen and merits were discussed with empirical nature of various extractants employed by different workers on various crops. Better correlation has been observed with methods employing boiling water, $NaHCO_3$, $Ba(OH)_2$ (for soluble glucose estimation) and $Ca(OH)_2$ as extractants rather than two alkaline $KMnO_4$ methods employed. This may be due to the higher efficiency of alkaline extractants in attacking the humid acid fraction.

Smith and Stanford (1971) studied the surface soils from U.S.A. for assessment of soil organic N availability under aerobic and anaerobic N mineralisation and reported that alkali distillable N correlated considerably better with aerobic ('r' value > 0.90 **) than with anaerobic mineralisation.

Bajaj (1972) and Dubey et al.(1972) evaluated three N soil test methods viz., Alkaline KMnO4 and $Ca(OH)_2$ extraction and organic carbon content and observed that alkaline KMnO4 extraction gave better and significant correlation (r = 0.642 **) between soil test values and percent yield. Next in performance was organic carbon content which showed a significant correlation coefficient of the order of 0.573 (**). Therefore it was concluded that these two tests in that order are suitable for assessment of nitrogen status of black (clayey) soils. Bajaj (1972) reported significant negative correlation for $Ca(OH)_2$, alkaline permanganate N and organic carbon with the yield of wheat, whereas Iowa nitrification index was positively correlated with the yield of wheat.

Baljit Singh (1973) observed significant negative correlation between the percent yield response and available soil nitrogen by alkaline permanganate method.

Kyuma and Kawaguchi (1973) tried a method of fertility evaluation for nitrogen in submerged paddy soils and found that a test of linear models with different combinations of independent variables revealed that the organic matter status has no relevance to the yield of paddy but the best linear model with inherent potentiality and available nitrogen status explained about 40 percent of the variance of yield.

Gupta et al. (1975) developed a new colorimetric procedure for determination of soil organic carbon which is simple and rapid and was found suitable for soils of varying texture containing $CaCO_3$ content upto 10% and chlorides upto 0.4%. A very significant correlation (0.996 **) was observed between the organic carbon values and yield of crops and the procedure was also reported to be simple and less expensive.

Fox and Preklelek (1978) tested several nitrogen availabilty indices at field level in south eastern Pennsylvania (USA) soils using corn (Zea mays L) as test crop in 1976 and 1977 taking into account of N-supplying capacity of soils and recorded signifcant corrletions with N-supplying capacity of a soil in a green house or laboratory experiments with boiling 0.01 m $CaCl_2$ and 0.01 M $NaHCO_3$ extractable N at 1 % level (r=0.86 and 0.77 respectively).

A laboratory method for assessment of nitrogen availability index determined as nitric acid potential gave significant correlations with the yield of bajra, wheat and rice crops in experiments conducted on alluvial soils of Delhi at IARI farm (Bajaj and Hasan 1978).

Relating available soil nitrogen to rice yield (Dolmat et al. (1980) using six chemical and two biological extraction methods in Louisiana (USA) soils it was reported that average percentage recovery of total soil nitrogen ranged widely from as high as 16.74 percent by the hot alkaline permanganate method, to the lowest value of 1.08 percent by boiling soils in 0.01 CaCl2 solution. The best prediction of yield appeared to be anaerobic incubation method which correlated highly with total soil N value (by Kjeldahl method) with an 'r' value of 0.814 (**), followed by the aerobic incubation method (r=0.764 **). The relationship was also established between yield increase from application of 112 kg/ha N and available soil N determined by the anaerobic incubation method.

Negi and Sud (1982) tried a new method which is based on the principle of micro diffusion (Conway,1947) and found that the proposed method correlated positively with percent yield and percent N uptake than other methods viz., readily oxidisable N and alkaline $KMnO_4$. The main advantage of this extraction procedure is the elimination of distillation step, which is a time consuming and more laborious.

Sahrawat (1982 a) found that amount of available N in Phil ippines rice soils extracted by alkaline permanganate method was significantly correlated with organic carbon, total nitrogen and potentially mineralisable N content determined by the anaerobic incubation methods. Alkaline permanganate N was highly correlated with N uptake and drymatter of rice grown under flooded conditions (r=0.81 ** and 0.40 * respectively).

Sahrawat and Burford (1982) found that standard alkaline permanganate method could assess the availability of soil N, including nitrogen from amino acid and NH4+ but not nitrogen from urea, NO_2^- or NO_3^- in the available N pool. They suggested the non-inclusion of NO_3-N that commonly accumulate in upland soils in the available N pool might be the reason for the poor predictability usually obtained by the method for upland crops. Nitrate formed in wetland soils are of little consequence to rice because they would be lost by denitrification, however NO_3^--N could be important for upland crops specially in the post-rainy season. Therfore, they proposed simple modification to use Devarda's alloy to include nitrate and nitrite N. Results showed that the NO_3-N content of the soil contributed to 40% of the available N assessed by the modified method.

Sahrawat (1983) investigating the relationship between available soil N, total N, organic carbon percent, N uptake and drymatter yield obtained a close correlation between all available indices of soil N and N uptake by rice while the correlation coefficient was found to be less for drymatter yield.

Faquir Hussain and Malick (1985) proposed modification of acid permanganate method for obtaining an index of soil nitrogen availability that allows for the estimation of soil mineral N simultaneously. The N values obtained by the modified method correlated highly and significantly with the mineral N of incubation test ($r = 0.80$ **, $P<0.01$) and plant uptake ($r=0.69$ **, $P<0.01$).

Singh (1988) used modification in rapid calorimetric method of determination of nitrate in soil and plant extracts which eliminated the use of barium sulphate and introduced diazatization of sulphanilamide by the nitrite ion obtained by the reduction of nitrate and subsequent coupling with N-1-napththalene-diamine dihydrochloride. Results proved highly reproducible with coefficient of variation of 2.2 and 2.9% for soil and plant extracts respectively.

Gupta et al. (1989) determined the critical values of soil test methods of nitrogen for rice from 15 different sites of Ludhiana and Gurdaspur districts of Punjab by employing 21 methods. The results show that organic carbon followed by alakli hydrolysable N, initial NH_4-N and hydrolysable NH_4-N were found suitable soil test methods of predicting N availability to rice. The critical value for rice was 0.45 % organic carbon, 30 µg/g alkali hydrolysable N, 22.3 µg/g initial NH_4 and 93.3 µg/g of hydrolysable NH_4-N.

Treating the soils with 2 M KCl at 100° C for 4 hours with a phosphate-borate buffer at pH 11.2 for 8 minutes was not found to be suitable for prediction of N supplying capability of soil to maize (Harg et al. 1990).

Nazirkar and Sonar (1991) worked a calibration of soil test methods for available N in black soils (Inceptisols) for sorghum and proved that alkaline $KMnO_4$ method as the best method for estimating available N in alkaline calcareous soils belonging to Sawagoan series (Vertic Ustopepts). An application of N fertilizer to sorghum was beneficial where the available N in soil was less than 230 kg/ha by alkaline permanganate method.

Sarna and Pomaraes (1992) compared the percent organic nitrogen extracted in the biological methods i.e., maize plants grown in pots and soil sludge mixtures incubated at 2, 4, 6, 8, 12 and 16 weeks with four chemical methods viz., autoclaving, 0.5 M $KMnO_4$, pepsin and 0.6 M HCl. They concluded that the HCl and pepsin methods predicted the availability of organic nitrogen in sludge better than biological methods. They suggested the use of pepsin and HCl extractions, because of high correlations obtained with biological measurements of N availability and considered that total N can be taken as a chemical index of N availability.

Sharif Zia et al (1992) working on rice soils of Pakisthan (low in organic matter) under green house study used several extractants for NH_4-N and concluded that they were correlated very well with each other and also with 2 N KCl, the most common extractant used for mineral N extraction (Keeney and Nelson 1982).

Vickery et al (1995) described simple procedure for colorimetric determination of organic carbon in soil which is a modification of the wet oxidation/digestion method based on potassium dichromate combined with a colorimetric method for determination of chromic oxides (Stevanson and Clare, 1962). A segmented flow analysis for the calorimetry was used and this procedure is capable of automated routine analysis of large number of samples and was shown to give high and acceptable recoveries of organic carbon from a range of compounds.

Available soil N measured by biological methods and chemical methods of N extraction by boiling water and boiling water + K_2SO_4 solution and dilute $Ba(OH)_2$ solution revealed that biological methods correlated with organic carbon and Total N content of the soil studied from wheat, corn and cotton field experiments (Setaton and Simonis, 1996).

2.1.2. SOIL TEST METHODS FOR PHOSPHORUS

Several methods have been suggested from time to time to estimate plant available phosphorus in soil, but all these cannot be adopted for routine soil testing for different crops and their suitability largely depends upon physico-chemical characteri-sation of the soil. Estimation of available P status of soil is necessary for delineating the areas of P-deficiency for developing P-recommendation and monitoring P fertility changes.

Olsen et al.(1954) in crop correlation studies found that 0.5 M $NaHCO_3$ and Bray's extractants are superior in their correlation with the response of wheat compared to other extractants. The Olsen's P was found to correlate best in relation to yield and P-uptake of paddy. Sodium bicarbonate extractable P was found to be a better index of P availability by many workers (Bajaj et al, 1967, Ramamoorthy and Bisen 1971, Goswami et al.1971, Pathak et al. 1976, and Ekpete, 1976).

2.2. PADDY YIELD RESPONSES TO N FERTILIZATION IN RELATION TO SOIL FERTILITY

Soils of India have low total N content (0.02 to 0.1%) due to the tropical and sub-tropical climate prevailing in the country (Prasad and Thomas, 1982) though relatvely higher values are encountered in some hilly regions of north-east and north-west.

2.2.1. SOILS RATING

Soils are rated for their fertility as low, medium and high in respect of their available nutrient and organic carbon contents. Muhr et al.(1965) suggested the following soil ratings :

Nutrient	Low	Medium	High
Organic carbon	< 0.5 %	0.5 - 0.75 %	> 0.75 %
Available N	< 280 kg/ha	280 - 560 kg/ha	> 560 kg/ha
Available P	< 10 kg/ha	10 - 25 kg/ha	> 25 kg/ha
Available K	< 108 kg/ha	108 - 280 kg/ha	> 280 kg/ha

Paddy, in general and HYV of paddy in particular respond significantly to the application of nitrogen fertilizer. In a pot culture experiment grain yield of paddy was shown to be significantly influenced by extractable NH4-N (Sims et al. 1967) and the yield of paddy (IR-20) was significantly correlated with amino acid nitrogen (Rani Perumal,1975).

Different soils with given soil test values for nutrients differ in their capacity to supply nutrients to crops and to produce yield. Crops vary in their nutrient requirement after a certain level of yield. However, one point is common in the soil test value for a particular nutrient, the higher is the response to the fertilizer nutrient with lower available nutrient content (Biswas and Mukherjee,1987). Sharma and Dev (1976) observed highest grain yields of rice variety 'Padma' at 150 kg N/ha. Further increase in N rates gave no additional yield while Krishnamoorthy et al (1979) reported higher yields at 180 kg N/ha. The grain yields of a rice dwarf variety increased significantly against a nitrogen level upto 120 kg/ha in two successive seasons. The yields recorded were 6265 and 6867 kg/ha respectively for both the seasons.

Bhattacharya and Rudra (1977) conducted a field experiment on HYV paddy (var : Ratna) during kharif season in red soil tract of West Bengal and calculated nutrient requirement (NR), Contribution from soil (CS) and Contribution from fertilizer (CF) with the plant uptake, yield, soil test values, and fertilizer doses using the following formulae for attaining targetted yields paddy thus viz.,

$$NR\ (kg/q) = \frac{\text{Total uptake (kg/ha)}}{\text{Grain yield (q/ha)}}$$

$$CS\ (\%) = \frac{\text{Total uptake of a nutrient (kg/ha) in control plot}}{\text{Soil test value (kg/ha) of control plot}} \times 100$$

$$CF\ (\%) = \frac{\text{(Total uptake of a nutrient) - (soil test value X CS)} \atop \text{(in treated plot (kg/ha))}}{\text{Fertilizer dose (kg/ha)}} \times 100$$

From the data obtained using the above formalae, the amount of fertilizer required for production of one quintal of grain were found to be 2.1 kg N, 0.58 kg P_2O_5 and 3.5 kg K_2O. The efficiencies of nutrients available from soil in respect of N, P_2O_5 and K_2O for contribution to grain production of paddy under the experiment were 20, 50 and 53 percent respectively. Similarly, the efficiencies of fertilizers were calculated separately which were 75 % for N, 10 % for P_2O_5 and 60 % for K_2O. The low efficiency of added P fertilizer could be due to higher soluble P content in such soils.

Dhillon et al. (1978) established fertilizer adjustment equation with field experiments on paddy (IR-8) and have shown possibilities of making precise fertilizer recommendations based on soil test values to get maximum yields, maximum profits and marginal returns on fertilizer investments from multiple regression equations with good R^2 values (significant at 1% level).

Gopalakrishna Pillai and Vasudevan (1978) in their field studies on an integrated nutrient supply system for rice at Hyderabad (India) found enhanced N-use efficiency by root zone placement of urea supergranules.

Studying nitrogen uptake at different growth stages of rice at Tirupathi, Ramakumar Reddy et al.(1978) observed that maximum nitrogen uptake of 413 mg/3 hills was in 'Vijaya' followed by 'Ratna' (363 mg/3 hills) and 'IR-20' (361 mg/3 hills). Among the fertility levels, maximum nitrogen uptake (487 mg/3 hills) was observed in 200 N : 100 P_2O_5 : 100 K_2O kg/ha which was significantly superior to 150 N : 75 P_2O_5 : 75 K_2O (380 mg/3 hills) and 100 N : 50 P_2O_5 : 50 K_2O kg/ha level (270 mg/3 hills). Maximum uptake of N was recorded at harvesting as compared to maximum tillering and panicle initiation stages.

Results of experiments conducted at CRRI, Cuttack on response to increasing levels of nitrogen over a period of three years involving short duration high yielding varieties of rice grown under ideal management practices (optimum stand establishment, perfect weed control, split application of fertilizer and incorporation into soil) indicated that the mean yield with a level of 30 kg N/ha produced a grain yield of 2496 kg/ha, representing grain response of 33.2 kg per kg N applied (Pande,1978).

For soils which are deficient in N and P, it is necessary to supply both nutrients through fertilizers in order to achieve maximum response to these nutrients. The positive N x P interaction is therefore of great significance. Singh and Verma (1971) found 160 kg N/ha and 60 kg P_2O_5/ha as optimum doses for paddy grown on clay loam soils, while Subba Rao et al.(1978) obtained maximum yield at 120 kg N and 120 kg P_2O_5/ha for black clayey soils. Mahatim Singh et al.(1979) noted an increase in grain yields from 3.16 to 4.3 t/ha.

Dev et al.(1978) studied fertilizer requirement for different yield targets of paddy based on soil test values in tropical arid brown soils at Punjab Agricultural University farm, Gurdaspur. It was reported that for the production of one quintal of paddy grain, on an average, the nutrient requirements were 2.11 kg N, 0.75 kg P_2O_5 and 4.41 kg K_2O. Further, the efficiency of soil available nutrients for contribution to grain production of paddy was 47% from alkaline $KMnO_4$ available N, 99% from Olsen-P and 220 % from ammonium acetate K. Similarly, the efficiency of applied nutrients was 83 % for N, 33 % for P_2O_5 and 167 % for K_2O.

Balasundaram (1979) employed Mitscherlich's Model for efficient and economic fertilizer N use in a field experiment at six different locations with sorghum as test crop. Interpretation of site specific recommendation for sorghum was possible based on initial soil test value. Utilising the mean C1 and C values for the loamy and sandy loam soils, fertilizer requirements were computed for the common range of soil test values from 100 to 400 kg/ha of alkaline permanganate N. The optimum rate of N application was also calculated taking into account the cost of fertilizer nitrogen (X) and the value of produce (Y). To calculate the most profitable fertilizer application, the differentiation of 'Y' with respect to 'X' in the Mitscherlich equation was obtained and equated with the ratio of unit price of fertilizer to the unit price of sorghum grain and the resulting equation was solved for 'X' (Balba et al. 1972).

$$C1 = \frac{dy}{dx} = - A.10^{-C1^{b}.10-CX}$$

$$\text{in } 10(-C) = \frac{\text{Price of X}}{\text{Price of Y}}$$

where X is price of 1 kg of fertilizer, and Y is value of 1 kg of produce.

Subbaiah et al. (1979) conducted a field experiment to determine the effect of neem cake blended urea application at different levels to rice (IR-20). The studies indicated that neem cake blended urea increased the grain and straw yield of rice over untreated urea. N and P uptake of grain and straw were also increased.

Pathak et al.(1976) obtained progressive increase in yield by N fertilizer even upto its highest level of application. The soil test values of alkaline $KMnO_4$ method of available N showed significant correlation with percent yield response (r=0.58 **).

Bajaj (1982) attempting an evaluation of various methods of making fertilizer recommendations for cereal crops in the cultivator's fields in villages around Delhi arrived at the conclusion that application of recommended fertilizer dose of the urea gave a higher net profit than the farmer's actual practice of fertilizer application. Methods of fertilizer recommendation which take into account the soil nutrient status along with the fertilizer nutrients were superior to those where fertilizer application was made on an ad-hoc basis. Among the methods based on soil tests, the method using multiple regression approach was superior to the one presently being adopted by the soil testing laboratories in India. Padmaja et al.(1982) predicted the yield of rice crop from N concentration in the different plant parts at major growth stages and grain yield at harvest. Among plant parts studied, top three leaves appeared to be the best indication of the grain yield at maximum tillering and flowering stages of growth of rice. Optimum N concentration in entire plant at initial tillering stage, top three leaves at maximum tillering and flowering stages were 3.0, 3.8 and 3.38 % respectively. At harvest maximum grain yield corresponded to 2.19 and 2.4 % N in grain and straw, respectively. Maximum grain yield was obtained when N percentage in the entire plant increased from 1.5 to 2.0 in the tillering stage and 2.5 to 3.0 in top three leaves at maximum tillering and harvest stages. Hence, the maximum response to applied N can be obtained for high yielding dwarf rice varieties at the above range of concentration of N in the plant tissue.

Relationship between available N determined by two anaerobic incubation methods (30° C for 2 weeks, 40° C for 1 week) and seven chemical indices (Organic Carbon, total N, ammonia released by acid dichromate, acid permanganate, alkaline permanganate, hydrogen peroxide and dilute H_2SO_4) and N % in rice plant, N uptake and drymatter yield of IR-26 rice grown under submerged conditions in pots were investigated. It was reported that all the availability indices were best correlated with nitrogen uptake of rice, followed by N % in rice plants at 55 days after seeding.

Prasada Rao (1984) conducted four field experiments to study the efficient use of integrated nutrient supply system for rice-rice rotation by using blue-green algae, farmyard manure and chemical fertilizers in kharif-rabi and rabi-kharif rotations. There was direct response to FYM application (response ratio = 14) equivalent to 10 kg/ha of inorganic N was observed in 'rabi' season where the available soil nitrogen was low. The following fertilizer adjustment equations based on regression analysis were developed for N and P to derive optimum doses for maximum profit/ha for any given soil test value.

Kharif rice :

$$FN = 225 - 0.1725\ SN - 9.58\ R$$

$$FP_2O_5 = 219 - 2.6200\ SP - 17.10\ R$$

Rabi rice :

$$FN = 213 - 0.0400\ SN - 4.31\ R$$

$$FP_2O_5 = 156 - 1.0900\ SP - 10.30\ R$$

The following fertilizer adjustment equations for desired yield targets were derived for N and P.

Kharif rice :

$$FN = 5.30\ T - 0.30\ SN$$

$$FP_2O_5 = 4.78\ T - 4.37\ SP$$

Rabi rice :

$$FN = 3.82\ T - 0.54\ SN$$

$$FP_2O_5 = 1.92\ T - 2.72\ SP$$

where F = fertilizer ; S = Soil ; T = Target

R = cost of 1 kg of fertilizer / value of 1 kg of the produce.

Anjaneyulu Goud (1991) studied rice crops grown in vertisol under Sreeramsagar Project area, Warangal for ascertaining the advantage of the integrated use of organic manure (FYM) with fertilizers. The following fertilizer adjustment equations were developed.

Fertilizer adjustment equations for maximum yield are

$$FN = 266 - 37.00\ SN \quad (OC\ (\%)\text{-}N)$$

$$FP_2O_5 = 251 - 7.18\ SP \quad (Olsen\text{-}P)$$

Fertilizer adjustment equations for maximum profit are

$$FN = 266 - 37.00\ SN - 19.53\ R \quad (OC\ (\%)\text{-}N)$$

$$FP_2O_5 = 251 - 7.18\ SP - 14.79\ R \quad (Olsen\text{-}P)$$

Fertilizer adjustment equations for desired yield targets are

$$FN = 6.66\ T - 363.69\ SN \quad (OC\ (\%)\text{-}N)$$

$$FP_2O_5 = 3.89\ T - 7.33\ SP \quad (Olsen\text{-}P)$$

where R is the ratio of cost of one kg of fertilizer and value of one kg of produce ; SN = soil N as estimated by OC (%) and SP = soil phosphorus as estimated by Olsen's method)

Renuka Rao (1990) also confirmed $KMnO_4$ oxidisable N as better index of available N for paddy in black clay loam soils of Warangal, and maximum N uptake observed was 126 kg/ha for a yield of 4934 kg/ha in the treatment N200-P30. The following fertilizer adjustment equations were developed based on regression analysis for N and P to derive optimum doses for maximum yield and maximum profit/ha for any given soil test value.

Maximum yield : $FN = 459 - 0.87\ SN$ (KMnO4-N)

$FP_2O_5 = 85 - 0.97\ SP$ (modified Olsen's P)

Maximum profit : $FN = 459 - 0.87\ SN - 21.80\ R$ (KMnO4-N)

$FP_2O_5 = 83 - 0.97\ SP - 4.84\ R$ (modified Olsen's P)

Studying the influence of N-levels on the yield and uptake by certain crops including rice and their impact on N-efficiency and recovery, Rani Perumal et al.(1985) observed the increase in yield and uptake of N by rice upto 150 kg N/ha where as such influence was not indicated as regards N recovery and N efficiency.

Umar et al.(1986) obtained higher yield of rice under the treatment N120-P40-K20 which was significantly higher than that at N80-P40-K20.

Saravana Pandian and Rani Perumal (1993) obtained higher grain yield response of 1931 kg/ha with 100 kg/ha in rice, thereafter the response decreased upto 200 kg N/ha. The same trend in response was reported by Biswas and Bhattacharya (1987).

2.3. SOIL TEST CALIBRATION

Soil testing is one of the several practical applications of scientific and technical knowledge of soil science to crop production. In other words, it is a tool for analysing the soil for its fertility evaluation. The diagnostic value of soil testing is both general and specific in the sense to give site specific fertilizer recommendation based on soil analysis of a farm holding and general in the sense to identify soil fertility problems and constraints in an area (Randhawa and Velayutham,1982).

A calibrated soil test value must answer two questions for each sample analysed.

i) Is the nutrient supply in the soil adequate for the crops to be grown ?

ii) If not, how much should be applied for the crop or for the rotation to follow ?

In soil testing, "available" is defined as an amount that is directly proportional to that taken up by growing plants in a given season. This means the extractant must remove from the soil in a few seconds, or a few minutes at most, an amount of nutrient that is proportional to that which a crop spends the growing season taking up (Cope and Evans,1985).

A soil testing programme comprises of the following stages :

i) Soil sampling ;

ii) Soil analysis ;

iii) Interpretation of the soil test values using various information on crop response to nutrients ;

iv) Fertilizer recommendation ;

v) Writing of soil test report and communication to the farmers ;

vi) Follow-up ; and

vii) Preparation of soil test summaries, soil fertility indices and soil fertility maps (Biswas and Mukherjee, 1987).

For this soil tests have to be calibrated. The process of determining the crop-soil relationship is commonly referred to as calibration of soil test values. A calibrated soil test value for a particular nutrient will indicate the degree of deficiency of that nutrient to achieve a desired yield goal and the amount of the nutrient needed as a fertilizer to correct the deficiency depending upon the expected marginal rate of return. The soil testing advisory service in India started in 1955-56. By 1985-86 in all 402 soil testing laboratories (330 static and 72 mobile) were established under various agencies in the country and the annual capacity of these is about 4.0 million samples. There is a need to do soil calibration on a continuing basis. The existing rating of low, medium and high had outlived their utility. The need for reevaluating the ratings is obvious.

The concept of critical limit of nutrients in soil and plant is a better approach than the three tier ratings. For each element, there are the upper and the lower critical limits. At moderate levels of management and fertilization the lower critical limits are adequate (Cate and Nelson 1971). There are different approaches to soil test interpretation and formulation of fertilizer recommendation such as :

i) General recommendation ;
ii) Soil test rating and fertilizer adjustment (Muhr et al 1965) ;
iii) Critical level of a nutrient in soil as sufficiency concept (Goswamy and Bajaj 1986) ;
iv) Build-up and maintenance concept ;
v) The concept of basic cation saturation ratio
vi) Recommendation for a certain percentage of yield maximum (Bray 1954) ;
vii) Fertilizer recommendation for maximum profit (Ramamoorthy et al 1971) ;

viii) Fertilizer recommendation for targetted yield (Troug 1960 and Ramamoorthy et al.1967). ;

ix) Fertilizer recommendation for crop-sequences (Ramamoorthy et al. 1975) ;

x) Mechanistic or modelling or systems approach (Tujeda et al. 1981).

2.4. SOIL TEST CROP RESPONSE CORRELATION STUDIES :

With the advent of establishment of soil testing laboratory during the year 1955-56, soil test crop response correlation work in the first phase started functioning at IARI with an objective of generalised calibration evolved for fertilizer recommendation based on limited number of green house and field experiments. With the introduction and spread of high yielding varieties of crops during the mid-sixties, the emphasis for efficiency in fertilizer use through soil testing became apparent and relevant. A coordinated programme on soil test crop response research was hence initiated in the country from 1967. The studies in the project have provided quantitative relationship for adjusting fertilizer doses with varying soil test values for obtaining maximum yield/ha, maximum profit/ha, for targetted yields of crops and for multiple cropping (Velayutham et al. 1984).

From the soil test crop response experiment with rice (var.IR-20) Duraiswamy et al.(1990) reported that the amount of N, P_2O_5 and K_2O required to produce one quintal of rice grain were 1.61, 0.43 and 1.42 kg/q respectively. The contribution from the soil and fertilizer for N, P_2O_5 and K_2O are 29, 58.8 and 39.5 % and 30, 17 and 48 % respectively. They also reported that it is possible to achieve yield targets upto 4.5 t/ha in case of short duration and more than 5 t/ha in medium duration varieties based on prescription procedure without much alteration to the soil fertility status.

2.4.1. FERTILIZER RECOMMENDATION BASED ON SOIL FERTILITY CATEGORIES

The soil tests are calibrated into different fertility categories such as low, medium and high. The general fertilizer recommendation is equated to the soil rated as medium. For soil testing low or high category, the fertilizer recommendation is increased or decreased by 30 to 50 % of the general recommendation (Muhr et al. 1965).

2.4.2. FERTILIZER RECOMMENDATION BASED ON SOIL CRITICAL LIMITS

Soil tests were also calibrated from the data of multilocation fertilizer rate trials to deduce a critical limit for the soil test value below which there is will be positive or economic response to added fertilizer and above which the response either diminishes at a much faster rate or there is no response (Cate and Nelson,1965). Krishnamurthy et al (1963) suggested an upper critical limit of available P_2O_5 as determined by Olsen's method between 60 and 80 lbs/acre.

2.4.3. FERTILIZER RECOMMENDATION BASED ON TARGETTED YIELD CONCEPT

According to Bray (1954) only relatively mobile nutrients like N tends to follow Liebig's law of limiting nutrients and the relatively immobile nutrients like P and K follow the percentage sufficiency of Mitcherlich-Baule. He defined the limits within which Liebeg and Mitscherlich-Baule concept can be expected to hold. Ramamoorthy et al. (1967) have defined the procedure of fertilizer prescription as given by Troug (1960) and later extended to different crops and soils (Ramamoorthy et al 1975, Velayutham, 1982). The procedure is a scientific basis for balanced fertilization and provides balance between applied nutrients and soil available nutrients.

Ramamoorthy et al.(1975) reported that the yield target and the required fertilizer dose can be calculated as

$$T = \frac{ns}{(m-r)} \quad \text{and} \quad Fd = \frac{rms}{(m-r)}$$

where T = targetted yield (q/ha)

n = ratio between the % contribution from soil and fertilizer nutrient

a = nutrient requirement in kg/ha for grain production

m = ratio between nutrient requirement and contribution from fertilizer nutrient

s = soil test value in kg/ha, and

Fd = fertilizer dose of a nutrient in kg/ha.

Velayutham (1979) presented the results obtained at various test centres of the All India Coordinated Soil Test Crop Response Schemes working on targetted yield approach. He indicated that fertility gradient has been obtained at the test centres with regard to phosphorus. It has been shown that the nutrient requirement per quintal of grain production was nearly the same for a given variety although variations between varieties of a crop and variations in the same variety between two seasons have been obtained. The nutrient requirement (kg/q of grain production) of rice variety IR-8 was 1.46 kg N, 0.62 kg P_2O_5 and 3.82 kg K_2O whereas the corresponding figures for rice variety IET-1991 were 1.78 kg N, 0.49 kg P_2O_5 and 4.34 kg K_2O in Raipur centre. By following soil analysis for fertilizer application for targetted yield and maintaining good crop husbandry it is possible to achieve the targetted yield within variations of ± 10 percent.

Agarwal and Ramamoorthy (1978) and Reddy et al. (1987) found significant linear relationship between the yield of grain and uptake of nutrients. This implies that for obtaining a specific yield (grain or any other economic produce) a definite quantity of the nutrient must be taken up.

From 43 experiments, Reddy et al. (1987) reported the mean nutrient requirement of different varieties of rice as 1.96, 0.85 and 3.01 kg/ha of N, P_2O_5 and K_2O respectively indicating a ratio of 2.3 : 1.0 : 3.5 of these nutrients in rice plants. They also reported that the percentage contribution of N, P and K was 25.3, 52.0 and 31.1 from soil and 56.0, 19.0 and 222.2 from fertilizers. Dev et al. (1978) reported a nutrient requirement of 2.11, 0.75 and 4.41 kg of N, P_2O_5 and K_2O per quintal of paddy grain.

2.4.4. FERTILIZER RECOMMENDATION FOR A MAXIMUM PROFIT

The amount of fertilizer that produces the greatest profit per hectare is called the optimum dressing (Cook 1972). Ramamoorthy et al. (1974) established a significant relationship between soil tests, the added fertilizers and the crop yields by fitting a regression of the quadratic form as

$$Y = a \pm b1\ SN \pm b2\ SN^2 \pm b3\ SP \pm b4\ SP^2 \pm b5\ SK \pm b6\ SK^2 \pm b7\ FN \pm b8\ FN^2 \pm b9\ FP \pm b10\ FP^2 \pm b11\ FK \pm b12\ FK^2 \pm b13\ FN\ SN \pm b14\ FP\ SP \pm b15\ FK\ SK$$

where Y is crop yield (kg/ha) ;

a is intercept (kg/ha) ;

b1,b2,b3 ....b15 are regression coefficients (kg/kg) ;

SN, SP and SK are soil available N, P and K test values (kg/ha) ;

FN, FP and FK are added fertiliser N, P and K nutrients (kg/ha).

2.5. SOIL TESTING AND FERTILIZER RECOMMENDATION FOR RICE IN ANDHRA PRADESH

In Andhra Pradesh, during the two year period of 1956-58, two soil testing laboratories were established, one at Rajendranagar and the other at Bapatla. Subsequently, in 1965 under IADP, a soil testing laboratory (STL) was established at Tadepalligudem in West Godavari district. During this period a policy decision was taken to establish one soil testing laboratory in each district. Currently, over a period of time during the decade starting in 1965, 27 soil testing laboratories (23 static and 4 mobile) were established in the state. This laboratories have annual analysing capacity of 3.44 lakh samples in the state.

The initial 3 STLs located at Rajendranagar, Bapatla and Tadepalligudem are now designated as Regional Soil Testing Laboratories (RSTL). The soil testing laboratories analyse the soil samples for texture by feel method, EC, pH, OC%, available P, available K and gypsum requirement (if necessary). The laboratories also perform testing of irrigation water. The cost of analysis of each soil sample was estimated as Rs.16.75 (Sithapathi Rao, 1988).

Based on 22.74 lakh soil samples analysed in the state STLs from 1975 to 1982, it was found that Andhra Pradesh soils were universally deficient in available N. About 63.9 and 16.3 percent were deficient in available P and K respectively (Soil Correlator, 1984). The fertility index of organic carbon was low in the districts of Prakasam, Nellore, Anantapur, Cuddapah, Chittoor, Kurnool, Karimnagar, Ranga Reddy and Khammam and the rest of districts were medium. The rating of fertility index was low when the value was less than 1.5, medium when 1.5 to 2.5, and high when the value was more than 2.5.

Soil testing laboratories in the state recommend fertilizer N based on crop response data with less emphasis on soil test value (STV). The general recommendation is slightly modified for soils testing low and medium with respect to organic carbon percent.

MATERIALS AND METHODS

CHAPTER III

3.0. MATERIALS AND METHODS

In order to evolve appropriate fertilizer N recommendation for rice crop under Sreeramsagar Project Command area with different nitrogen availability indices, the present investigation was undertaken with the following objectives :

1. To conduct a survey of irrigated rice soils in Sreeramsagar Project for determining N fertility status and to classify the soils into different fertility groups ;
2. To evaluate the utility of currently adopted N availability indices in soil testing laboratories in Andhra Pradesh for recommending N ferilizers to rice ;
3. To assess yield response of rice to nitrogen fertilization at different levels of N availability by conducting field experiments in two districts of the state which are served by the command of Sreeramsagar project ;
4. To develop a basis for recommending N fertilizer based on soil fertility, uptake of N and yield of rice.

The materials and methods adopted in the investigation are described in two parts as

1. Survey of Sreeramsagar project command to determine native soil fertility status ; and

Table 1. Villages selected (mandal & distributory-wise) for the survey

V No.	Unit No.	District	Village name	Mandal name	D.allotted
I. SARASWATHI CANAL MANDALS					
1.	1	Adilabad	Pakapatla	Nirmal	D-1
2.		Adilabad	Soan	Nirmal	D-13
3.		Adilabad	Kadthal	Nirmal	
4.	2	Adilabad	L.chanda	L.chanda	D-16
5.		Adilabad	Vadiyal	L.chanda	D-17
6.	3	Adilabad	Ponkal	Mamda	D-25
II. KAKATIYA CANAL MANDALS					
7.	4	Nizamabad	Mandora	Balkonda	D-6,8,9
8.		Nizamabad	Doodgaon	Balkonda	D-9
9.	5	Nizamabad	Yeragatla	Morthad	D-18,19,20
10.	6	Karimnagar	K.Kondapur	I.Patnam	D-20,21,22
11.		Karimnagar	I.Patnam	I.Patnam	D-22,24,25
12.		Karimnagar	Thimmapur	I.Patnam	D-25
13.		Karimnagar	Gudur	I.Patnam	D-29
14.	7	Karimnagar	Mutyampet	Mallapur	D-29
15.		Karimnagar	Raghavpet	Mallapur	D-29
16.		Karimnagar	Nadukude	Mallapur	D-29
17.		Karimnagar	Mogilipet	Mallapur	D-29
18.	8	Karimnagar	Metpally	Metpally	D-29,30,31
19.		Karimnagar	Vempet	Metpally	D-29
20.		Karimnagar	Vellulla	Metpally	D-32
21.		Karimnagar	Chowlamaddi	Metpally	D-34
22.	9	Karimnagar	Itkyal	Raikal	D-29
23.		Karimnagar	Raikal	Raikal	D-53
24.		Karimnagar	Alipoor	Raikal	D-53
25.		Karimnagar	Kummarapally	Raikal	D-53
26.	10	Karimnagar	Koratla	Koratla	D-53
27.		Karimnagar	Sangam	Koratla	D-38
28.	11	Karimnagar	Polasa	Jagityal	D-61
29.		Karimnagar	Chelgal	Jagityal	D-61
30.	12	Karimnagar	Beerpur	Sarangpur	D-53

31.		Karimnagar	Kolvai	Sarangpur	D-53
32.	13	Karimnagar	Dharmapuri	Dharmapuri	D-53
33.		Karimnagar	Donnur	Dharmapuri	D-53
34.	14	Karimnagar	Rapalle	Gollapalle	D-53
35.		Karimnagar	Gollapalli	Gollapalle	D-64
36.	15	Karimnagar	Arevally	Pegadapalli	D-67
37.		Karimnagar	Pegadapally	Pegadapalli	D-76
38.		Karimnagar	Thirumalapur	Pegadapalli	D-83
39.	16	Karimnagar	C.koluvala	Sultanabad	D-86
40.		Karimnagar	Narayanpur	Sultanabad	D-86
41.	17	Karimnagar	Wadkapur	Julapally	
42.		Karimnagar	Kajapur	Julapally	
43.		Karimnagar	Lokapet	Julapally	
44.	18	Karimnagar	Katkampally	Dharmaram	D-83
45.		Karimnagar	Sayampet	Dharmaram	D-83
46.	19	Karimnagar	Peddapally	Peddapally	L-8,9,10
47.		Karimnagar	Peddabankur	Peddapally	L-12 to B-83
48.	20	Karimnagar	Parepally	Kamanpur	D-83
49.		Karimnagar	Gundaram	Kamanpur	D-83
50.	21	Karimnagar	Puttapaka	Manthani	RHB
51.		Karimnagar	Nagaram	Manthani	RHB
52.	22	Karimnagar	Huzurabad	Huzurabad	DBM-17
53.		Karimnagar	P.reddypet	Huzurabad	DBM-13
54.	23	Karimnagar	Jammikunta	Jammikunta	DBM-15
55.	24	Karimnagar	Dandepally	Elkathathurthy	DBM-21,21A
56.	25	Warangal	Vallampally	Chityal	DBM-13
57.		Warangal	Gummadavally	Chityal	DBM-16
58.	26	Warangal	Dubial	Mogulapally	DBM-16
59.		Warangal	Parlapally	Mogulapally	DBM-16
60.	27	Warangal	Pembarthy	Hasanparthy	DBM-24

Table 2. Wet area details of command area under Sree Ramsagar Project (SRSP)

Unit No. (Grid)	Percentage of paddy command area under SRSP	No. of villages allotted
1	9.61	6
2	0.39	
3	0.15	
4	9.99	6
5	3.15	2
6	16.51	10
7	6.72	4
8	0.59	
9	0.18	
10	0.15	
11	3.36	2
12	0.14	
13	1.55	1
14	0.23	
15	0.46	
16	0.28	
17	0.69	1
18	6.23	4
19	1.85	1
20	5.78	4
21	32.02	19

2. Field experiments to evolve appropriate fertilizer recommendations.

3.1. SURVEY OF IRRIGATED RICE SOILS OF SREERAMSAGAR PROJECT COMMAND

A detailed survey of the area under the project command was undertaken by delineating the area into different categories based on soil type in the four districts viz., Karimnagar, Warangal, Adilabad and Nizamabad. The four districts are the main beneficiaries of the project command accounting to 2.55 lakh ha of land area irrigated by the project out of the total command of 3.97 lakh ha. The project command area maps and index maps showing wet cultivated area of distribution under two canals studied viz., Saraswathi canal, Kakatiya canal of Sreeramsagar project were utilized for undertaking the survey. The maps are prepared by the Command Area Development Authority, Govt. of Andhra Pradesh. Percentage of paddy command area under Sree Ramsagar project was divided into 21 units and 60 villages were selected covering from four districts of command area viz., Karimnagar, Warangal, Adilabad and Nizamabad. The selection of villages mandal wise, distributory wise under Sree Ramsagar project command area are shown in Table 1. Wet area details of command area are given in Table 2. A questionnaire was prepared for the survey which is included in Appendix 1.

3.1.1. SREERAMSAGAR PROJECT :

Sreeramsagar Project reservoir is constructed across the Godavari river near Pochampad village of Nizamabad district in the northern Telangana zone of Andhra Pradesh. It is proposed to utilise 200 TMC of Godavari waters through this Project to irrigate an area of 8.48 lakh hectares under its command spread over the districts of Adilabad, Nizamabad, Karimnagar, Warangal, Khammam and Nalgonda under the following canal systems which are depicted in SRSP command area maps enclosed within.

3.1.1.1. KAKATIYA CANAL :

The canal will cover an area of 5.87 lakh hectares in the districts of Nizamabad, Karimnagar, Khammam and Nalgonda.

3.1.1.2. SARASWATHI CANAL :

This canal will cover an area of 0.89 lakh hectares in the district of Adilabad.

3.1.1.3. LAXMI CANAL :

This canal will cover an area of 0.067 lakh hectares in Nizamabad district.

The topography of the command area is rolling type with undulating physical features. The slope of land ranges from 1 to 3 percent. The nature of soils in the command area is 65 percent red soil comprising of red sandy loams and red loamy sands and 35 percent black soils comprising of clay and silty clay soils.

3.1.2. CLIMATE :

The climate of the command area is semi-arid with dry hot summer and fairly severe winter (minimum temperatures recorded 9-10° C). The average annual rainfall is 944 mm.

3.1.3. SOILS :

The soils of the command area are red and black soils with sandy loam to clay loam in texture. Alfisols (red) usually cover elevated area and vertisols (black) occupy low lying flat region.

3.1.3.1. LOCATIONS :

Totally 60 villages consisting of four districts viz., Karimnagar, Warangal, Nizamabad and Adilabad under command area where rice is cultivated were covered and from each village soil samples from 5 locations from rice fields were collected. Thus total number of 300 soil samples were collected.

The survey work which was undertaken on two occasions i.e., i) collection of initial soil samples for soil characterization before transplantation of rice ; and ii) rice plant sampling (third leaf from above) at panicle initiation stage from the same place where the soil samples were collected. Supporting information regarding fertilizer practices and other details were collected simultaneously through a questionnaire prepared for the purpose. The locations for soil sampling were selected using Sreeramsagar command area maps to cover second soil sampling and spread out to cover the command area. Enough care was taken by way of either fixing land marks or otheriwse to identify the sampled site at a later date for collecting yield data. Yield data was also obtained by organising crop cutting at the concerned farmer's fields at the harvest of rice crop and also soil samples for the third time at post-harvest stage with the help of departmental field assistants/officers from as many sites as possible through communication.

3.1.3.2. SELECTION OF VILLAGES / SITES :

The sampling sites lie between 17°42' and 19°84' north latitude and 77°35' and 81°16' east longitude. Selection of 60 villages were done by grids/ units mapped in Sree Ramsagar Project command area taking ayacut road map of

SRSP with the help of toposheets. Base maps were also prepared and area was calculated from the grids. Total number of grids selected were 21. Total area of wet land as per unit is 965.75 sq.km.

3.1.3.3. COLLECTION OF SOIL SAMPLES:

The soil samples were collected from the farmers' fields in the months of May and June when there were no standing crops. Representative soil samples from 300 contact farmers' fields of 60 villages of command area were collected from 0-15 cm depth by grid system following quartering method even at the time of panicle initiation stage for estimating soil test values for N by two methods and soil samples for the third time at the time of harvest were also collected. They were brought to laboratory and were air dried in shade and then powdered in wooden mortar to pass through 2 mm sieve and stored in polythene bags. Proper labelling was done and estimation was carried out following standard methods and results were expressed on air dry basis.

3.2. METHODS OF SOIL ANALYSIS

The soils were studied for physical, chemical characteristics viz., soil reaction, soluble salt content, texture, total N, organic carbon and available nitrogen by alkaline permanganate method and calcium hydroxide distillation methods. Nitrogen estimation and other initial characterisation of soils as followed for routine analysis in the soil testing laboratories in Andhra pradesh were also carried out. Analysis for available P and K contents were also carried out.

3.2.1. SOIL REACTION (pH) :

The pH of soil was determined in a 1:2.5 soil water suspension using a digital pH meter with glass electrode assembly (ECIL) (Jackson, 1973).

3.2.2. SOLUBLE SALT CONTENT (EC) :

Soluble salt content in the soil was estimated by measuring the electrical conductivity of 1:2.5 soil water extract by using digital electrical conductivity meter (ECIL) as given by Jackson (1973) and expressed as dSm^{-1}.

3.2.3. TEXTURE :

Soil texture was determined by Feel method as described in the Laboratory Manual of Soil Science (1985) and was used in survey soils of initial, panicle initiation and post-harvest samples and quick tests.

3.2.4. MECHANICAL ANALYSIS :

Mechanical composition of experimental soils was determined by international pipette method (Piper, 1950) and the content of sand, silt and clay were expressed as percent and this method was done in the experimental soils of Jagtial and Warangal.

3.2.5. **CATION EXCHANGE CAPACITY (CEC) :**

The Cation exchange capacity of soil was determined by following the methods described by Jackson (1973) and was expressed in (C mol (p+) kg^{-1}.

3.2.6. **TOTAL NITROGEN :**

The total nitrogen in samples was estimated using salicyclic acid thiosulphate modification of macrokjeldahl digestion method as described by Bremner (1965 b).

3.2.7. **SOIL TEST METHODS FOR NITROGEN :**

Nitrogen was estimated using different methods as outlined below.

3.2.7.1. **OXIDISABLE ORGANIC CARBON :**

Organic carbon was estimated by following the modified titrimetric method of Walkley and Black (1934) as described by Piper (1950) and visual colour method as followed in State Soil Testing Laboratories of Andhra Pradesh.

3.2.7.2. **AVAILABLE NITROGEN**

Available nitrogen was estimated by two different methods. The first is the Subbaiah and Asija (1956) method of alkaline permanganate ($KMnO_4$ method) estimation and the result was expressed as kg/ha.

The second method used was based on Hot $Ca(OH)_2$ distillation as outlined by Prasad (1966) was estimated and the result was expressed as kg/ha.

3.2.8. SOIL TESTING METHOD FOR PHOSPHORUS

The available phosphorus was extracted using 0.5 M NaHCO3 at pH 8.5 at soil : solution ratio of 1:20 and shaking for 30 minutes as estimated by Olsen et al. (1954). The colour was developed by ascorbic acid method and was expressed as kg/ha (Watanabe and Olsen, 1965).

3.2.8.1. PHOSPHOROUS FIXING CAPACITY OF SOILS

The method followed is that of Ghosh et al. (1983) procedure is outlined below :

2.5 gm of soil were weighed in each of five 150 ml conical flasks. To each flask 5 ml of 5, 12.5, 25 and 37.5 ppm P_2O_5 prepared from stock solution of 1000 ppm P_2O_5 was added so as to achieve desired levels of 22.4, 66, 112 and 168 kg P_2O_5. A blank was also run for adding 5 ml of the distilled water to 2.5 gm of soil. The flasks were stoppered and incubated for 48 hours. At the end of incubation 45 ml of 0.5 N $NaHCO_3$ (pH 8.5) was added to each of the flasks shaken for 30 minutes and P was estimated using ascorbic acid as reducing agent. Difference between extracted and added P was termed as fixed P_2O_5 and the results were expressed as % fixation of added P_2O_5 and the remaining as recovery P_2O_5.

3.2.9. SOIL TESTING METHOD FOR POTASSIUM

The available potassium was determined in neutral normal ammonium acetate (1 N.NH_4OAC) extract of soil (Muhr et al. 1965) using flame photometer (ELICO Model CL-22A).

3.2.9.1. POTASSIUM FIXING CAPACITY OF SOILS

The potassium fixing capacity of soils was determined by following the wet oxidisation method as outlined by Ghosh et al. (1983). Well processed soil (5 gm) was taken in each of 11 conical flasks and potassium through KCl solution was added to give the concentration of 0, 10, 20, 40, 50, 100, 200, 400, 600 and 1000 µg/g of soil in such a manner that the final soil : solution ration was adjusted to 1 : 2. The contents in the flask were incubated for 72 hours at room temperature taking all necessary precautions to prevent evaporation. After incubation, 25 ml of N NH_4OAC solution was added to all the conical flasks. The contents were shaken for 5 minutes and filtered and K in the filtrate was estimated by flame photometer (Model CL-22A).

3.3. QUICK SOIL TESTS ADOPTED BY SOIL TESTING LABORATORIES

3.3.1. ORGANIC CARBON TEST :

Organic carbon status of the soils under the study was assessed by following the visual colour comparator method which is routinely followed in the soil testing laboratories of Andhra Pradesh. To 1 gm of soil, 2 ml of 2.5 N $K_2Cr_2O_7$ and 2 ml concentrated H_2SO_4 was added. After 30 min. standing, 5 ml distilled water was added to the tube and the colour of the suspension was compared with the standard colour chart. If the colour is

Green / Blue : Organic carbon is high

Thick brown : Organic carbon is medium

Reddish / Yellowish : Organic carbon is low

3.4. FIELD EXPERIMENTS TO STUDY RESPONSE OF RICE TO N FERTILISATION

Two field experiments were conducted in each fertility category in the main cropping season (kharif 1996) based on large area of the project command and sample size in Karimnagar and potential irrigated area in Warangal district, two locations were selected in the command area, one each at Regional Agricultural Research Station, Jagtial and the other at Agricultural Research Station, Warangal. These two

Table 2(a). Weekly rainfall (mm) at Jagtial and Warangal in 1996 (at Standard weeks)

Standard Week	Jagtial	Warangal
22	0.0	1.0
23	6.4	60.0
24	31.4	167.0
25	18.6	2.0
26	0.0	6.0
27	25.0	58.0
28	42.0	141.0
29	42.0	137.0
30	31.4	66.0
31	68.6	52.0
32	29.2	101.0
33	19.2	67.0
34	88.0	140.0
35	104.0	42.0
36	68.0	123.0
37	0.0	20.0
38	9.2	1.0
39	26.6	56.0
40	62.0	7.0
41	0.0	0.0
42	0.0	4.0
43	0.0	2.0

Fig.1(a). Weekly rainfall (mm) at Jagtial in 1996 (at Standard weeks)

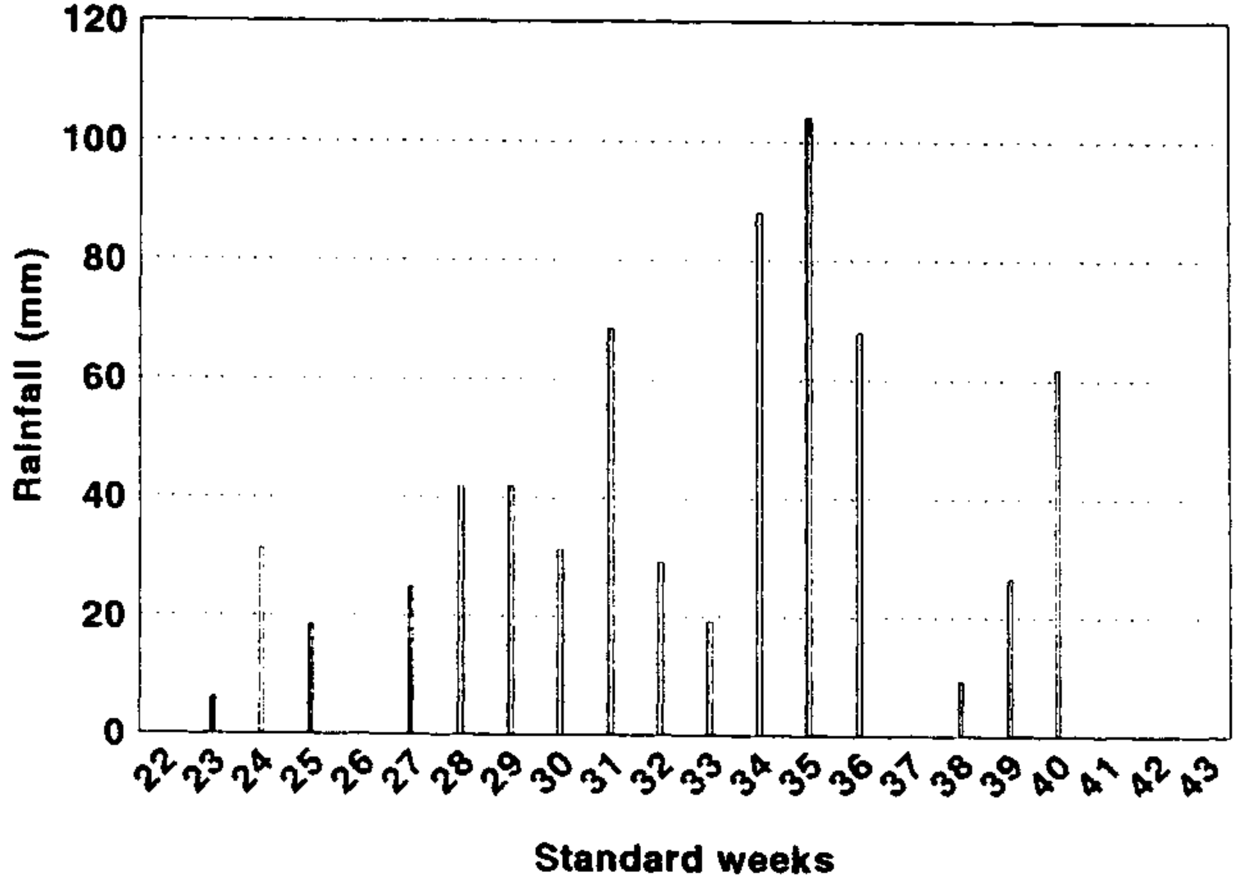


Fig.1(b). Weekly rainfall (mm) at Warangal in 1996 (at Standard weeks)

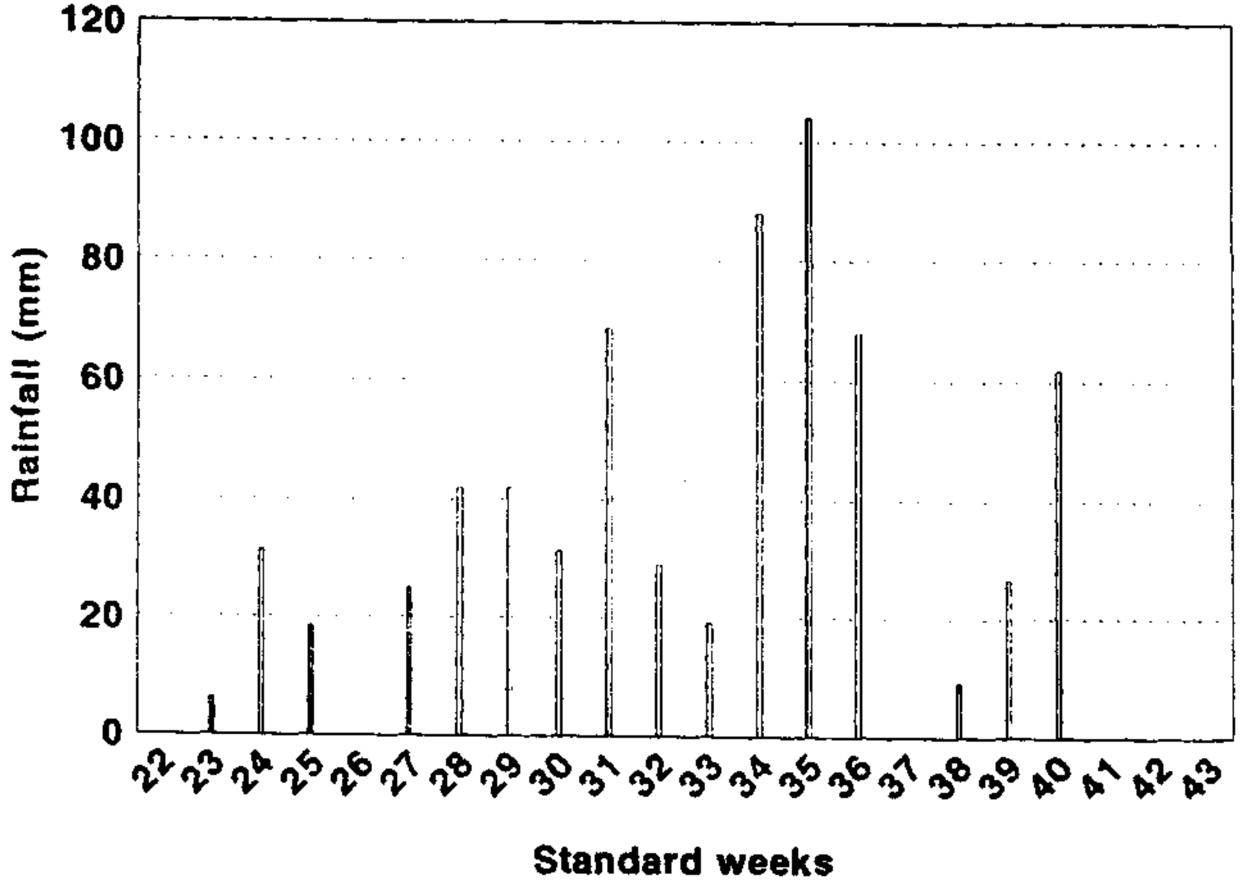


Table 2(b). Layout of field experiment conducted at Jagtial

Rep-I		Rep-II		Rep-III	
T8	T5	T1	T6	T10	T3
	C	A	N	L	
T14	T9	T11	T9	T14	T7
	C	A	N	L	
T3	T13	T4	T12	T4	T11
	C	A	N	L	
T10	T1	T13	T2	T2	T9
	C	A	N	L	
T6	T11	T8	T14	T8	T5
	C	A	N	L	
T12	T4	T10	T5	T6	T13
	C	A	N	L	
T2	T7	T3	T7	T12	T1
BUND		BUND		BUND	

T1 :	0-0-0	: (CONTROL)
T2 :	NO-PB-KB	: 0-60-50
T3 :	N1/2B-PB-KB	: 60-60-50
T4 :	NB-PB-KB	: 120-60-50
T5 :	N1 1/2 B-PB-KB	: 180-60-50
T6 :	NB-PO-KB	: 120-0-50
T7 :	NB-P1/2 B-KB	: 120-30-50
T8 :	NB-P1 1/2 B-KB	: 120-90-50
T9 :	NB-PB-KO	: 120-60-0
T10 :	NB - PB - K1/2 B	: 120-60-25
T11 :	NB-PB-K1 1/2B	: 120-60-75
T12 :	N1 1/2B-P1 1/2B-K1 1/2B	: 180-90-75
T13 :	Farmer's Practice	: 80-60-0
T14 :	General recommended dose	: 120-60-30

Design : Factorial R.B.D. Replications : 3

Gross plot size : 6 x 3 sq.m

Net plot size : 15.39 sq.m

Table 2(c). Layout of field experiment conducted at Warangal

Rep-I		Rep-II		Rep-III	
T8	T5	T1	T6	T10	T3
T14	T9	T11	T9	T14	T7
	C	A	N	L	
T3	T13	T4	T12	T4	T11
	C	A	N	L	
T10	T1	T13	T2	T2	T9
	C	A	N	L	
T6	T11	T8	T14	T8	T5
	C	A	N	L	
T12	T4	T10	T5	T6	T13
	C	A	N	L	
T2	T7	T3	T7	T12	T1

BUND BUND BUND

T1	0-0-0	(CONTROL)
T2	N0-PB-KB	0-60-50
T3	N1/2B-PB-KB	60-60-50
T4	NB-PB-KB	120-60-50
T5	N1 1/2 B-PB-KB	180-60-50
T6	NB-P0-KB	120-0-50
T7	NB-P1/2 B-KB	120-30-50
T8	NB-P1 1/2 B-KB	120-90-50
T9	NB-PB-K0	120-60-0
T10	NB - PB - K1/2 B	120-60-25
T11	NB-PB-K1 1/2B	120-60-75
T12	N1 1/2B-P1 1/2B-K1 1/2B	180-90-75
T13	Farmer's Practice	80-60-0
T14	General recommended dose	120-60-30

Design : Factorial R.B.D. Replications : 3

Gross plot size : 6.5 x 3 sq.m

Net plot size : 16.74 sq.m

represent the similar farming situation of soils and soil fertility category of farmers fields. Rice is the test crop used at both the centres. The experimental design adopted was a factorial Randomised Block Design (RBD) with three replications, and the layout of the experiment is given in Table 2(b) and Table 2(c) for Jagtial and Warangal experimental stations respectively. The weekly rainfall recorded during the crop growth in standard weeks in kharif 1996 at Jagtial and Warangal are given in Table 2(a) and shown in Fig. 1(a) and 1(b) for the above two locations respectively.

3.4.1. JAGTIAL CENTRE

Rice as a test crop was taken up in field experiment adopting a factorial RBD with the variety 'IR-64'. The rice crop was grown as per the recommended package of practices and treatments were randomised within fertilizer plots (or replications) before taking up the crop. The initial soil samples were analysed for soil properties and are shown in Table 2(d). Twelve fertilizer treatments as per the International Soil Fertility Evaluation Programme were adopted as detailed by Waughs and Fitts (1965), and one treatment each of farmer's practice (FP) and general recommended dose were also used. The 14 treatments thus

Table 2(d). Initial soil test values of the field experiment at Jagtial

S.No	Soil characteristic	Value
1.	pH (1:2.5 soil water extract)	8.09
2.	Electrical conductivity (dsm^{-1})	0.28
3.	Organic carbon (%)	0.31
4.	Total nitrogen (kg ha^{-1})	845
5.	Cation exchange capacity (C mol P+ kg^{-1})	6.44
6.	Available nitrogen ($KMnO_4$ method) (kg ha^{-1})	124.2
7.	Available nitrogen ($Ca(OH)_2$ method)	96.0
8.	Available phosphorus (Olsen method)(kg ha^{-1})	16.22
9.	Available potassium (NH_4OAC method) (kg ha^{-1})	272
10.	Critical level of P_2O_5 (kg ha^{-1})	34
11.	P fixation (%)	45
12.	P recovery (%)	55
13.	Texture	RSL
14.	Mechanical analysis Clay (%) Silt (%) Sand (%)	 16 9 75

RSL = Red sandy loam

PLATE - 1
GENERAL VIEW OF THE EXPERIMENTAL PLOT AT JAGTIAL

PLATE - 2
TREATMENTAL DIFFERENCES IN THE FIELD AT JAGTIAL - A CLOSE LOOK

obtained were replicated thrice in the field layout. Thus there were a total of 42 experimental plots at this location. The soil P critical value of Jagtial location was found to be 34 kg P_2O_5 ha^{-1} and P fixation capacity was 45 percent and percentage of P recovery was 55. The fertilizer doses of N, P and K were calculated based on P fixation and K fixation capacity of the soil. Nitrogen was taken as blanket recommendation for the area/or zone.

3.4.1.1. PARTICULARS OF FERTILIZER TREATMENTS EXPERIMENTED AT JAGTIAL AND WARANGAL

Treatment	Fertilizer dose (kg/ha)
T 1 = N0 P0 K0	N0 P0 K0
T 2 = N0 PB KB	N0 P60 K50
T 3 = N1/2 B PB KB	N60 P60 K50
T 4 = NB PB KB	N120 P60 K50
T 5 = N1 1/2 B PB KB	N180 P60 K50
T 6 = NB P0 KB	N120 P0 K50
T 7 = NB P1/2B KB	N120 P30 K50
T 8 = NB P1 1/2 B KB	N120 P90 K50
T 9 = NB PB K0	N120 P60 K0
T 10 = NB PB K1/2 B	N120 P60 K25
T 11 = NB PB K1 1/2 B	N120 P60 K75
T 12 = N 1 1/2 B P 1 1/2 B K 1 1/2 B	N180 P90 K75

T 13 = Farmer's Practice N80 P60 K0

T 14 = General Recommendation N120 P60 K30

Here P and K denote P_2O_5 and K_2O.

B = base value or blanket recommendation worked out by taking into account P fixation capacity of the soil for phosphorus. The doses worked out for N,P K were as follows :

N fertilizer doses :

N 0 = Control

N 1/2 B = 60 kg/ha

N B = 120 kg/ha

N 1 1/2 B = 180 kg/ha

P fertilizer doses :

P 0 = Control

P 1/2 B = 30 kg/ha

P B = 60 kg/ha

P 1 1/2 B = 90 kg/ha

K fertilizer doses :

K 0 = Control

K 1/2 B = 25 kg/ha

K B = 50 kg/ha

K 1 1/2 B = 75 kg/ha

Source of fertilizers were N through urea, P through single superphosphate, and K through muriate of

PLATE - 3
VIEW OF FARMERS PRACTICE TREATMENT AT JAGTIAL

PLATE - 4
VIEW OF GENERAL RECOMMENDATION TREATMENT AT JAGTIAL

potash. The layout of the field experiment with three replications is given below.

3.4.1.2. FIELD EXPERIMENT :

The paddy variety used was 'IR-64' which is widely cultivated during the kharif season in the region. The individual plot gross area was 6m x 3m, i.e. with 18 sq.m. The net plot area was 15.39 sq.m. The dates of nursery, transplanting and harvest were 21.6.1996, 28.7.1996 and 17.10.1996 respectively. Spacing between plant to plant was 15 cm, and row to row spacing was maintained as 15 cm. Appropriate plant protection measures were taken. The experimental design adopted was a factorial RBD with three replications of the above mentioned 14 fertilizer treatments. The soil samples were collected and analysed for N by organic carbon, $KMnO_4$ and $Ca(OH)_2$ methods, P by olsen's method and K by ammonium acetate method. The plant uptake of N, P and K were also calculated for each of the plots. The drymatter yields were recorded at harvest.

A few agronomical observations on plant height, tiller number, panicle length were also recorded at panicle initiation stage.

3.4.1.3. METHODS OF SOIL ANALYSIS :

These procedures adopted have been outlined previously under Materials and Methods section 3.4.

3.4.1.4. COLLECTION AND ANALYSIS OF PLANT SAMPLES :

Straw and grain samples were collected from each subplot at the time of harvest and their fresh weights were recorded. The samples were dried in hot air oven at 70°C to a constant weight, ground in wiley mill and stored after proper labelling. These were later analysed for N, P and K content to compute the plant uptake values.

3.4.1.5. PLANT ANALYSIS :

The plant samples were analysed for both grain and straw for N, P and K content in the plant by following standard methods as outlined below.

3.4.1.6. NITROGEN :

The nitrogen contents of grain and straw samples were estimated by microkjeldahl method (AOAC, 1970) and were expressed as percent.

3.4.1.7. PHOSPHORUS AND POTASSIUM

The plant samples were also digested by the wet digestion method using a mixture of nitric and Perchloric acid in the ratio of 9:4 (Diacid mixture) (Piper, 1950).

Table 2(e). Initial soil test values of the field experiment at Warangal

S.No	Soil characteristic	Value
1.	pH (1:2.5 soil water extract)	8.64
2.	Electrical conductivity (ds^{-1})	0.80
3.	Organic carbon (%)	0.53
4.	Total nitrogen (kg ha^{-1})	1204
5.	Cation exchange capacity (C mol P+ kg^{-1})	14.95
6.	Available nitrogen ($KMnO_4$) (kg ha^{-1})	184.6
7.	Available nitrogen ($Ca(OH)_2$) (kg ha^{-1})	110
8.	Available phosphorus (Olsen) (kg ha^{-1})	29.36
9.	Available potassium (NH_4OAC) (kg ha^{-1})	512
10.	Critical level of P_2O_5 (kg ha^{-1})	40
11.	P fixation (%)	65
12.	P recovery (%)	35
13.	Texture	Clay
14.	Mechanical analysis Clay (%) Silt (%) Sand (%)	 47.5 15.0 37.5

PLATE - 5

GENERAL VIEW OF THE EXPERIMENTAL PLOT AT WARANGAL

PLATE - 6

ANOTHER VIEW OF EXPERIMENTAL PLOT AT WARANGAL

Phosphorus in the digested material was determined colorimetrically by Vanadomolybdate-phosphate yellow colour method of Koenig and Johnson (1942) using a Klett-Summerson photo electric colorimeter using blue filter at 480 mμ. Potassium was estimated by using a flame photometer (Elico-Model L-224) as described by Jackson (1973).

The grain and straw yields, soil test values at panicle initiation and post-harvest stages are given in Appendix 6.

3.4.2. WARANGAL CENTRE

A test crop with variety 'Yerramallelu (WGL-20471)' of paddy was grown in kharif 1996 with a factorial Randomised Block Design by adopting recommended package of practices of the area and standard treatments of International Soil Fertility Evaluation Programme as detailed for the experiment at Jagtial centre. The initial soil samples were collected and analysed for different physical and chemical characteristics are shown in Table 2(e).

The particulars of fertilizer treatments adopted were the same as was detailed for the experiment conducted at Jagtial centre.

PLATE - 7

VIEW OF FARMERS PRACTICE TREATMENT AT WARANGAL

PLATE - 8

VIEW OF GENERAL RECOMMENDATION TREATMENT AT WARANGAL

3.4.2.1. FIELD EXPERIMENT

The details of the layout of field experiment are as follows :

i)	Gross plot size	: 6.5 m X 3.5 m
ii)	Plot area	: 19.5 sq.m
iii)	Net plot area	: 16.74 sq.m
iv)	Spacing between plots	: 60 cm
v)	Spacing between replications	: 90 cm
vi)	Within replication bund	: 75 cm
vii)	Test crop	: Paddy
viii)	Variety	: Yerramallelu (WGL-20471)
ix)	Plant to plant	: 15 cm
x)	Row to row	: 15 cm
xi)	Date of sowing nursery	: 25.6.1996
xii)	Date of transplanting	: 21.7.1996
xiii)	Date of harvesting	: 29.10.1996

3.4.2.2. METHODS OF SOIL AND PLANT ANALYSIS

After the harvest of crop, the drymatter yields were recorded. The soil samples were also collected and analysed for soil characteristics. Plant samples were analysed for N, P and K contents in grain and straw adopting standard procedures as outlined in sections 3.2. and 3.4.1.4. of Jagtial centre. The grain and straw yields, soil test values at panicle initiation and post-harvest stages are given in Appendix 7.

3.5. COMPUTATIONS

The following calculations were done using the data generated from the field experiment.

3.5.1. TOTAL UPTAKE (kg/ha)

Total uptake = (nutrient in grain (%) / 100) X grain yield
+ (nutrient in straw (%) / 100) X straw yield

3.5.2. BASIC DATA UNDER CONVENTIONAL PROCEDURE

Using the nutrient uptake data, soil test values, applied fertiliser doses, grain yield data the basic data required for making fertilizer recommendations were calculated as follows.

a) Nutrient requirement (NR) (kg/q)

$$= \frac{\text{Total uptake (kg/ha)}}{\text{Grain yield (q/ha)}}$$

b) Contribution from soil (CS %) (from control plots)

$$= \frac{\text{Total uptake (kg/ha)}}{\text{Soil test value (kg/ha)}} \times 100$$

c) Contribution from fertilizer (CF %) (from treated plots)

$$= \frac{[\text{Total uptake}] - [\text{soil test value} * \text{CS}]}{[\text{Fertilizer dose}]} \times 100$$

NR was worked out for all the 42 treatment combinations, CS from only control plots (3 plots), and CF from only fertilized plots (39 plots). Since the estimates are to be used as N, P_2O_5 and K_2O, P was converted to P_2O_5 by multiplying the estimate with 2.29, and K to K_2O by multiplying the estimate with 1.2046.

3.5.3. FERTILIZER ADJUSTMENT EQUATIONS FOR TARGETTED YIELDS UNDER CONVENTIONAL PROCEDURE

The fertilizer adjustment equations were worked out using the NR, CS and CF data and fertilizer N, P2O5 and K2O adjustment equations for targetted yields were be worked out as detailed below.

$$FD = \frac{NR}{CF} \times T - \frac{CS}{CF} \times STV$$

where FD : fertiliser dose (kg/ha)

NR : nutrient requirement (kg/q)

CS : contribution from soil (unit value)

CF : contribution from fertilizer (unit value)

T : yield target (q/ha)

STV : soil test value of a nutrient (kg/ha)

3.5.4. BASIC DATA UNDER SIMULTANEOUS ESTIMATION PROCEDURE

The estimates of contributions from soil (CS) and fertiliser (CF) can also be derived from each pair of plots using the procedure as discussed by Sankar et al. (1983).

Out of the estimates derived from all possible pairs of plots, the estimates which are with in the stipulated range of 0 to 1 for all the nutrients together from a pair of plots are chosen for the calibration of targetted yield equations. The nutrient requirement (NR) is derived from only those plots which are involved in the computation and selection of pairs of plots for estimating CS and CF for N, P and K nutrients together by the formulae as mentioned above. The NR is also computed by using all the 14 plots as an alternative to the estimate based on the selected plots which were involved in the computation of CS and CF estimates as discussed by Sankar et al. (1983).

3.5.5. TARGETTED YIELD EQUATIONS UNDER THE SIMULTANEOUS ESTIMATION PROCEDURE

The targetted yield equations can be computed based on the equations described in the section 3.5.3. under the conventional procedure. Two sets of equations can be derived for each nutrient by computing and using the NR for all the 14 plots, and computing and using NR from only those plots which are involved in the computation and selection of CS and CF. Although the estimate of NR might slightly differ, the same estimate of CS and CF is used for working out targetted yield equations.

3.6. CORRELATION AND REGRESSION ANALYSIS

3.6.1. CORRELATION ANALYSIS

The estimates of correlation of yield, plant uptake, soil test values and applied fertilizer doses of N, P and K nutrients are to be derived using the standard statistical procedure for computing Karl-Pearson correlation coefficients. The values are tested by using 't-test' for their significance and their use in calibrating multiple regression models. The correlations would indicate different types of relations among variables, high or low, positive or negative, significant or non-significant for judging the variables for their further utility in regression analysis.

3.6.2. MULTIPLE REGRESSION ANALYSIS

For predicting the grain yield through soil test values and fertilizer doses of N, P and K nutrients, and their interactions, the standard multiple regression model as postulated below is calibrated for the data generated in the survey of the farmer's fields and at Jagtial and Warangal locations following the procedures as described in Draper and Smith (1969). The models have been calibrated on a Pentium Computer using the standard regression software as followed for statistical analysis of data in the Soil Test Crop Response Correlation Project. The postulated multiple regression model is of the form

$$Y = a \pm b1\ SN \pm b2\ SN^2 \pm b3\ SP \pm b4\ SP^2 \pm b5\ SK \pm b6\ SK^2$$
$$\pm b7\ FN \pm b8\ FN^2 \pm b9\ FP \pm b10\ FP^2 \pm b11\ FK \pm b12\ FK^2$$
$$\pm b13\ FNSN \pm b14\ FPSP \pm b15\ FKSK$$

where SN, SP and SK are soil N, P and K nutrients (kg/ha) ; FN, FP and FK are fertilizer N, P and K nutrients (kg/ha) ; a is intercept ; b1,b2,..b15 are regression coefficients ; Y is grain yield (kg/ha).

3.6.3. FERTILIZER ADJUSTMENT EQUATIONS AND OPTIMISATION OF FERTILIZER DOSES

Using the multiple regression models which have a high estimate of R^2 value ($R^2 > 0.67$) the fertilizer adjustment equations can be separately derived by differentiating grain yield partially with respect to fertlizer N, P and K nutrients. The equations have to be derived only if the fertilizer response type is (+ - -) for a nutrient, say N, where the sign of the linear fertilizer term is +, quadratic term is -, and interaction of soil and fertilizer is - respectively. The regression equation is used for deriving fertilizer adjustment equation for maximum yield, maximum profit, and also for a desired rate of return as discussed by Sankar (1986).

Using the fertilizer adjustment equations, Ready Reckoners can be developed which provide optimal fertiliser doses for varying soil test values and also for varying marginal rates of return from a given experiment. This type of information can also be derived from the regression results of survey data generated with this study for the Sreeramsagar Project command area in different soils.

3.7. RESPONSE TO ADDED NITROGEN

The response to added nitrogen was calculated by the formula as given by Thakur (1993). The response to N can be given as

$$\text{Response to added N (kg grain/kg applied N)} = \frac{\text{GY of treated plot (kg/ha)} - \text{GY of control plot (kg/ha)}}{\text{Fertilizer N dose (kg/ha)}}$$

3.8. SOIL NUTRIENT INDEX

Biswas and Mukherjee (1987) suggested the following formula for computing soil nutrient index (NI) by giving weightages to number of samples falling into low, medium and high fertility classes :

$$NI = \frac{Nl + 2\ Nm + 3\ Nh}{Nl + Nm + Nh}$$

where Nl, Nm and Nh are the number of soil samples falling under Low, Medium and High nutrient status and are given weightages of 1, 2 and 3 respectively.

RESULTS

CHAPTER IV

4.0. RESULTS

A survey of soils for fertility evaluation was conducted in Sreeramsagar project command area where predominantly rice is grown as the principal crop during the year 1994. Surface (0-15 cm) soil samples from farmer's fields were collected in the months of May and June covering the project command spread over four districts of Telangana region of Andhra Pradesh viz., Karimnagar, Warangal, Nizamabad and Adilabad with the help of command area maps. A questionnaire was prepared for collecting information from 300 farmers spread over 60 villages. Soil samples were collected from the selected fields before transplantation of rice, at panicle initiation and at post-harvest stages of crop growth. Plant samples were collected at panicle initiation stage from the same fields where soil samples were collected. The technical format of the Soil Test Crop Response Correlation Project was adopted for collection and interpretation of soil test data for obtaining correlations of initial and post-harvest soil test values. This is also done for differentiating textural classes and to classify the soils into 'low', 'medium' and 'high' categories with respect to available N. This categorisation was later subjected to scrutiny based on field experiments conducted during kharif 1996 at Jagtial and Warangal locations using rice as test crop and its response at different levels of N fertilization.

4.1. SURVEY IN FARMER'S FIELDS IN SREERAMSAGAR PROJECT COMMAND AREA

Based on the information collected through the questionnaire on different parameters like initial soil test values, soil test values at the panicle initiation stage, and at harvest of rice crop, applied fertilizer doses, grain yield, plant nitrogen content at panicle intiation stage and various other details, the data was evaluated critically by using different statistical techniques. The data collected on different parameters covered 300 farmers from 60 villages (5 farmers from each village) covering 21 mandals from 4 districts of Andhra Pradesh viz., Karimanagar, Nizamabad, Warangal and Adilabad. The villages selected under each mandal covered area irrigated by the 'Saraswathi Canal' and the 'Kakatiya Canal', and also distributory-wise locations are given in Table 1. The questionnaire used for conducting the survey is given in Appendix 1. The original data of initial soil test values collected and screened in the sample survey for each district under each soil texture group are provided in the Appendix 2. The wet area details of the command area under the Sreeramsagar project are provided in Table 2. The results of the sample survey in the farmer's fields are discussed below.

4.1.1. SOIL-FERTILITY STATUS AND FERTILIZATION PRACTICES OF FARMERS OF SREERAMSAGAR PROJECT COMMAND AREA

Fertility status of command area soils revealed that red (alfisols and inceptisols) chalka and black (vertisols) clay soils are predominant groups. The data on different parameters have been examined for each district within each soil texture group. There was a wide range of variability in the initial soil test values for organic carbon (OC) and available Nitrogen ($KMnO_4$) methods, available P (Olsen's P) and ammonium acetate extractable K. The values of OC (%) were found to range between 0.09 and 1.97 with a mean of 0.95 (S.D. of 0.03) for Karimnagar district, 0.73 and 1.66 with a mean of 1.02 (0.25) for Nizamabad district, 0.31 and 2.02 with a mean of 0.80 (0.46) for Warangal district, and 0.65 and 1.92 with a mean of 1.13 (0.32) for Adilabad district. The mean $KMnO_4$-N was found to be 186 for Karimnagar, 226.9 for Nizamabad, 183.5 for Warangal and 202.6 for Adilabad. The corresponding post-harvest soil N estimates were 167.1, 213.7, 189.3 and 232.9 kg/ha in the 4 districts

Table 3. Descriptive statistics of soil test values and yield based on survey data under Sreeramsagar project

Variable	Minimum	Maximum	Mean	S.D.	CV.( )
KARIMNAGAR					
GY	12.0	52.8	25.9	11.1	42.8
OC (I)	0.09	1.97	0.95	0.03	34.6
KM (I)	75.3	360.6	186.0	49.7	26.7
OL (I)	4.0	55.0	23.2	11.5	49.5
AM (I)	96.0	528.0	255.3	90.8	35.6
KM (PH)	62.0	316.0	167.1	42.2	25.2
OL (PH)	6.0	80.0	27.2	12.6	46.3
AM (PH)	106.0	546.0	264.7	93.5	35.3
NIZAMABAD					
GY	14.0	21.0	17.6	2.5	14.1
OC (I)	0.73	1.66	1.02	0.25	24.8
KM (I)	106.6	404.5	226.9	70.4	31.0
OL (I)	18.0	46.0	25.3	7.9	31.1
AM (I)	189.0	645.0	376.9	129.1	34.2
KM (PH)	124.0	410.0	213.7	75.7	124.0
OL (PH)	19.0	46.0	30.4	8.6	28.5
AM (PH)	162.0	616.0	323.8	141.2	162.0

OC : Organic carbon (%)
KM : $KMnO_4$-N (kg ha^{-1})
OL : Olsen-P (kg ha^{-1})
AM : Ammonium acetate-K (kg ha^{-1})
GY : Grain yield (q ha^{-1})
I : Initial soil test values
PH : Post-harvest soil test values

Table 4. Descriptive statistics of soil test values and yield based on survey data under Sreeramsagar project

Variable	Minimum	Maximum	Mean	S.D.	C.V.(%)
WARANGAL					
GY	16.0	42.0	25.6	8.1	31.7
OC (I)	0.3	2.0	0.8	0.5	57.9
KM (I)	116.0	279.1	183.5	43.2	23.6
OL (I)	7.0	38.0	22.4	9.2	41.2
AM (I)	102.0	382.0	246.8	70.4	28.5
KM (PH)	128.0	305.0	189.3	46.4	24.5
OL (PH)	10.0	46.0	28.1	9.2	32.8
AM (PH)	102.0	402.0	219.6	68.0	31.0
ADILABAD					
GY	14.0	28.0	19.8	4.0	20.2
OC (I)	0.7	1.9	1.1	0.3	28.3
KM (I)	131.7	266.6	202.6	38.6	19.1
OL (I)	10.0	61.0	30.9	14.6	47.2
AM (I)	109.0	502.0	232.9	127.6	54.8
KM (PH)	138.0	270.0	206.6	40.4	19.6
OL (PH)	12.0	60.0	37.3	16.4	43.9
AM (PH)	88.0	486.0	190.9	107.8	56.5

OC : Organic carbon (%)
KM : $KMnO_4$-N (kg ha^{-1})
OL : Olsen-P (kg ha^{-1})
AM : Ammonium acetate-K (kg ha^{-1})
GY : Grain yield (q ha^{-1})
I : Initial soil test values
PH : Post-harvest soil test values

respectively. A wide range in soil N, P and K nutrients at post-harvest stage were observed in all the districts. The data of different parameters collected at initial stage are given in Appendix 2. The data of different parameters collected at panicle initiation and post-harvest stages are given in Appendix 3. The descriptive statistics of different variables of Karimnagar and Nizamabad are given in Table 3 and Warangal and Adilabad districts are given in Table 4.

4.1.1.1. RICE YIELD OBTAINED IN FARMERS FIELDS OF SURVEYED DISTRICTS

The grain yield data obtained from available farmers fields of surveyed districts at harvest indicate that grain yield ranged from 12 to 52.8 q/ha in Karimnagar, 17.6 to 21 q/ha in Nizamabad, 16 to 42 q/ha in Warangal, and from 14 to 28 q/ha in Adilabad district. Thus there was a wide range of yields obtained by farmers in the surveyed districts. The standard deviation (q/ha) and C.V. (%) of grain yield in farmers fields were found to be 11.1 q/ha (42.8 %) in Karimnagar, 2.5 (14.1) in Nizamabad, 8.1 (31.7) in Warangal, and 4 q/ha (20.2 %) in Adilabad district. The data of yield and post-harvest soil test values were obtained from 132, 11, 25 and 18 farmers of Karimnagar, Nizamabad, Warangal and Adilabad districts are used for analysis.

Table 5. Estimates of correlation between soil test values, fertilizer doses and grain yield based on survey data of farmers fields under Sreeramsagar project

Variables	Karimnagar	Nizamabad	Warangal	Adilabad
GY , IOC	0.03	-0.61 *	0.02	-0.33
GY , IKM	-0.03	-0.46	-0.28	-0.03
GY , IOL	-0.33 **	-0.60 *	-0.41 *	-0.15
GY , IAM	-0.25 **	-0.21	0.40 *	-0.21
GY , FN	0.39 **	0.44	0.27	0.49 *
GY , FP	0.21 *	0.12	0.25	0.48 *
GY , FK	0.46 **	-0.33	0.39 *	0.34
GY , PIN	0.52 **	0.61 *	0.41 *	0.50 *
IOC , FN	0.01	-0.38	0.21	-0.31
IKM , FN	0.01	-0.39	0.04	-0.35
IOL , FP	0.05	0.03	0.04	-0.36
IAM , FK	-0.24	0.04	-0.30	-0.31
IKM , PHKM	0.83 **	0.87 **	0.92 **	0.71 **
IOL , PHOL	0.78 **	0.84 **	0.82 **	0.90 **
IAM , PHAM	0.72 **	0.61 *	0.73 **	0.93 **
PIOC , PIN	0.51 **	0.38	0.31	0.34
PIKM , PIN	0.59 **	0.36	0.46 *	0.49 *

GY : Grain yield (kg ha^{-1})
FN, FP and FK : Fertilizer N, P and K doses (kg ha^{-1})
IOC : Initial organic carbon (%)
IKM : Initial soil N (kg ha^{-1}) ($KMnO_4$-N)
IOL : Initial soil P (kg ha^{-1}) (Olsen-P)
IAM : Initial soil K (kg ha^{-1}) (Ammonium acetate-K)
PHKM : Post-harvest soil N (kg ha^{-1}) ($KMnO_4$-N)
PHOL : Post-harvest soil P (kg ha^{-1}) (Olsen-P)
PHAM : Post-harvest soil K (kg ha^{-1}) (Ammonium acetate-K)
PIN : Plant N (%) at panicle initiation stage
PIOC : Organic carbon (%) at panicle initiation stage
PIKM : Soil N (kg ha^{-1}) at panicle initiation stage ($KMNO_4$-N)

4.1.2. CORRELATION OF SOIL TEST VALUES, FERTILISER DOSES AND YIELD FROM THE DATA FARMER'S FIELD

The relations between different variables have been examined by computing the estimates of correlation between different variables of initial soil test values, applied fertilizer doses of N, P and K nutrients, percent N content in the plant, available soil N at the panicle initiation stage, grain yield at harvest, and also post-harvest soil test values for N, P and K nutrients. The estimates of correlations of different variables at each district are given in Table 5.

The correlations have indicated that there was a high and significant relation between initial, panicle initiation and post-harvest soil test values for N, P and K nutrients in all the four districts surveyed. The estimates of correlations were 0.83 (**), 0.78 (**), 0.72 (**) for N, P and K nutrients at Karimnagar district. The values for the three nutrients were 0.87 (**), 0.84 (**), 0.61 (*) at Nizamabad, 0.92 (**), 0.82 (**), 0.73 (**) at Warangal, and 0.71 (**), 0.90 (**), 0.93 (**) at Adilabad respectively.

It was observed that grain yield had significant negative correlation with initial soil P (-0.33 **) and K (-0.25 **), significant positive correlation with fertilizer

N (0.39 **), P (0.21 *) and K (0.46 **) nutrients at Karimnagar, and significant negative correlation (-0.61 *) with OC (%) and Olsen's P (-0.60 *) at Nizamabad district. While grain yield had significant negative correlation with soil P (-0.41 *) but significant positive correlation with soil K (0.40 *), significant positive correlation with fertilizer K (0.39 *) at Warangal, where as it had negative and non-significant relation with soil test values, and positive and significant relation with fertilizer N (0.49 *) and P (0.48 *) nutrients at Adilabad district. There was a significant correlation between plant N content and the total soil N of 0.51 ** (with organic carbon) and 0.59 ** (with $KMnO_4$-N) at panicle initiation stage of the crop in Karimnagar district. The similar correlations were 0.38 and 0.36 at Nizamabad, 0.31 and 0.46 (*) at Warangal, and 0.34 and 0.49 (*) at Adilabad respectively. The correlation between grain yield and plant N at panicle initiation stage was found to be 0.52 (**) at Karimnagar, 0.61 (*) at Nizamabad, 0.41 (*) at Warangal and 0.50 (*) at Adilabad.

4.1.3. PREDICTION OF SOIL TEST VALUES UNDER FARMER'S FIELD CONDITIONS BASED ON THE SURVEY DATA

Multiple regression equations of post-harvest soil test values through initial soil test values, applied

Table 6. Prediction equations of post-harvest soil test values through initial soil test values in different districts of survey soils under SRSP command

District	Nutrient	Multiple regression equation	R2 value
Karimnagar	N	KM (PH) = 29.65 + 0.704 KM (I) ** + 0.134 FN - 0.149 GY	0.69 **
	P	OL (PH) = 10.60 + 0.884 OL (I) * - 0.115 FP + 0.063 GY	0.62 **
	K	AM (PH) = 100.8 + 0.712 AM (I) ** - 0.348 FK - 0.324 GY	0.52 **
Nizamabad	N	KM (PH) = -180 + 1.075 KM (I) ** + 0.001 FN + 8.553 GY	0.82 **
	P	OL (PH) = 5.22 + 0.144 OL (I) ** + 0.209 FP + 0.638 GY	0.66 **
	K	AM (PH) = -245 + 0.679 AM (I) * + 5.411 FK + 2.554 GY	0.48 *
Warangal	N	KM (PH) = -0.60 + 1.000 KM (I) ** - 0.033 FN + 0.369 GY	0.84 **
	P	OL (PH) = 14.95 + 0.933 OL (I) ** - 0.307 FP + 0.286 GY	0.77 **
	K	AM (PH) = 5.01 + 0.573 AM (I) * - 0.001 FK + 2.856 GY	0.63 **
Adilabad	N	KM (PH) = 16.27 + 0.747 KM (I) ** - 0.001 FN + 1.958 GY	0.54 **
	P	OL (PH) = -13 + 1.055 OL (I) ** + 0.606 FP - 0.867 GY	0.85 **
	K	AM (PH) = -30.2 + 0.788 AM (I) ** - 0.001 FK + 1.889 GY	0.88 **

KM (I), OL (I), AM (I) : Initial soil test values of $KMnO_4$-N, Olsen's P, Ammonium acetate K (kg/ha)
KM (PH), OL (PH), AM (PH) : Post-harvest soil test values of $KMnO_4$-N, Olsen's P, Ammonium acetate K (kg/ha)
GY : Grain yield (kg/ha)
FN, FP, FK : Applied fertilizer N, P and K nutrients (kg/ha)
** : significant at 1 % level of significance

fertilzer doses and harvested grain yield have been worked out for each district for predicting soil N, P and K nutrients under farmer's field conditions in each of the four districts under the Sreeramsagar command area. Since the post-harvest soil test values are highly and significantly correlated with initial soil test values, the prediction equations would give a basis for predicting soil test values, which can be used by soil testing laboratories for making fertilizer recommendations. The Soil N, P and K regression equations for Karimnagar district are as follows :

$$SN\ (PH) = 29.65 + 0.704^{**}\ SN\ (I) + 0.134\ FN - 0.149\ GY$$

$$(R^2 = 0.69^{**} \quad \sigma = 23.7 \quad C.V.\ (\%) = 14.2)$$

$$SP\ (PH) = 10.60 + 0.884^{**}\ SP\ (I) - 0.884\ FP + 0.063\ GY$$

$$(R^2 = 0.62^{**} \quad \sigma = 7.8 \quad C.V.\ (\%) = 28.7)$$

$$SK\ (PH) = 100.76 + 0.712^{**}\ SK\ (I) - 0.348\ FK - 0.324\ GY$$

$$(R^2 = 0.52^{**} \quad \sigma = 65.7 \quad C.V.\ (\%) = 24.8)$$

The results indicate that significant predictions can be made with the surveyed data of Karimnagar district for all the three nutrients. Similar results have been worked out using the data generated under the survey in the other three districts, and the results are given in Table 6. The regression coefficients of soil N, P and K nutrients were found to be highly significant for making post-harvest soil test predictions. Thus the results indicate that it is possible to predict the soil available nutrient status based on the $KMnO_4$ method for N, Olsen's method for P and Ammonium acetate method for K from the survey data for all the four districts under the Sreeramsagar project command area. The number of farmers surveyed from the four districts were 230 from Karimnagar, 15 from Nizamabad, 25 from Warangal, and 30 from Adilabad. The sample size in Karimnagar district is comparitively large because a large area of the project command is in that district.

4.1.4. PREDICTION OF SOIL NITROGEN ($KMnO_4$-N) THROUGH ORGANIC CARBON CONTENT IN DIFFERENT SOILS

Significant relations were found between organic carbon (%) and available soil N as estimated through $KMnO_4$ method. Hence an attempt has been made to predict available nitrogen through organic carbon content (%) in different soils of each district under the project. The prediction equations of each district over all the textures are as follows :

Table 7. A ready reckoner for predicting alkaline permanganate N through organic carbon (%) at different districts of survey soils

	Predicted soil N (kg/ha)			
O.C. (%)	Karimnagar	Nizamabad	Warangal	Adilabad
0.1	153	282	175	132
0.3	156	270	178	146
0.5	158	258	180	159
0.7	161	246	183	173
0.9	164	234	185	187
1.1	166	222	187	201
1.3	169	210	190	215
1.5	171	198	192	228
1.7	174	186	195	242
1.9	176	174	197	256
2.1	179	162	200	270

Prediction equations of each district are :

Karimnagar	KM = 152 + 12.78 OC (%)	R^2 = 0.66 **
Nizamabad	KM = 288 - 59.81 OC (%)	R^2 = 0.60 **
Warangal	KM = 174 + 12.25 OC (%)	R^2 = 0.61 **
Adilabad	KM = 125 + 68.99 OC (%)	R^2 = 0.71 **

Table 8. Relation between organic carbon and alkaline permanganate N and their prediction in different soil textures of Karimnagar soils

Texture	No.of samples	Prediction equation	R^2 value
Clay loam	51	KM = 159 + 39.9 OC **	0.62 **
Sandy clay loam	123	KM = 168 + 22.7 OC **	0.69 **
Sandy loam	41	KM = 148 + 44.3 OC **	0.57 **
Silt loam	10	KM = 78 + 145.8 OC **	0.59 **

OC : Organic carbon (%)

KM : Alkaline permanganate nitrogen (kg ha^{-1})

** : Significant at 1 % level of significance

Karimnagar : $KMnO_4\text{-N} = 152 + 12.78^{**}\ OC\ (\%)$

($R^2 = 0.66^{**}$, $\sigma = 48.4$, C.V. (%) = 25.1)

Nizamabad : $KMnO_4\text{-N} = 288 - 59.81^{**}\ OC\ (\%)$

($R^2 = 0.59^{**}$, $\sigma = 72.5$, C.V. (%) = 34.4)

Warangal : $KMnO_4\text{-N} = 174 + 12.25^{**}\ OC\ (\%)$

($R^2 = 0.61^{**}$, $\sigma = 43.8$, C.V. (%) = 23.8)

Adilabad : $KMnO_4\text{-N} = 125 + 68.99^{**}\ OC\ (\%)$

($R^2 = 0.71^{**}$, $\sigma = 32.7$, C.V. (%) = 15.8)

Based on the above prediction equations, estimates of soil N have been predicted at different organic carbon levels for each district and are given in the form of a ready reckoner in Table 7. The relation between organic carbon and KMnO4-N in each texture of Karimnagar soils and the prediction equations are given in Table 8.

4.1.5. CLASSIFICATION OF SOILS INTO LOW, MEDIUM AND HIGH CATEGORIES BASED ON THE SURVEY DATA

The categorisation of soil test values of initial and panicle initiation stages based on low, medium and high ratings alongwith nutrient index values have been compiled for the four surveyed districts and are given in Tables 9 and 10 respectively. Soil fertility ratings based on different

Table-9. District-wise classification of N fertility indices using initial soil test values under Sreeramsagar Project Command Area

District	Organic carbon (%) Low No.	Low Percent	Medium No.	Medium Percent	High No.	High Percent	Total	NI	Alkaline permanganate N Low No.	Low Percent	Medium No.	Medium Percent	High No.	High Percent	Total	NI
Karimnagar	14	6.1	40	17.4	176	76.5	230	2.70	221	96.1	8	3.5	1	0.4	230	1.04
Warangal	10	40.0	5	20.0	10	40.0	25	2.00	25	100.0	0	0.0	0	0.0	25	1.00
Nizamabad	0	0.0	2	13.3	13	86.7	15	2.87	14	93.3	1	6.7	0	0.0	15	1.07
Adilabad	1	3.3	2	6.7	27	90.0	30	2.87	28	93.3	2	6.7	0	0.0	30	1.07
Total	25	8.3	49	16.3	226	75.3	300	2.67*	288	96.0	11	3.7	1	0.3	300	1.04*

* Mean nutrinet index over all districts in command area

Table-10. District-wise classification of N fertility indices using soil test values at panicle initiation stage under Sreeramsagar Project Command Area

District	Organic carbon (%) Low No.	Low Percent	Medium No.	Medium Percent	High No.	High Percent	Total	NI	Alkaline permanganate N Low No.	Low Percent	Medium No.	Medium Percent	High No.	High Percent	Total	NI
Karimnagar	10	4.3	39	17.0	181	78.7	230	2.74	219	95.2	9	3.9	2	0.9	230	1.06
Warangal	4	16.0	6	24.0	15	60.0	25	2.44	24	96.0	1	4.0	0	0.0	25	1.04
Nizamabad	1	6.7	0	0.0	14	93.3	15	2.87	14	93.3	1	6.7	0	0.0	15	1.07
Adilabad	2	6.7	3	10.0	25	83.3	30	2.77	28	93.3	2	6.7	0	0.0	30	1.07
Total	17	5.7	48	16.0	235	78.3	300	2.66*	285	95.0	13	4.3	2	0.7	300	1.05*

* Mean nutrinet index over all districts in command area

Table-11. District-wise classification of soils based on textural classes using initial N soil test values under Sreeramsagar Project Command Area

	Organic carbon (%)								Alkaline permanganate N							
	Low		Medium		High				Low		Medium		High			
Texture	No.	Percent	No.	Percent	No.	Percent	Total	NI	No.	Percent	No.	Percent	No.	Percent	Total	NI
KARIMNAGAR																
Clay loam	3	5.8	12	23.1	37	71.2	52	2.65	50	89.3	6	10.7	0	0.0	56	1.11
Clayey	0	0.0	2	66.7	1	33.3	3	2.33	2	100.0	0	0.0	0	0.0	2	1.00
Loamy sand	0	0.0	2	100.0	0	0.0	2	2.00	2	100.0	0	0.0	0	0.0	2	1.00
Sandy clay loam	9	7.1	14	11.0	104	81.9	127	2.75	124	98.4	1	0.8	1	0.8	126	1.02
Sandy loam	2	5.0	7	17.5	31	77.5	40	2.73	36	97.3	1	2.7	0	0.0	37	1.03
Silt loam	0	0.0	3	50.0	3	50.0	6	2.50	7	100.0	0	0.0	0	0.0	7	1.00
Total	14	6.1	40	17.4	176	76.5	230	2.49*	221	96.1	8	3.5	1	0.4	230	1.03*
NIZAMABAD																
Clay loam	0	0.0	0	0.0	1	100.0	1	3.00	1	100.0	0	0.0	0	0.0	1	1.00
Sandy clay loam	0	0.0	0	0.0	5	100.0	5	3.00	4	80.0	1	20.0	0	0.0	5	1.20
Sandy loam	0	0.0	0	0.0	2	100.0	2	3.00	2	100.0	0	0.0	0	0.0	2	1.00
Silt clay loam	0	0.0	2	40.0	3	60.0	5	2.60	5	100.0	0	0.0	0	0.0	5	1.00
Silt loam	0	0.0	0	0.0	2	100.0	2	3.00	2	100.0	0	0.0	0	0.0	2	1.00
Total	0	0.0	2	13.3	13	86.7	15	2.92*	14	93.3	1	6.7	0	0.0	15	1.04*
WARANGAL																
Clay loam	3	27.3	1	9.1	7	63.6	11	2.36	10	100.0	0	0.0	0	0.0	10	1.00
Sandy clay loam	6	50.0	4	33.3	2	16.7	12	1.67	13	100.0	0	0.0	0	0.0	13	1.00
Silt clay loam	1	50.0	0	0.0	1	50.0	2	2.00	2	100.0	0	0.0	0	0.0	2	1.00
Total	10	40.0	5	20.0	10	40.0	25	2.00*	25	100.0	0	0.0	0	0.0	25	1.00*
ADILABAD																
Clay loam	0	0.0	2	9.1	20	90.9	22	2.91	21	95.5	1	4.5	0	0.0	22	1.05
Loamy sand	0	0.0	0	0.0	2	100.0	2	3.00	1	50.0	1	50.0	0	0.0	2	1.50
Sandy clay loam	1	25.0	0	0.0	3	75.0	4	2.50	4	100.0	0	0.0	0	0.0	4	1.00
Sandy loam	0	0.0	0	0.0	1	100.0	1	3.00	1	100.0	0	0.0	0	0.0	1	1.00
Silt loam	0	0.0	0	0.0	1	100.0	1	3.00	1	100.0	0	0.0	0	0.0	1	1.00
Total	1	3.3	2	6.7	27	90.0	30	2.87*	28	93.3	2	6.7	0	0.0	30	1.07*

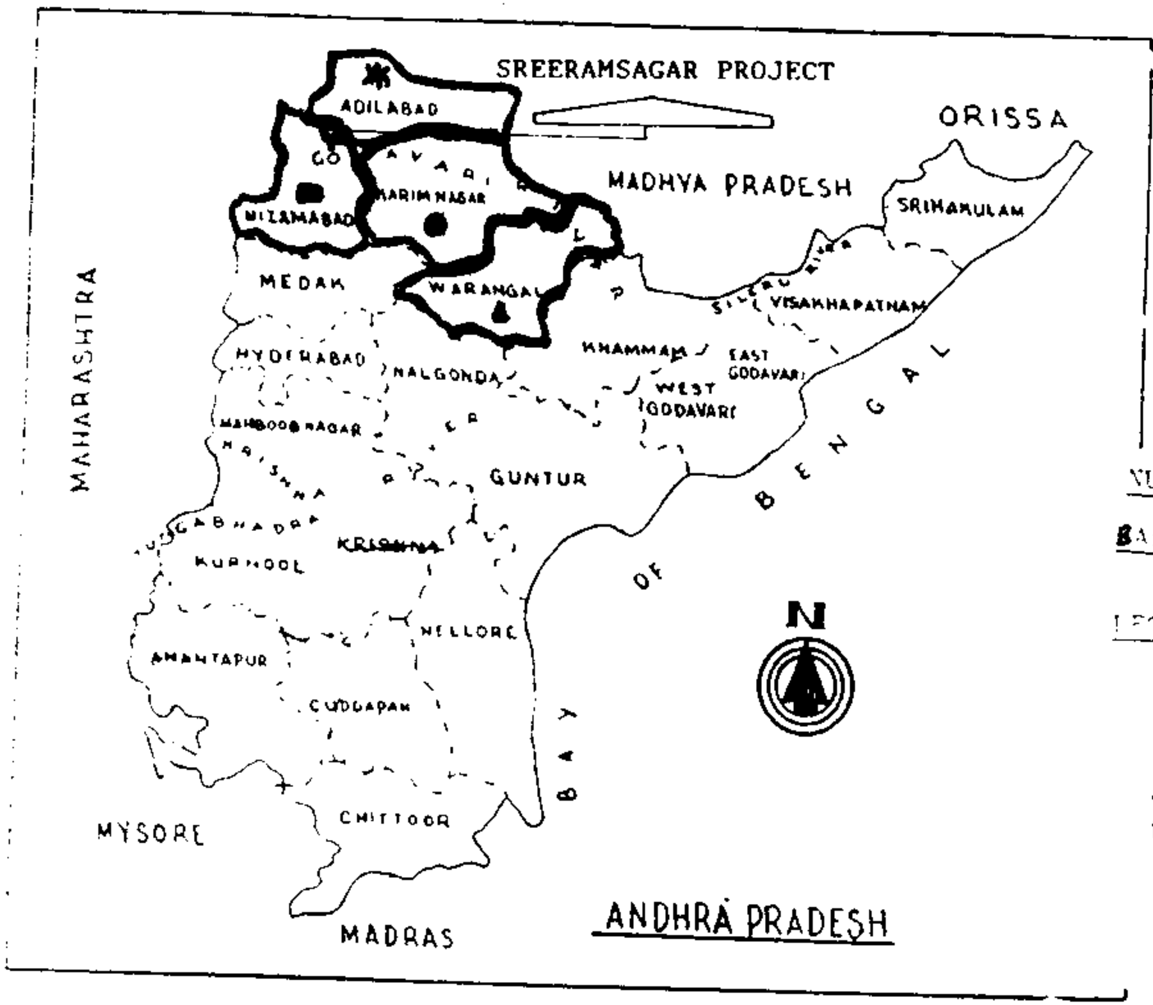
* Mean nutrient index over textures

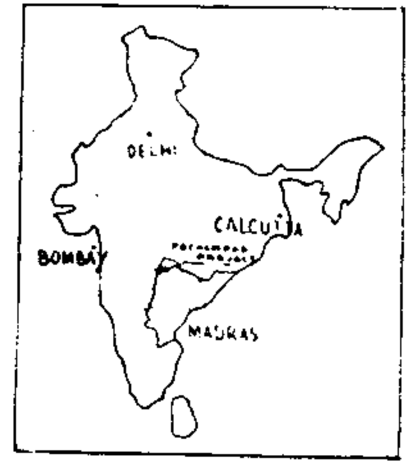
Table-12. District-wise textural classification of soils based on N soil test values collected at panicle initiation stage of rice growth under Sreeramsagar Project Command Area

Texture	Organic carbon (%) Low No.	Low Percent	Medium No.	Medium Percent	High No.	High Percent	Total	NI	Alkaline permanganate N Low No.	Low Percent	Medium No.	Medium Percent	High No.	High Percent	Total	NI
KARIMNAGAR																
Clay loam	4	7.8	11	21.6	36	70.6	51	2.63	51	100.0	0	0.0	0	0.0	51	1.00
Clayey	0	0.0	0	0.0	2	100.0	2	3.00	2	100.0	0	0.0	0	0.0	2	1.00
Loamy sand	0	0.0	0	0.0	4	100.0	4	3.00	3	75.0	0	0.0	1	25.0	4	1.50
Sandy clay loam	5	4.1	17	13.8	101	82.1	123	2.78	115	93.5	5	4.1	3	2.4	123	1.09
Sandy loam	1	2.8	3	8.3	32	88.9	36	2.86	34	94.4	2	5.6	0	0.0	36	1.06
Silt loam	2	14.3	2	14.3	10	71.4	14	2.57	14	100.0	0	0.0	0	0.0	14	1.00
Total	12	5.2	33	14.3	185	80.4	230	2.75*	219	95.2	7	3.0	4	1.7	230	1.07*
NIZAMABAD																
Clay loam	0	0.0	0	0.0	1	100.0	1	3.00	1	100.0	0	0.0	0	0.0	1	1.00
Sandy clay loam	0	0.0	1	20.0	4	80.0	5	2.80	5	100.0	0	0.0	0	0.0	5	1.00
Sandy loam	0	0.0	0	0.0	2	100.0	2	3.00	2	100.0	0	0.0	0	0.0	2	1.00
Silt clay loam	1	20.0	1	20.0	3	60.0	5	2.40	5	100.0	0	0.0	0	0.0	5	1.00
Silt loam	0	0.0	0	0.0	2	100.0	2	3.00	2	100.0	0	0.0	0	0.0	2	1.00
Total	1	6.7	2	13.3	12	80.0	15	2.73*	15	100.0	0	0.0	0	0.0	15	1.00*
WARANGAL																
Clay loam	2	25.0	2	25.0	4	50.0	8	2.25	8	100.0	0	0.0	0	0.0	8	1.00
Sandy clay loam	2	13.3	4	26.7	9	60.0	15	2.47	14	93.3	1	6.7	0	0.0	15	1.07
Silt clay loam	0	0.0	0	0.0	2	100.0	2	3.00	2	100.0	0	0.0	0	0.0	2	1.00
Total	4	16.0	6	24.0	15	60.0	25	2.44*	24	96.0	1	4.0	0	0.0	25	1.04*
ADILABAD																
Clay loam	1	4.8	1	4.8	19	90.5	21	2.86	20	95.2	1	4.8	0	0.0	21	1.05
Loamy sand	0	0.0	0	0.0	2	100.0	2	3.00	2	100.0	0	0.0	0	0.0	2	1.00
Sandy clay loam	1	25.0	1	25.0	2	50.0	4	2.25	3	75.0	1	25.0	0	0.0	4	1.25
Sandy loam	0	0.0	0	0.0	1	100.0	1	3.00	1	100.0	0	0.0	0	0.0	1	1.00
Silt loam	0	0.0	0	0.0	2	100.0	2	3.00	2	100.0	0	0.0	0	0.0	2	1.00
Total	2	6.7	2	6.7	26	86.7	30	2.80*	28	93.3	2	6.7	0	0.0	30	1.07*

* Mean nutrient index over textures

MAP NO·2 N FERTILITY INDEXES OF SURVEYED DISTRICTS





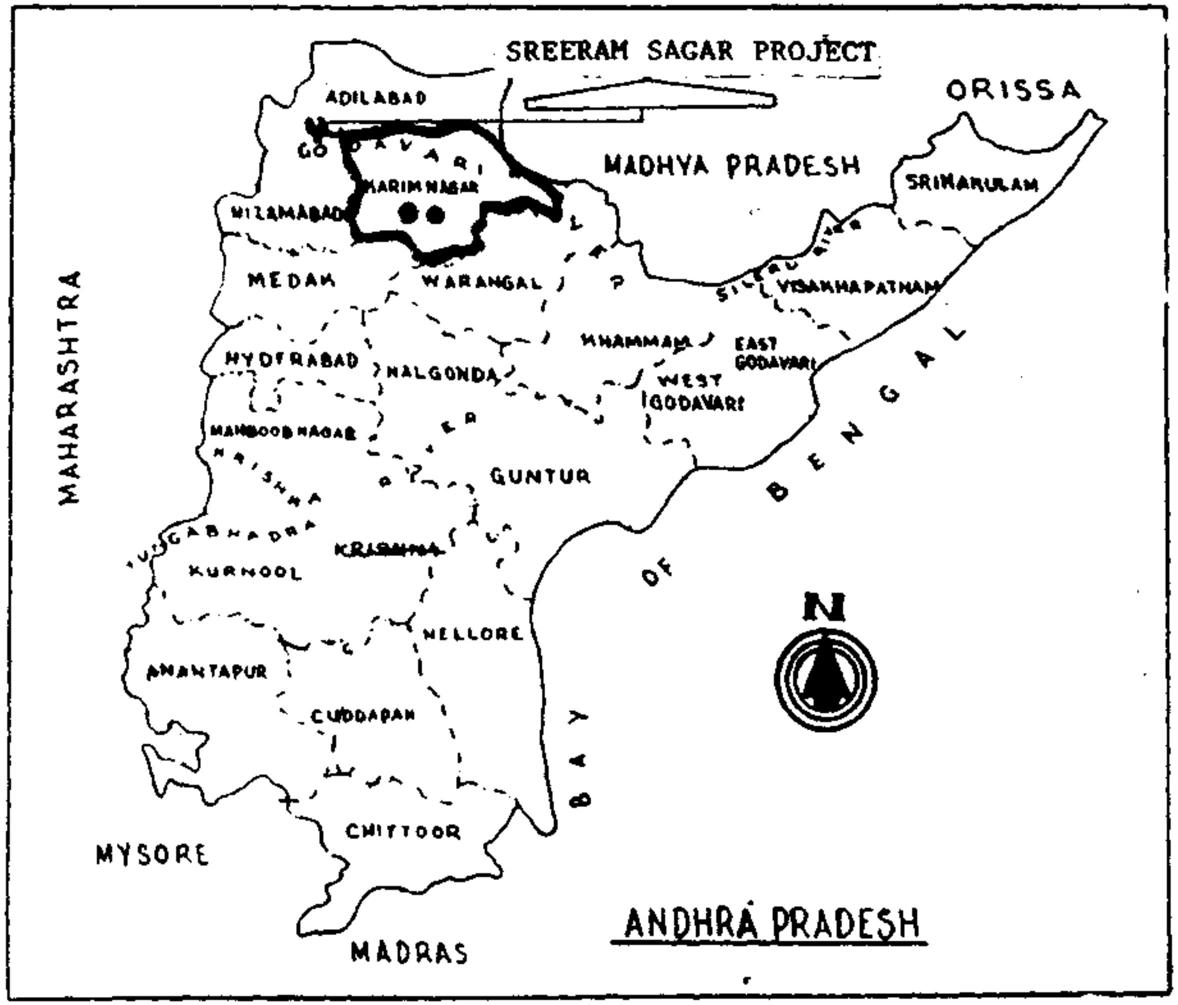
KEY PLAN OF (AP)

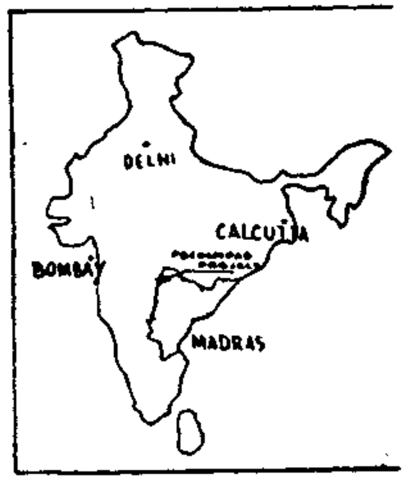
NUTRIENT INDEX

BASED ON INITIAL STV

LEGEND	O.C.	SOIL N (KMnO4)
●	2.70	1.04
▲	2.00	1.00
■	2.97	1.07
*	2.97	1.07

MAP No: 3 NUTRIENT INDKES OF NITROGEN TEXTUREWISE IN KARIMNAGAR DIST OF SRSP





KEY PLAN OF (AP)

NUTRIENT INDEX
TEXTURAL WISE
(at harvest of rice)
Karimnagar Dist. ●●
(Based on Alkaline Permanganate N)

Clay Loam	1.11
Clayey	1.00
Loamy sand	1.00
Sandy clay Loam	1.01
Sandy Loam	1.00
Silt Loam	1.00

Table-13. District-wise textural classification of soils based on N soil test values collected at harvest of rice under Sreeramsagar Project Command Area

	Alkaline permanganate N							
	Low		Medium		High			
Texture	No.	Percent	No.	Percent	No.	Percent	Total	NI
KARIMNAGAR								
Clay loam	26	92.9	1	3.6	1	3.6	28	1.11
Clayey	2	100.0	0	0.0	0	0.0	2	1.00
Loamy sand	1	100.0	0	0.0	0	0.0	1	1.00
Sandy clay loam	69	98.6	1	1.4	0	0.0	70	1.01
Sandy loam	22	100.0	0	0.0	0	0.0	22	1.00
Silt loam	9	100.0	0	0.0	0	0.0	9	1.00
Total	129	97.7	2	1.5	1	0.8	132	1.03*
NIZAMABAD								
Clay loam	1	100.0	0	0.0	0	0.0	1	1.00
Sandy clay loam	3	75.0	1	25.0	0	0.0	4	1.25
Sandy loam	0	0.0	1	100.0	0	0.0	1	2.00
Silt clay loam	0	0.0	4	100.0	0	0.0	4	2.00
Silt loam	0	0.0	1	100.0	0	0.0	1	2.00
Total	4	36.4	7	63.6	0	0.0	11	1.64*
WARANGAL								
Clay loam	7	87.5	1	12.5	0	0.0	8	1.13
Sandy clay loam	14	93.3	1	6.7	0	0.0	15	1.07
Silt clay loam	2	100.0	0	0.0	0	0.0	2	1.00
Total	23	92.0	2	8.0	0	0.0	25	1.08*
ADILABAD								
Clay loam	12	100.0	0	0.0	0	0.0	12	1.00
Loamy sand	1	100.0	0	0.0	0	0.0	1	1.00
Sandy clay loam	2	100.0	0	0.0	0	0.0	2	1.00
Sandy loam	1	100.0	0	0.0	0	0.0	1	1.00
Silt loam	2	100.0	0	0.0	0	0.0	2	1.00
Total	18	100.0	0	0.0	0	0.0	18	1.00*

* Mean nutrient index over textures

textures with initial N soil test values of farmers fields into different categories have been worked out for each district and are given in Table 11. This is done to assess the soil fertility status of the farmer's fields and examine the basis of fertilizer recommendation.

Farmers have been applying fertilizers based on general fertilizer recommendations prescribed by the government/ agricultural university. Since there is a need to correct the dose by taking into account the native soil fertility status, an attempt has been made to assess the soil fertility of farmer's fields based on the existing ratings of low, medium and high groups of N status. It was found that 221 fields were low, 8 were medium and 1 was high in Karimnagar district. The frequencies for the other districts were 14,1,0 under L, M and H for Nizamabad, 25,0,0 for Warangal, and 28,2,0 for Adilabad districts respectively. This indicates that most of the farmer's fields (about 97 % surveyed) are low to medium for all the three nutrients. An attempt was made on texture-wise classification of soils based on soil test values collected at panicle initiation and post-harvest stages of rice growth in all the four districts surveyed and are given in Tables 12 and 13 respectively. The district wise textural classification of soils based on P and

Total	NI
28	2.46
2	2.00
1	3.00
70	2.44
22	2.55
9	2.33
132	2.45*
1	3.00
4	2.75
1	2.00
4	2.50
1	3.00
11	2.64*
8	2.38
15	2.07
2	1.50
25	2.12*
12	1.75
1	2.00
2	2.00
1	2.00
2	2.00
18	1.83*

Table-13(a). District-wise textural classification of soils based on P and K soil test values collected at harvest of rice under Sreeramsagar Project Command Area

Texture	Olsen's - P Low No.	Low Percent	Medium No.	Medium Percent	High No.	High Percent	Total	NI	Ammonium Acetate - K Low No.	Low Percent	Medium No.	Medium Percent	High No.	High Percent	Total	NI
KARIMNAGAR																
Clay loam	1	3.6	10	35.7	17	60.7	28	2.57	1	3.6	13	46.4	14	50.0	28	2.46
Clayey	0	0.0	1	50.0	1	50.0	2	2.50	0	0.0	2	100.0	0	0.0	2	2.00
Loamy sand	0	0.0	1	100.0	0	0.0	1	2.00	0	0.0	1	100.0	0	0.0	1	2.00
Sandy clay loam	4	5.7	25	35.7	41	58.6	70	2.53	1	1.4	37	52.9	32	45.7	70	2.44
Sandy loam	1	4.5	9	40.9	12	54.5	22	2.50	0	0.0	10	45.5	12	54.5	22	2.55
Silt loam	0	0.0	7	77.8	2	22.2	9	2.22	1	11.1	4	44.4	4	44.4	9	2.33
Total	6	4.5	53	40.2	73	55.3	132	2.51*	3	2.3	67	50.8	62	47.0	132	2.45*
NIZAMABAD																
Clay loam	0	0.0	1	100.0	0	0.0	1	2.00	0	0.0	0	0.0	1	100.0	1	3.00
Sandy clay loam	0	0.0	0	0.0	4	100.0	4	3.00	0	0.0	1	25.0	3	75.0	4	2.75
Sandy loam	0	0.0	1	100.0	0	0.0	1	2.00	0	0.0	1	100.0	0	0.0	1	2.00
Silt clay loam	0	0.0	1	25.0	3	75.0	4	2.75	0	0.0	2	50.0	2	50.0	4	2.50
Silt loam	0	0.0	0	0.0	1	100.0	1	3.00	0	0.0	0	0.0	1	100.0	1	3.00
Total	0	0.0	3	27.3	8	72.7	11	2.73*	0	0.0	4	36.4	7	63.6	11	2.64*
WARANGAL																
Clay loam	0	0.0	2	25.0	6	75.0	8	2.75	0	0.0	5	62.5	3	37.5	8	2.38
Sandy clay loam	1	6.7	3	20.0	11	73.3	15	2.67	1	6.7	12	80.0	2	13.3	15	2.07
Silt clay loam	0	0.0	1	50.0	1	50.0	2	2.50	1	50.0	1	50.0	0	0.0	2	1.50
Total	1	4.0	6	24.0	18	72.0	25	2.68*	2	8.0	18	72.0	5	20.0	25	2.12*
ADILABAD																
Clay loam	0	0.0	2	16.7	10	83.3	12	2.83	6	50.0	3	25.0	3	25.0	12	1.75
Loamy sand	0	0.0	1	100.0	0	0.0	1	2.00	0	0.0	1	100.0	0	0.0	1	2.00
Sandy clay loam	0	0.0	1	50.0	1	50.0	2	2.50	0	0.0	2	100.0	0	0.0	2	2.00
Sandy loam	0	0.0	0	0.0	1	100.0	1	3.00	0	0.0	1	100.0	0	0.0	1	2.00
Silt loam	0	0.0	1	50.0	1	50.0	2	2.50	0	0.0	2	100.0	0	0.0	2	2.00
Total	0	0.0	5	27.8	13	72.2	18	2.72*	6	33.3	9	50.0	3	16.7	18	1.83*

* Mean nutrient index over textures

K soil test values collected at harvest of rice crop into different ratings and nutrient indices are given in Table 13(a).

4.1.6. A QUICK SOIL TEST METHOD FOR ASSESSING SOIL FERTILITY OF FARMER'S FIELDS

Based on quick soil test of colour comparison of organic carbon determination as an index of N in soils which is adopted in the State Soil Testing Laboratories of Andhra Pradesh, a survey of soil samples of 150 farmers covering four districts were assessed and the conclusions drawn from the test are indicated below.

Out of 120 soils studied in Karimnagar district it was observed that 83.7 % of soil samples were rated as 'low', 7 % 'medium' and 9.3 % 'high' under sandy clay loam texture (SCL), 97.1 % under clay loam (CL) and 88.4 % under sandy loam (SL) were rated as low in these districts. A negligible percent was observed under medium and high soil fertility index of OC in clay loam texture, where as 9.3 % were in sandy loam texture in the same district.

In Nizamabad and Warangal districts, all the samples were found to be in the low category of organic carbon status. In Adilabad district, 85.7 % were low and 14.3 % were medium under sandy clay loam, 57.1 % were low and

Table-14. Classification of N soil test values texture-wise in four districts of survey rice soils (based on QUICK SOIL TESTS)

District	Texture	Organic carbon (%)							
		Low	Percent	Medium	Percent	High	Percent	Total	NI
Karimnagar	Sandy clay loam	36	83.7	3	7.0	4	9.3	43	1.26
	Clay loam	33	97.1	1	2.9	0	0.0	34	1.03
	Sandy loam	38	88.4	1	2.3	4	9.3	43	1.21
	Total	107	89.2	5	4.2	8	6.7	120	1.17*
Nizamabad	Sandy clay loam	6	100.0	0	0.0	0	0.0	6	1.00
	Clay loam	1	100.0	0	0.0	0	0.0	1	1.00
	Sandy loam	1	100.0	0	0.0	0	0.0	1	1.00
	Total	8	100.0	0	0.0	0	0.0	8	1.00*
Warangal	Sandy clay loam	4	100.0	0	0.0	0	0.0	4	1.00
	Clay loam	2	100.0	0	0.0	0	0.0	2	1.00
	Sandy loam	2	100.0	0	0.0	0	0.0	2	1.00
	Total	8	100.0	0	0.0	0	0.0	8	1.00*
Adilabad	Sandy clay loam	6	85.7	1	14.3	0	0.0	7	1.14
	Sandy loam	4	57.1	3	42.9	0	0.0	7	1.43
	Total	10	71.4	4	28.6	0	0.0	14	1.29*

* mean nutrient index

Table 14(a). Evaluation of N methods as estimated by Visual Colour Comparitive (Quick test), Organic carbon and Alkaline Permanganate methods

Nitrogen methods	N status	Karimnagar		Nizamabad		Warangal		Adilabad		Total
		No.	Percent	No.	Percent	No.	Percent	No.	Percent	
Visual Colour method (Quick test of Organic Carbon)	Low	107	89.2	8	100	8	100	10	71.4	133
	Medium	5	4.2	0	0	0	0	4	28.6	9
	High	8	6.7	0	0	0	0	0	0	8
Walkley & Black method of Organic Carbon (Titrimetric)	Low	9	7.5	0	0	6	75	0	0	15
	Medium	20	16.7	0	0	0	0	0	0	20
	High	91	75.8	8	100	2	25	14	100	115
Subbiah and Asija method of available N (Alkaline (permanganate method)	Low	114	95	8	100	8	100	13	92.9	143
	Medium	6	5	0	0	0	0	1	7.1	7
	High	0	0	0	0	0	0	0	0	0

Rating	OC (%)	Available N
Low	< 0.50	< 280
Medium	0.5 - 0.7	280-560
High	> 0.75	> 560

Table 15 . A comparison of N nutrient indices in survey districts as done by Soil Testing Laboratories and under routine soil test methods

District	Colour comparitive method of OC (%) (Quick test)	Routine laboratory methods	
		Titrimetric method	Permanganate soil N method
Karimnagar	1.17	2.68	1.05
Nizamabad	1.00	3.00	1.00
Warangal	1.00	1.50	1.00
Adilabad	1.29	3.00	1.07

Note : Nutrient indices given are over different textures

42.9 % medium under sandy loam texture and the results are given in Table 14.

N status as determined by three methods viz., Visual colour comparitive method as done in Soil Testing Laboratories, Organic carbon by Walkley and Black Titration method, and alkaline permanganate soil N method (Subbiah and Asija (1956) were compared for 150 soils selected and ratings were given with nutrient indices in Table 14(a). The nutrient indices have been worked out for these three methods as a comparison and are given in Table 15. It is observed that 133 cases were low, 9 were medium and 8 were high under Visual colour comparitive method. The low, medium and high cases were 15, 20 and 115 under Titrimetric method. There were 143 under low and 7 under medium under the alkaline permanganate method of N in the surveyed distrcts. A comparison of N nutrient indices in the surveyed districts as given in Table 15 indicated that low nutient index was existing in all the four districts under the quick test based on organic carbon. While Karimnagar, Nizamabad and Adilabad were having high nutrient indexes, Warangal was found to have medium nutrient index under the routine soil test based on Titrimetric method. All the four districts were found to be having low nutrient indexes based on the routine soil test of alkaline permanganate method of N.

4.1.7. FERTILIZATION PRACTICES ADOPTED BY FARMERS

Farmers have been using fertilizers based on the general recommended dose as prescribed in the state by the government from time to time. The doses were varying from district to district depending on the soil texture, P fixation and release of the soils, and also based on the farmer's investment capacity, expectation from investment and choice and availability of fertilizers. There was no uniform dose applied even in a same village, or mandal or the district. Inspite of this, farmers have obtained high grain yields of rice varieties in most of the villages which was evident from the survey. In view of this, there is an urgent need to standardise the fertilizer doses based on soil test values based on the recommendations of the All India Coordinated Soil Test Crop Response Correlation Project.

4.2. FIELD EXPERIMENTS AT JAGTIAL AND WARANGAL

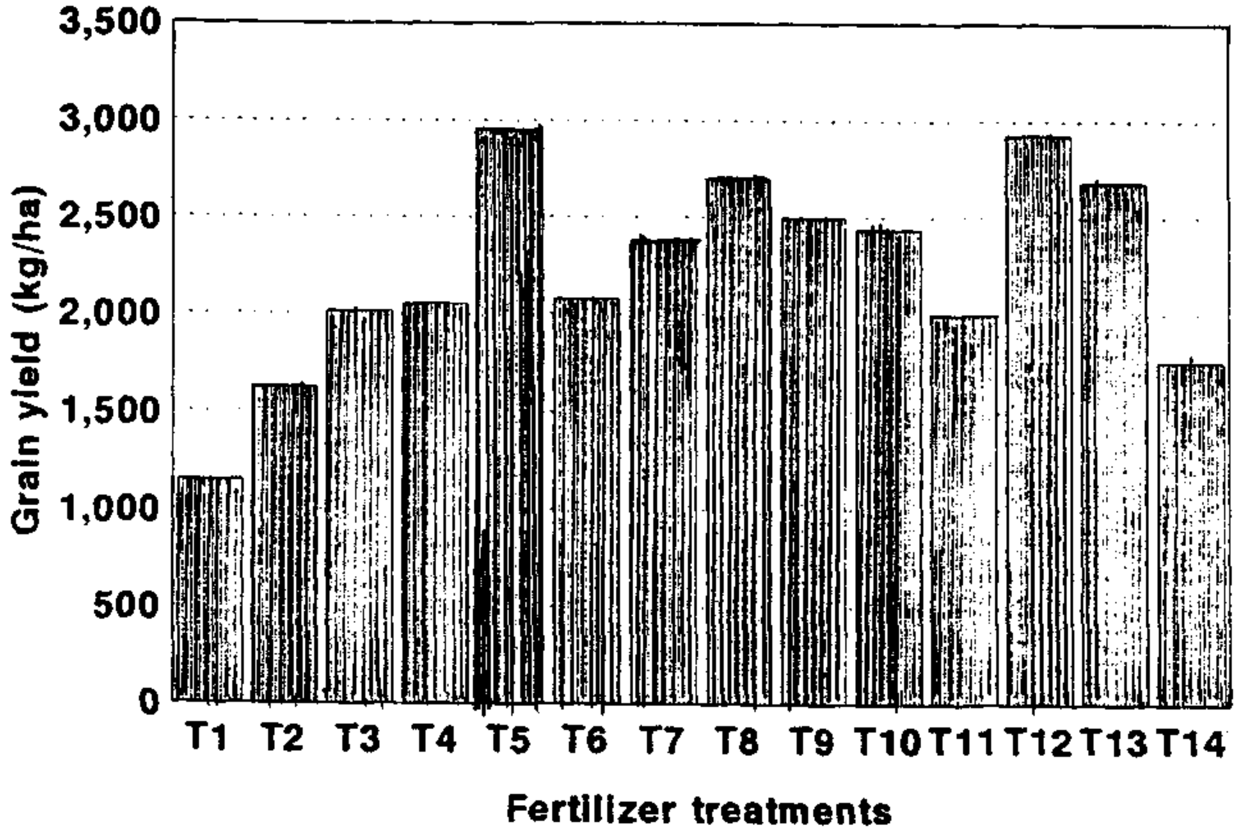
The data of field experiments conducted at Regional Agricultural Research Station, Jagtial and the Agricultural Research Station, Warangal have been analysed using different statistical techniques with the objective of developing a suitable fertilizer recommendation based on soil tests for alfisols and vertisols and the results are detailed in the following sections. The weekly rainfall during crop growth

Table 16. Analysis of variance of grain yield, drymatter production and composition in rice at Jagtial during kharif 1996

S.No.	Treatment	GY	SY	GR-N	GR-P	GR-K	ST-N	ST-P	ST-K
1	0-0-0	1155	1538	1.12	0.19	0.19	0.98	0.11	1.11
2	0-60-50	1624	2480	1.42	0.15	0.34	1.21	0.12	1.06
3	60-60-50	2012	2892	1.27	0.15	0.19	0.80	0.12	1.11
4	120-60-50	2452	4418	1.47	0.13	0.18	0.42	0.11	1.11
5	180-60-50	2952	4397	2.32	0.14	0.19	0.94	0.14	1.14
6	120-0-50	2077	3646	2.70	0.15	0.18	0.67	0.14	1.02
7	120-30-50	2378	4418	2.74	0.15	0.17	0.43	0.13	1.09
8	120-90-50	2701	3595	2.70	0.13	0.17	0.41	0.13	1.10
9	120-60-0	2493	3530	2.82	0.14	0.17	0.48	0.15	1.15
10	120-60-25	2434	4776	1.93	0.15	0.17	0.37	0.14	1.07
11	120-60-75	1997	3617	1.58	0.14	0.16	0.55	0.14	1.07
12	180-90-75	2928	5025	2.20	0.12	0.30	0.92	0.16	1.05
13	80-60-0	2681	3357	1.85	0.14	0.17	0.50	0.11	1.16
14	120-60-30	1759	3336	2.12	0.15	0.17	0.89	0.10	1.15
Mean		2260	3645	2.02	0.15	0.20	0.68	0.13	1.10
SEm		303.2	349.7	0.05	0.02	0.05	0.04	0.02	0.04
CD (5%)		909.6	101.6	0.16	-	-	0.10	-	-
C.V. (%)		23.2	16.6	4.6	20.4	45.4	8.8	20.7	6.0
F-test		**	**	**	NS	NS	**	NS	NS

GY : Grain yield (kg/ha)
SY : Straw yield (kg/ha)
GR-N, GR-P and GR-K : N (%), P (%), K (%) in grain
ST-N, ST-P and ST-K : N (%), P(%), K(%) in Straw
** : Significant 1 % level of significance
NS : Not significant

Fig.2(a). Mean grain yield of different fertilizer treatments obtained at Jagtial during Kharif 1996



recorded in the standard weeks in kharif 1996 at Jagtial and Warangal are given in Table 2(a), and shown in Fig.1(a) and 1(b) for the two centres respectively in "Materials and Methods" chapter.

4.2.1. DESCRIPTIVE STATISTICS OF DIFFERENT PARAMETERS

4.2.1.1. JAGTIAL CENTRE

4.2.1.1.1. DRYMATTER PRODUCTION AND GRAIN YIELD

Crop experiment with test crop as paddy (IR-64) was laid out at Jagtial during kharif 1996. Grain and drymatter yields were recorded at harvest, and it was observed that the maximum grain yield of 2928 kg/ha was recorded in T12 treatment (180-90-75). This is followed by T8 (120-90-50) treatment with 2701 kg/ha. The highest drymatter production was observed in T12 treatment (5025 kg/ha) and followed by T10 (120-60-25) with 4776 kg/ha. It was observed that 180 kg N application has increased the grain and drymatter yields, whereas farmer's practice has provided a grain yield of 2681 and drymatter of 3357 kg/ha. The observed data of each treatment are presented in Table 16. The replicated data of grain and straw yields, along with all other parameters are given in Appendix 6. The grain yield obtained at different fertilizer treatments is given in Fig.2(a).

Table 18. Descriptive statistics of yield, plant uptake and soil nutients at Jagtial and Warangal

Variable	Minimum	Maximum	Mean	S.D.	C.V.(%)
JAGTIAL					
GY	948.70	3691.00	2260.00	660.70	29.2
UN	24.10	126.90	70.90	26.20	36.9
UP	3.70	13.30	8.00	2.50	31.0
UK	16.60	65.10	44.50	12.30	27.6
OC-N	0.06	0.73	0.29	0.16	53.2
KM-N	94.10	435.90	157.80	75.20	47.7
CA-N	75.30	348.70	126.30	60.20	47.6
OL-P	11.00	50.00	22.90	10.00	43.6
AM-K	134.40	211.20	174.40	19.10	10.9
WARANGAL					
GY	2210.00	4719.00	3297.00	525.50	15.9
UN	26.90	145.80	62.90	25.60	40.6
UP	3.80	10.00	6.50	1.50	23.6
UK	28.30	60.30	39.30	7.30	18.7
OC-N	0.12	1.05	0.64	0.23	35.8
KM-N	141.60	351.20	201.70	40.90	20.3
CA-N	115.30	281.00	161.60	32.70	20.2
OL-P	44.00	87.00	69.60	13.00	18.7
AM-K	496.30	628.10	578.10	33.90	5.9

GY : Grain yield (kg ha^{-1})
UN, UP, UK : Plant uptake N, P and K nutrients (kg ha^{-1})
OC-N : Organic carbon (%)
KM-N : Alkaline permonganate N (kg ha^{-1})
CA-N : Calcium hydroxide N (kg ha^{-1})
OL-P : Olsen's-P (kg ha^{-1})
AM-K : Ammonium acetate-K (kg ha^{-1})

Fig.3(a). Mean uptake N obtained in different fertilizer treatments at Jagtial during Kharif 1996

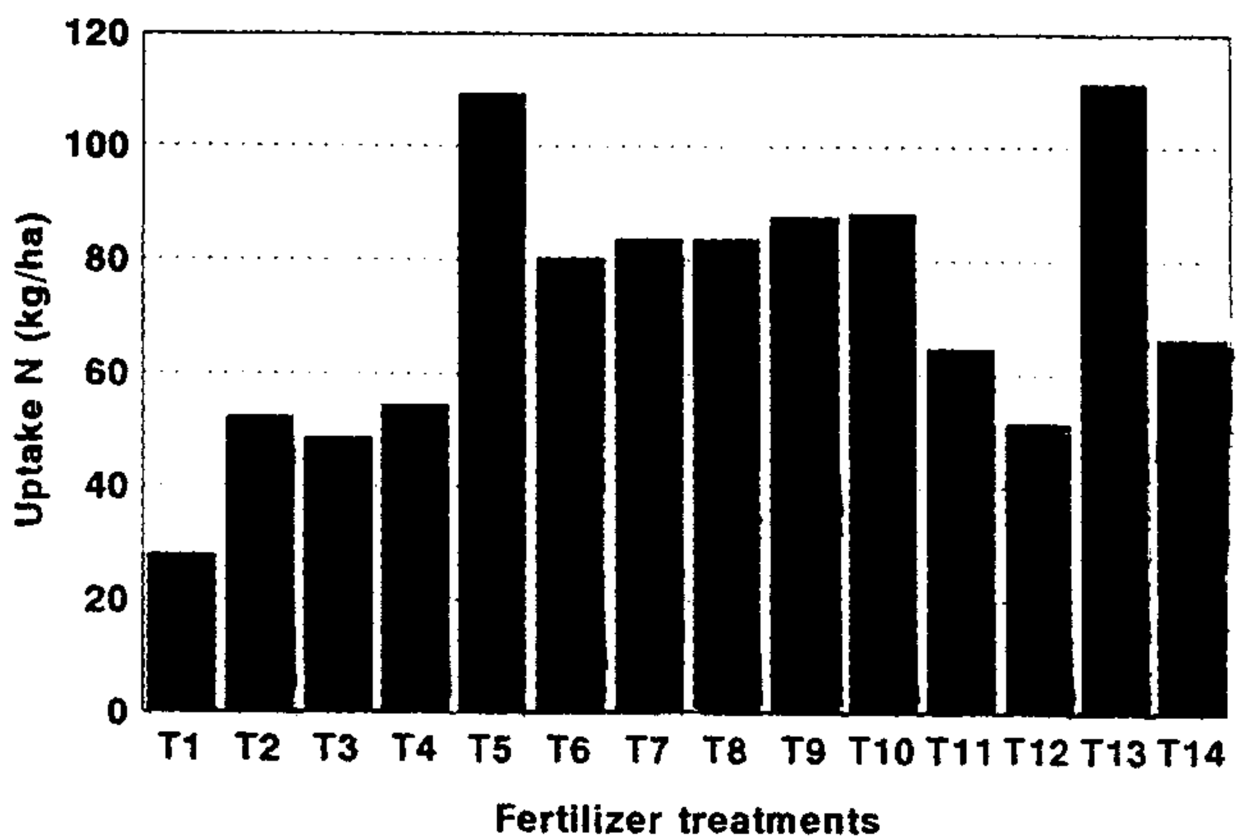


Fig.4(a). Mean uptake P obtained in different fertilizer treatments at Jagtial during Kharif 1996

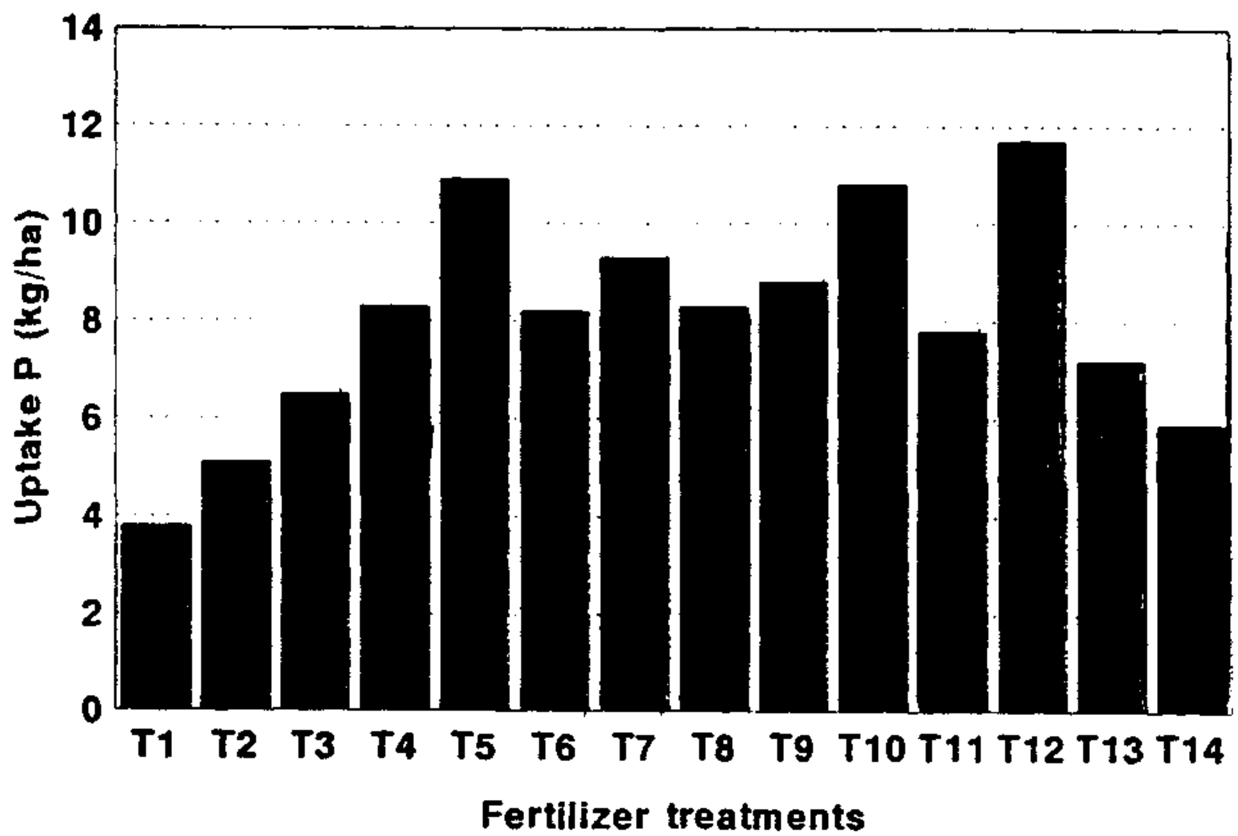
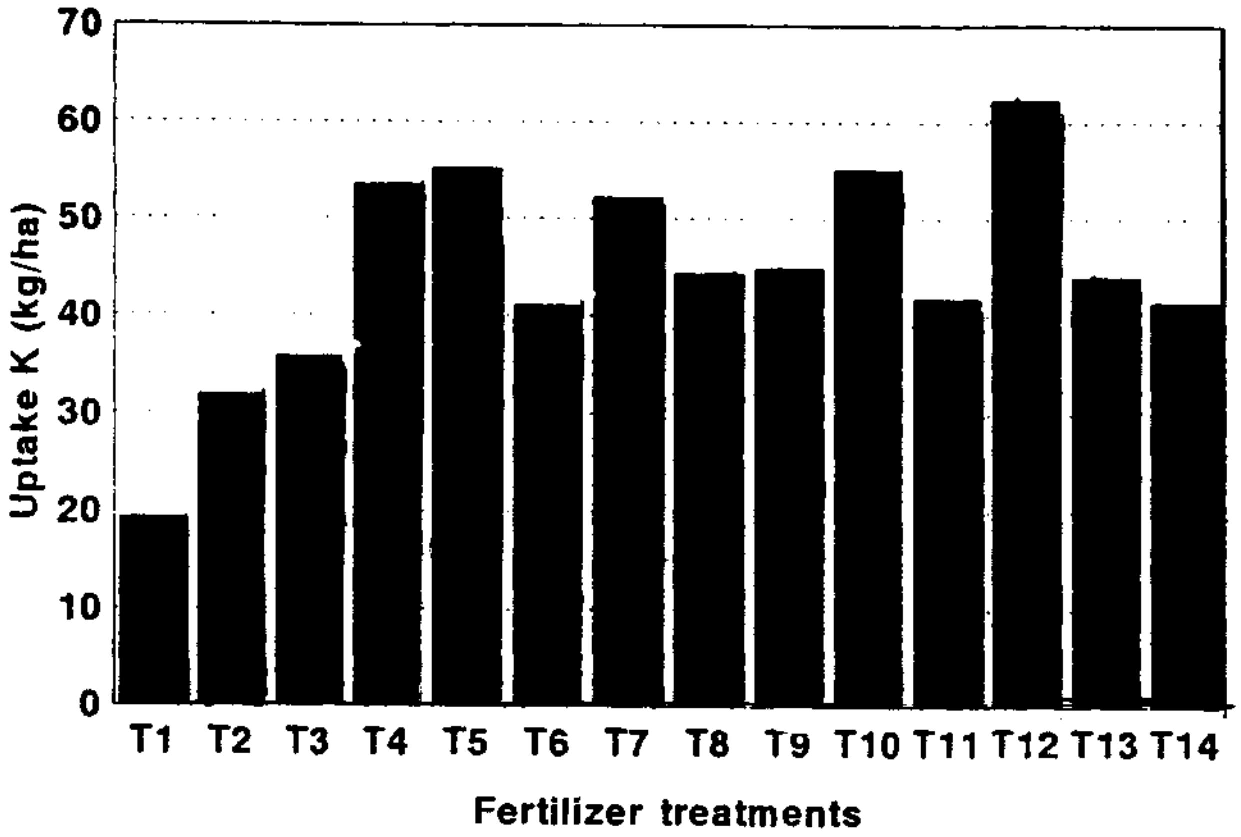


Fig.5(a). Mean uptake K obtained in different fertilizer treatments at Jagtial during Kharif 1996



4.2.1.1.2. GRAIN AND STRAW COMPOSITION :

The data of grain and straw composition are given Table 16. This table reveals that the N content in grain in T9 treatment (120-60-0) was maximum, i.e., 2.82 %, followed by T7 (120-30-50) with 2.74 %. P and K contents among different treatments were not significant. In straw K, T13 treatment (Farmer's practice) recorded high i.e., 1.16 % and minimum was in T6 treatment. N and P contents in drymatter ranged from 0.41 to 1.21, and 0.1 to 0.14 respectively.

4.2.1.1.3. SOIL NUTRIENT CONCENTRATION, PLANT UPTAKE AND YIELD

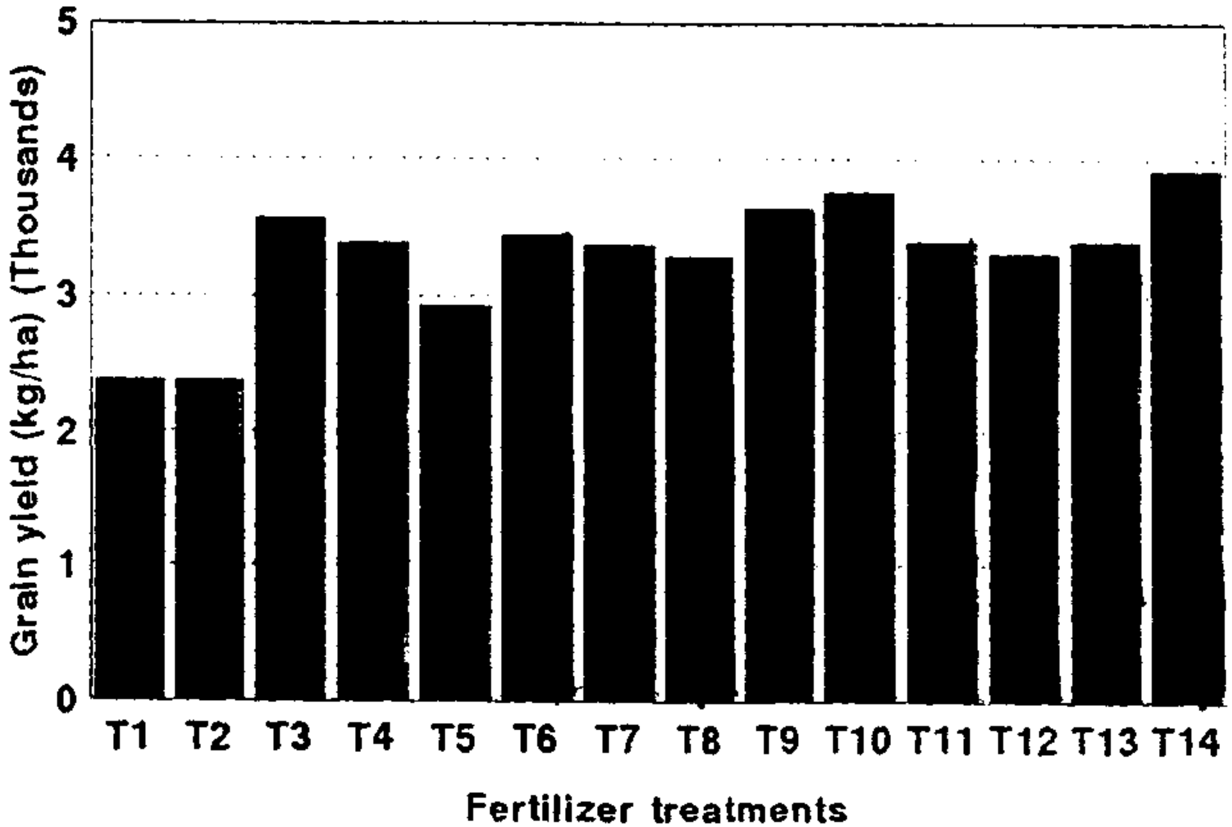
The distribution of grain and straw yield, soil test values, plant uptake values, and applied fertilizer doses of N, P and K nutrients have been computed and are given in Table 18. The grain yield (GY) ranged between 2339 to 3691 with a mean (S.D.) of 2260 (660.7) kg/ha. The plant uptake of N ranged between 24.1 and 126.9, P between 3.7 and 13.3, and K between 16.6 and 65.1 with a mean (S.D.) of 70.9 (26.2), 8.0 (2.5) and 44.5 (12.3) kg/ha respectively. The mean plant uptake of N, P and K obtained at different fertilizer treatments in the experiment are given in Fig.3(a), 4(a) and 5(a) respectively.

Table 19. Soil test values of N, P and K nutrients at panicle initiation stage at Jagtial during kharif 1996

SN	Treatments			OC	KM	CA	OL	AM
1	0	0	0	0.06	96.5	77.2	15.3	281.0
2	0	60	50	0.19	97.7	75.5	29.6	316.3
3	60	60	50	0.25	168.9	128.7	14.6	281.0
4	120	60	50	0.14	99.8	79.8	12.0	297.6
5	180	60	50	0.21	96.4	75.8	10.3	276.6
6	120	0	50	0.27	188.7	150.7	12.6	297.3
7	120	30	50	0.08	80.1	64.1	17.3	291.3
8	120	90	50	0.25	77.3	61.7	36.6	292.3
9	120	60	0	0.11	91.9	74.5	18.3	231.3
10	120	60	25	0.39	88.8	71.1	26.3	229.6
11	120	60	75	0.42	100.9	80.5	16.6	340.0
12	180	90	75	0.22	177.0	132.2	23.6	314.3
13	80	60	0	0.14	79.0	63.1	11.0	260.3
14	120	60	30	0.29	87.8	70.2	15.0	283.3
	Mean			0.21	109.4	86.1	18.5	285.2
	SEm			0.04	19.7	14.3	1.4	4.6
	CD (5%)			0.10	57.3	41.4	4.1	13.5
	CV (%)			28.1	31.2	28.7	13.3	2.8
	F-test			**	**	**	**	**

OC : Organic carbon (%)
KM : Alkaline permanganate N (kg/ha)
CA : Calcium hydroxide N (kg/ha)
OL : Olsen's P (kg/ha)
AM : Ammonium acetate K (kg/ha)

Fig.2(b). Mean grain yield of different fertilizer treatments at Warangal during Kharif 1996



The soil N ($KMnO_4$) varied between 94.1 to 435.9 with a mean (S.D.) of 157.8 (75.2) kg/ha, while organic carbon content was found to range from 0.06 to 0.73 percent with a mean (S.D.) of 0.29 percent (0.16). The estimate of soil N based on $Ca(OH)_2$ method was found to range between 75.3 and 348.7 with a mean and S.D. of 126.3 and 60.2 kg/ha. The soil P and K nutrients were also found to have a wide range of variation and the data of yield, soil, plant and fertiliser nutrients were subjected to correlation and regression analysis. The soil test values of N, P and K at panicle initiation stage are indicated in Table 19.

4.2.1.2. WARANGAL CENTRE

4.2.1.2.1. DRYMATTER PRODUCTION AND GRAIN YIELDS :

In the experiment with variety 'Erramallelu' as test crop, it was observed that the treatment T14 (120-60-30) recorded highest grain yield (3915 kg/ha) and T6 (120-60-50) recorded highest drymatter production (5340 kg/ha). The data of mean grain and drymatter of different treatments are given in Table 17. The replicated data of grain and straw yields along with other parameters are given in Appendix 7. The grain yield obtained in different fertilizer treatments is given in Fig.2(b).

Table 17. Effect of fertilizer treatments on grain yield, drymatter production and co N,P and K in rice at Warangal during kharif 1996

S.No.	Treatment	GY	SY	GR-N	GR-P	GR-K	ST-N	ST-P	ST-K
1	0-0-0	2380	3186	0.81	0.09	0.18	0.46	0.06	0.84
2	0-60-50	2380	3246	0.91	0.11	0.23	0.64	0.07	0.88
3	60-60-50	3564	4311	0.70	0.09	0.19	0.52	0.06	0.75
4	120-60-50	3385	4749	1.05	0.09	0.18	0.58	0.07	0.82
5	180-60-50	2917	4769	1.05	0.10	0.19	0.56	0.09	0.77
6	120-0-50	3445	5340	1.49	0.11	0.21	0.59	0.08	0.85
7	120-30-50	3375	4701	1.40	0.09	0.17	0.47	0.06	0.75
8	120-90-50	3285	4211	1.13	0.09	0.20	0.35	0.07	0.74
9	120-60-0	3644	4968	1.39	0.12	0.19	0.48	0.10	0.84
10	120-60-25	3763	4968	1.33	0.12	0.20	0.45	0.09	0.80
11	120-60-75	3395	4430	1.44	0.13	0.19	0.57	0.09	0.93
12	180-90-75	3315	5088	0.82	0.10	0.21	0.59	0.09	0.94
13	80-60-0	3395	4480	1.28	0.09	0.20	0.50	0.07	0.74
14	120-60-30	3915	5317	2.33	0.13	0.18	0.57	0.08	0.69
Mean		3297	4090.0	1.23	3.44	0.19	0.52	0.08	0.81
SEm		177	305.0	0.26	0.29	0.01	0.06	0.01	0.01
CD (5%)		537	885.0	0.76	0.85	0.02	-	0.02	0.03
C.V. (%)		9.3	12.9	37.1	14.7	5.3	20.5	11.5	2.1
F-test		**	**	*	*	**	NS	**	**

GY : Grain yield (kg/ha)
SY : Straw yield (kg/ha)
GR-N, GR-P and GR-K : N (%), P (%), K (%) in grain
ST-N, ST-P and ST-K : N (%), P(%), K(%) in Straw
* and ** : Significant at 5 % and 1 % level of significance respectively
NS : Not significant

Fig.3(b). Mean Uptake N obtained different fertilizer treatments at Warangal during Kharif 1996

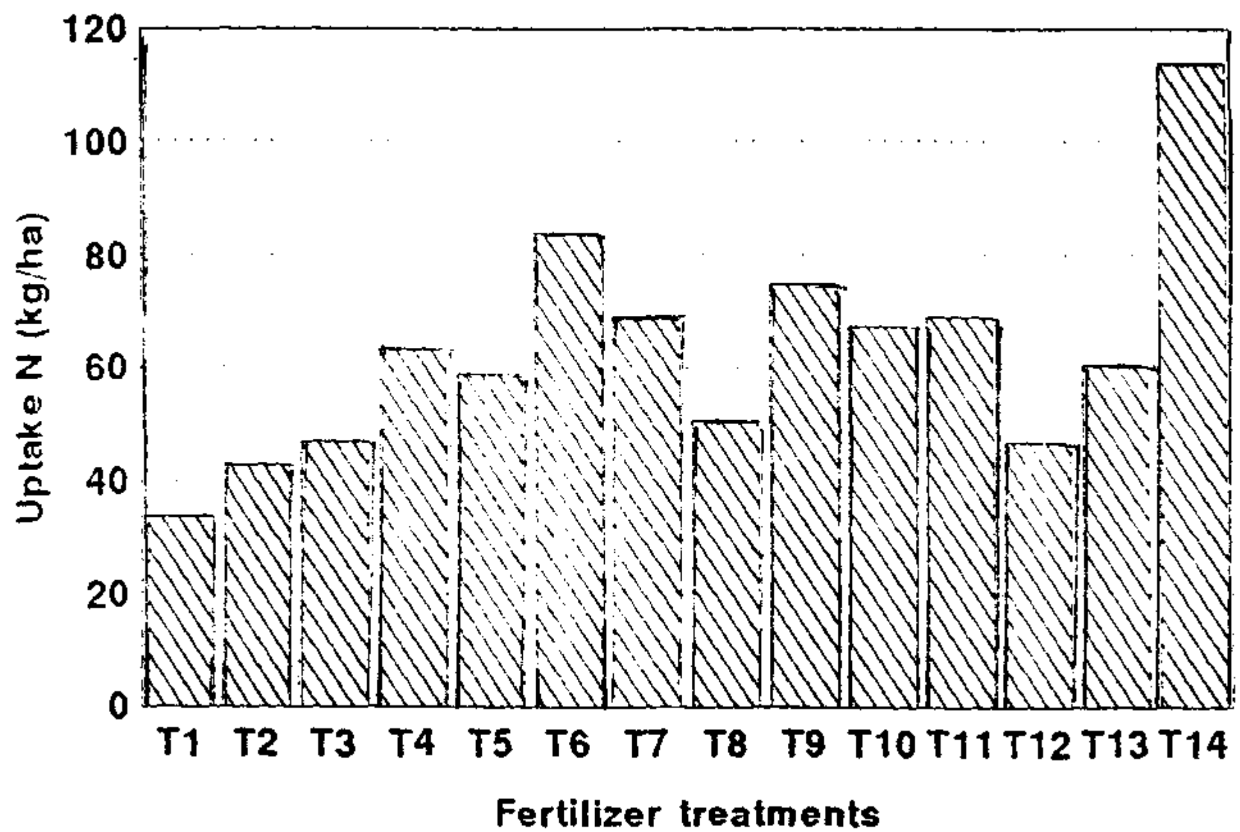


Fig.4(b). Mean Uptake P obtained in different fertilizer treatments at Warangal during Kharif 1996

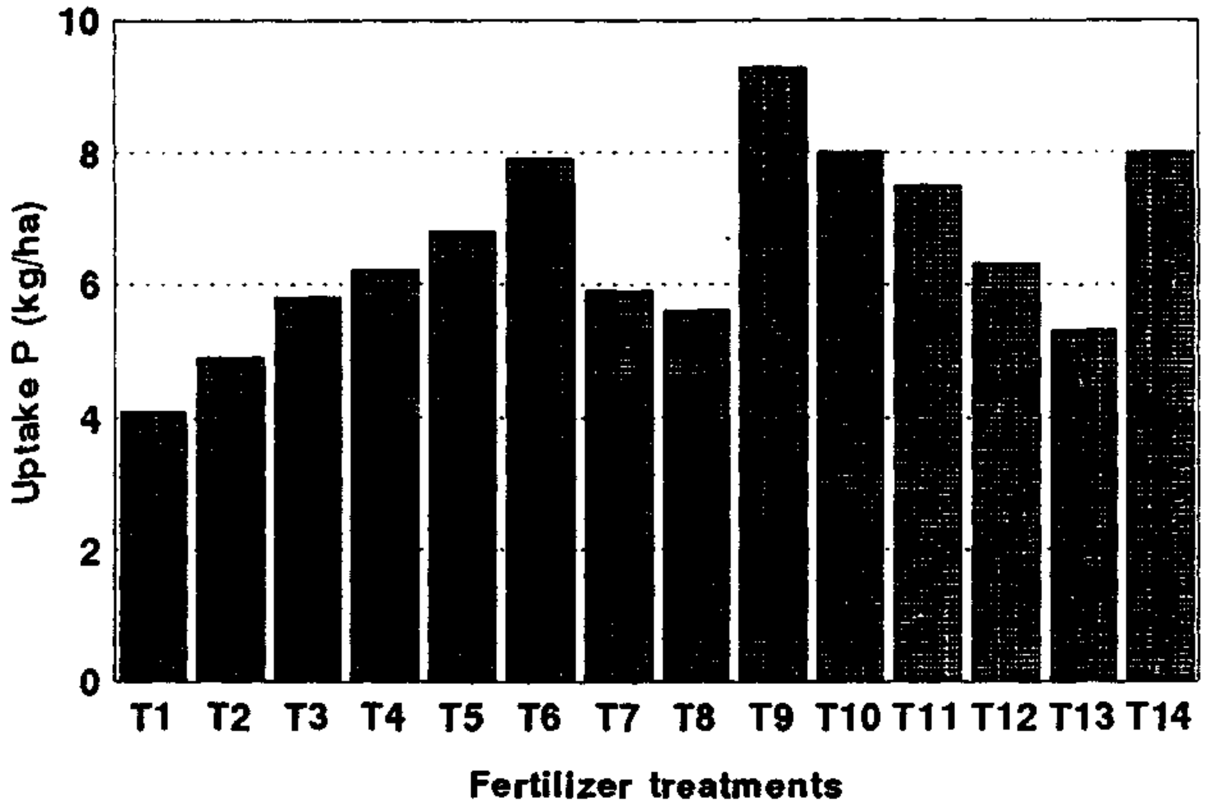
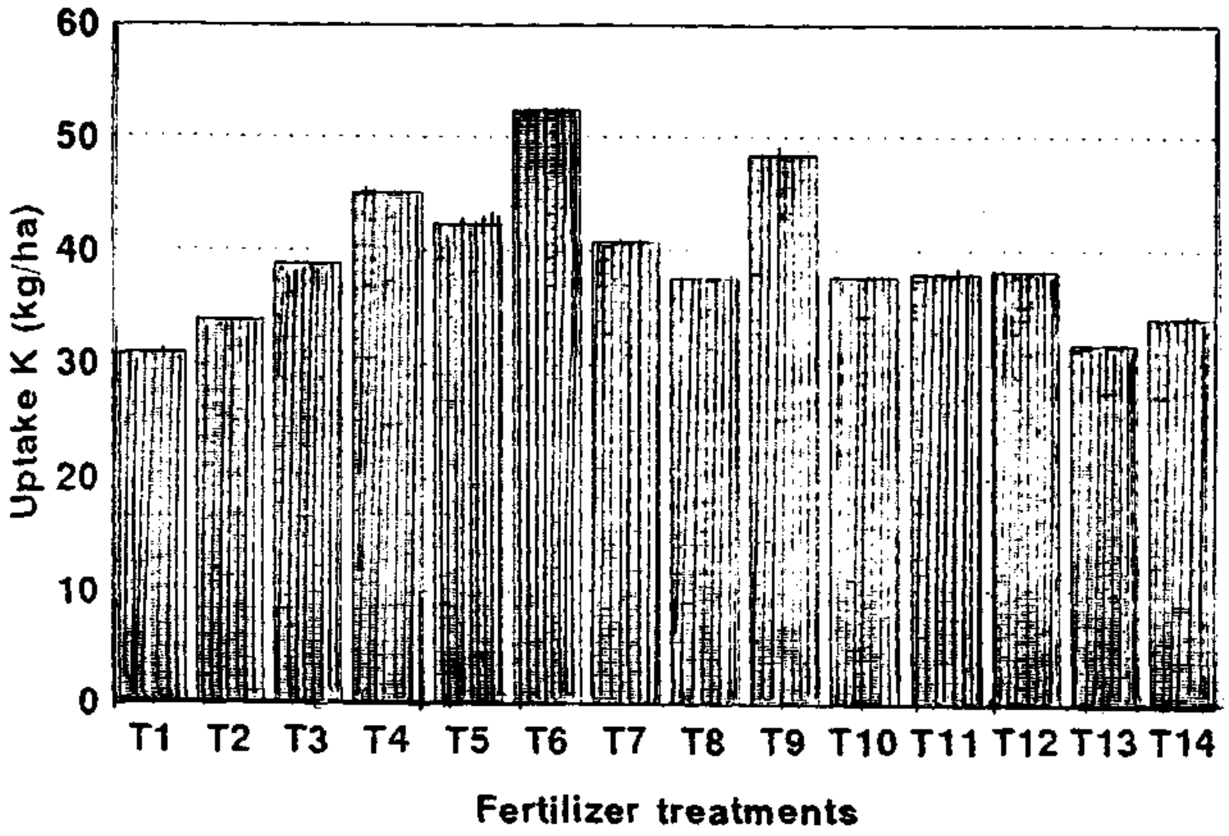


Fig.5(b). Mean Uptake K obtained in different fertilizer treatments at Warangal during Kharif 1996



4.2.1.2.2. GRAIN AND STRAW COMPOSITION :

From the experiment it was observed that the grain N was found to be high in T14 treatment (GRD) i.e., 2.33 %, followed by T6 (120-0-50) with 1.49 %. P and K contents in grain ranged from 0.09 to 0.13, and 0.18 to 0.23 % respectively. In the case of straw N, P and K, the ranges were 0.35 to 0.64, 0.06 to 0.1, and 0.69 to 0.88 respectively. The mean data of these variables are given in Table 17.

4.2.1.2.3. SOIL NUTRIENT CONCENTRATION, PLANT UPTAKE AND YIELD

The descriptive statistics of grain yield, soil test values, plant uptake values, and applied fertilizer doses of N, P and K nutrients have been calculated and are given in Table 18. The grain yield (GY) ranged between 2210 to 4719 with a mean (S.D.) of 3297 (525.5) kg/ha. The uptake N was found to range between 26.9 and 145.8, P between 3.8 and 10.0, and K between 28.3 and 60.3 with a mean (S.D.) of 63.0 (25.6), 6.5 (1.5) and 39.3 (7.3) kg/ha respectively. The mean plant uptake of N, P and K obtained at different fertilizer treatments are given in Fig.3(b), 4(b) and 5(b).

The soil N ($KMnO_4$) was found to be varying between 141.6 to 351.2 with a mean (S.D.) of 201.7 (40.9) kg/ha,

Table 20. Soil test values of N, P and K nutrients at panicle initiation stage at Warangal during kharif 1996

SN	Treatments			OC	KM	CA	OL	AM
1	0	0	0	0.19	116.6	93.8	34.9	465.1
2	0	60	50	0.57	100.4	89.8	35.4	473.0
3	60	60	50	0.51	132.6	105.5	21.8	547.6
4	120	60	50	0.52	146.0	116.6	28.4	532.3
5	180	60	50	0.40	142.4	114.5	33.4	499.9
6	120	0	50	0.51	170.6	136.5	29.0	511.4
7	120	30	50	0.58	111.6	90.7	24.6	542.5
8	120	90	50	0.35	177.2	139.1	28.0	544.0
9	120	60	0	0.53	145.5	118.7	25.5	540.8
10	120	60	25	0.54	133.2	108.0	22.1	543.2
11	120	60	75	0.63	138.1	110.8	24.0	525.5
12	180	90	75	0.57	178.0	146.9	35.3	521.6
13	80	60	0	0.61	117.3	107.2	20.2	504.2
14	120	60	30	0.21	118.5	94.3	27.7	482.7
	Mean			0.48	137.7	112.4	27.9	516.7
	SEm			0.07	8.3	7.0	1.0	10.1
	CD (5%)			0.20	24.2	20.2	3.0	29.3
	CV (%)			24.5	10.5	10.7	6.4	3.4
	F-test			**	**	**	**	**

OC : Organic carbon (%)
KM : Alkaline permanganate N (kg/ha)
CA : Calcium hydroxide N (kg/ha)
OL : Olsen's P (kg/ha)
AM : Ammonium acetate K (kg/ha)

Table 21.Effect of different fertilizer treatments on grain yield, plant uptake and soil nutients of rice at Jagtial during kharif 1996(post-harvest)

SN	TREATMENT	GY	UN	UP	UK	OC (%)	KMNO4-N	CA(OH)2	OLSEN-P	AMAC-K	TOTAL-N
1	0-0-0	1152	27.9	3.8	19.3	0.09	137.9	110.4	20.7	171.5	941.3
2	0-60-50	1624	52.3	5.1	31.9	0.26	135.9	108.7	48.0	192.8	975.3
3	60-60-50	2012	48.7	6.5	35.8	0.34	246.2	197.6	18.0	172.4	1221.3
4	120-60-50	2051	54.5	8.3	53.5	0.19	142.7	114.2	17.0	180.4	931.3
5	180-60-50	2952	109.3	10.9	55.2	0.29	137.9	110.4	14.7	168.5	915.7
6	120-0-50	2077	80.4	8.2	41.1	0.37	286.9	229.6	17.7	180.2	1198.0
7	120-30-50	2378	83.8	9.3	52.2	0.11	114.5	91.6	27.0	177.2	790.0
8	120-90-50	2701	83.8	8.3	44.4	0.34	111.3	89.1	41.0	138.1	766.3
9	120-60-0	2493	87.6	8.8	44.9	0.14	133.3	106.6	19.7	141.7	882.0
10	120-60-25	2434	88.2	10.8	55.1	0.53	127.1	101.6	26.7	206.1	832.7
11	120-60-75	1997	64.6	7.8	41.8	0.56	144.3	115.4	17.7	190.3	1053.0
12	180-90-75	2928	51.5	11.7	62.3	0.30	252.9	202.3	24.7	193.4	1525.7
13	80-60-0	2681	111.3	7.2	44.0	0.20	112.9	90.3	13.0	157.9	716.3
14	120-60-30	1759	66.4	5.9	41.4	0.38	125.4	100.4	16.0	171.8	871.0
	Mean	2260	70.9	8.0	44.5	0.29	157.8	126.3	22.9	174.4	972.9
	Sem	303.2	8.2	0.8	4.1	0.05	30.0	23.9	1.1	2.9	88.5
	CD (5%)	880.9	23.7	2.3	11.9	0.14	87.2	69.6	3.2	8.4	257.2
	C.V. (%)	23.2	19.9	16.8	15.9	29.0	32.9	32.9	8.3	2.9	15.8
	F-test	**	**	**	**	**	**	**	**	**	**

OC (%) : Organic carbon (%)
KMNO4-N : Alkaline permanganate N (kg/ha)
CA(OH)2 : Calcium hydroxide N (kg/ha)
OLSEN-P : Olsen's P (kg/ha)
AMAC-K : Ammonium acetate K (kg/ha)
GY : Grain yield (kg/ha)
UN, UP and UK : Plant uptake N, P and K nutrients (kg/ha)
TOTAL N : Total N available in the soil (kg/ha)

Organic carbon (%) was found to vary from 0.12 to 1.05 with a mean (S.D.) of 0.64 (0.23). The estimate of available soil N based on $Ca(OH)_2$ method ranged from 115.3 to 281.0 with a mean and S.D. of 161.6 and 32.7 kg/ha. Wide variation in soil test values was found to exist in the soil P and K nutrients concentration. The soil test values of N, P and K at panicle initiation stage are given in Table 20.

4.2.2. ANALYSIS OF VARIANCE OF YIELD AND OTHER VARIABLES

4.2.2.1. JAGTIAL CENTRE

The analysis of variance (ANOVA) of data of grain yield, plant and soil nutrients have been carried out to examine the significances of fertilizer application through different levels of basal doses. The statistical scrutiny indicated that the variation due to the application of fertilizers through the 14 fertilizer treatments experimented were found to be significantly different. An attempt has been made to identify the fertilizer treatments which are on par with each other based on the Duncan's Multiple Range Test (DMRT) at 5% level of significance. The means, standard errors, critical difference of treatments, coefficient of variation along with F-test of differences between treatments for their effects on yield, plant uptake, soil test values at post-harvest stage are given in Table 21.

Table 22. Effect of fertilizer treatments on grain yield, plant uptake and soil nutrients of rice at Warangal during kharif 1996 (Post-harvest stage)

S.No.	Treatment	GY	UN	UP	UK	OC (%)	KM	CA	OL	AM	Total N
1	0-0-0	2380	33.9	4.1	31.0	0.25	167.5	134.0	35.8	516.8	1087.0
2	0-60-50	2380	42.7	4.9	33.9	0.76	160.5	128.4	36.9	525.6	1043.3
3	60-60-50	3564	46.8	5.8	38.8	0.67	189.5	151.6	27.1	608.6	1232.7
4	120-60-50	3385	63.2	6.2	45.1	0.69	208.7	166.9	35.4	600.1	1358.3
5	180-60-50	2917	58.7	6.8	42.3	0.54	203.4	164.0	20.8	562.0	1322.7
6	120-0-50	3445	83.8	7.9	52.4	0.67	243.7	195.0	31.9	575.8	1575.0
7	120-30-50	3375	69.1	5.9	40.8	0.77	161.1	129.5	24.9	604.7	1047.3
8	120-90-50	3285	50.7	5.6	37.6	0.48	267.1	213.9	31.9	604.5	1776.0
9	120-60-0	3644	74.7	9.3	48.5	0.70	209.5	167.6	25.8	600.9	1360.7
10	120-60-25	3763	67.2	8.0	37.7	0.72	190.0	153.3	24.3	606.9	1235.3
11	120-60-75	3395	69.1	7.5	38.0	0.84	197.8	158.2	35.8	584.9	1241.0
12	180-90-75	3315	46.9	6.3	38.1	0.76	267.7	214.1	34.5	579.6	1739.0
13	80-60-0	3395	60.4	5.3	31.7	0.82	188.0	150.4	24.3	585.8	1222.7
14	120-60-30	3915	113.9	8.0	34.1	0.28	168.4	134.7	35.8	538.2	1094.7
Mean		3297	62.9	6.5	39.3	0.64	201.7	161.6	30.4	578.1	1309.7
SEm		177	11.1	0.5	2.7	0.09	14.9	11.9	1.9	9.5	73.5
CD (5%)		513	32.2	1.3	7.9	0.26	43.5	34.6	5.4	27.7	213.6
C.V. (%)		9.3	30.5	12.3	12.0	24.3	12.9	12.7	4.6	2.9	9.7
F-test		**	**	**	**	**	**	**	**	**	**

GY : Grain yield (kg/ha)
UN, UP, UK are plant uptake N, P and K nutrients (kg/ha)
OC (%) : Organic carbon (%)
KM : Alkaline permanganate N (kg/ha)
CA : Calcium hydroxide N (kg/ha)
OL : Olsen's P (kg/ha)
AM : Ammonium acetate K (kg/ha)
** : Significant at 1 % level of significance

4.2.2.3. **WARANGAL CENTRE**

Similar to the Jagtial data, an analysis of variance (ANOVA) of data of grain yield, plant and soil nutrients have been carried out to examine the significances of fertilizer application through different levels of basal doses. The statistical scrutiny of different variables has indicated that the variation due to the application of fertilizers through the 14 fertilizer treatments experimented were found to be significantly different. A comparison of fertilizer treatments has been made to identify the fertilizer treatments which are on par with each other based on the Duncan's Multiple Range Test (DMRT) at 5% level of significance. The means, standard errors, critical difference of treatments, coefficient of variation along with F-test of differences between treatments for their effects on yield, plant uptake, soil test values at post-harvest stage are given in Table 22.

4.2.3. **CORRELATION ANALYSIS**

4.2.3.1. **JAGTIAL CENTRE :**

Estimates of correlation have been worked out between soil, plant, applied fertilizer nutrients and grain and straw yield from the experimental data. It was found that significant correlations were existing between grain yield

Fig.6(a). Soil test values of organic carbon at panicle initiation (PI) and post-harvest (PH) stages at Jagtial site

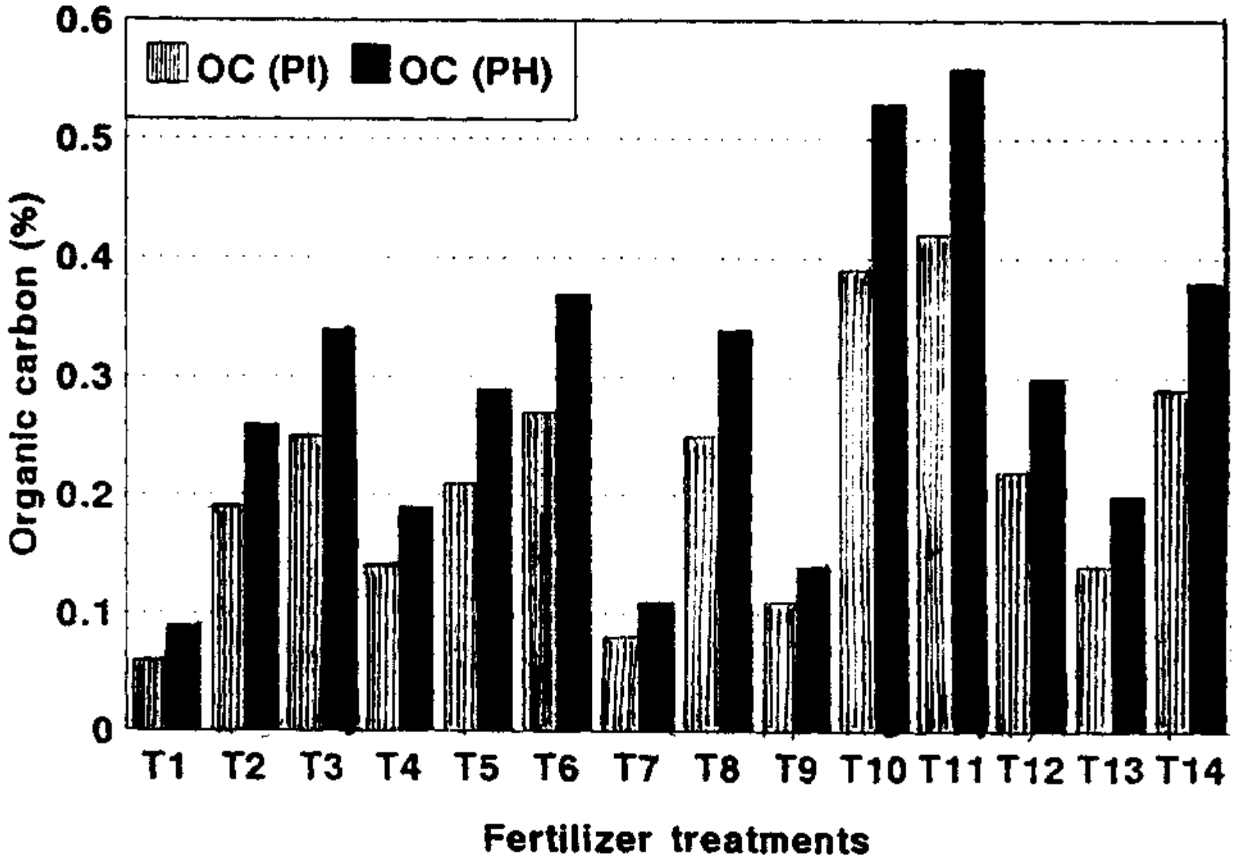


Fig.7(a). Soil test values of N at panicle initiation (PI) and post-harvest stages (PH) at Jagtial site

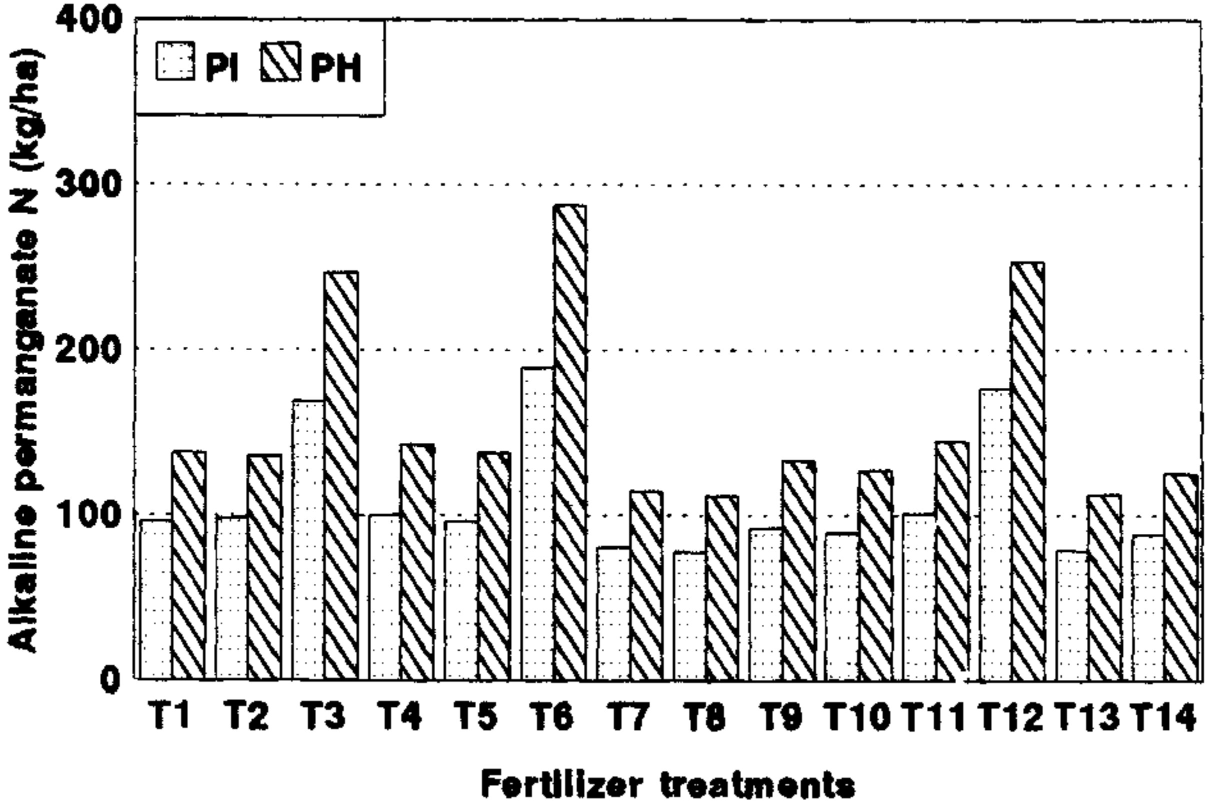


Fig.8(a). Soil test values of N at panicle initiation (PI) and post-harvest stages (PH) at Jagtial site

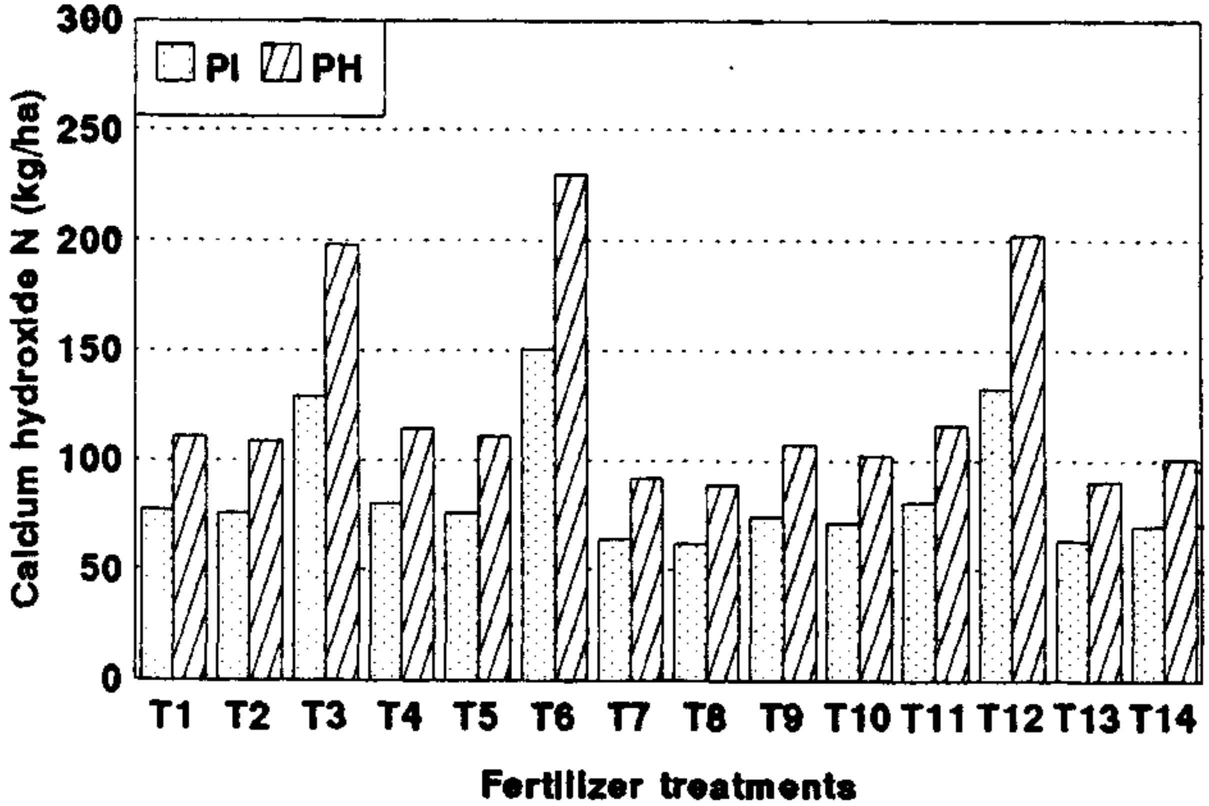


Fig.9(a). Soil test values of P at panicle initiation (PI) and post-harvest stages (PH) at Jagtial site

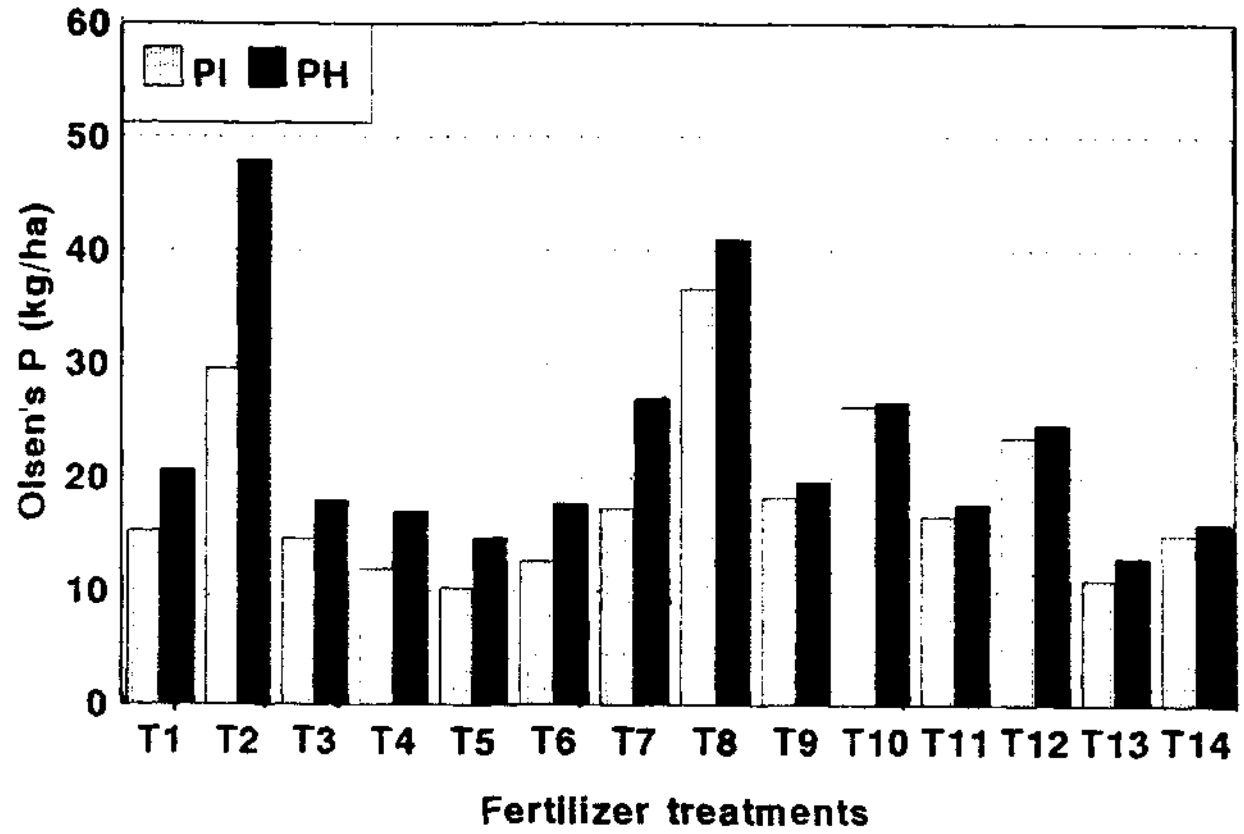
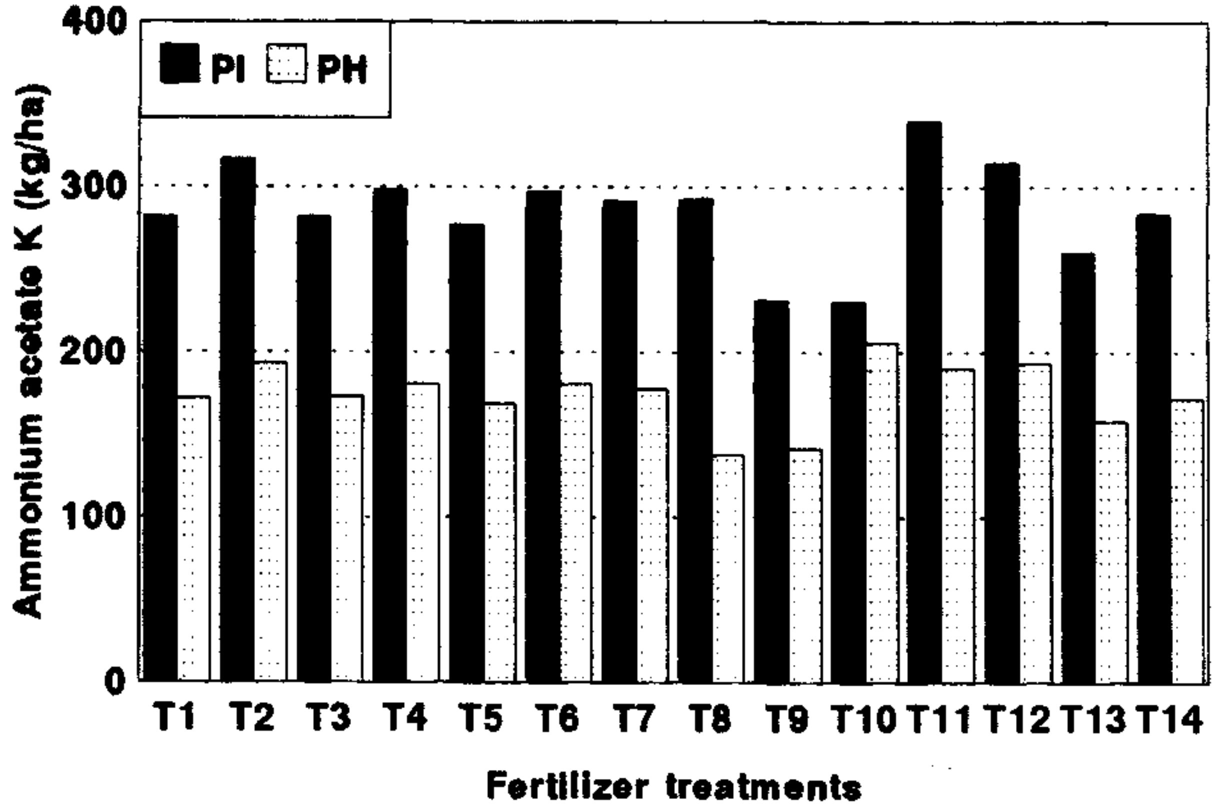


Fig.10(a). Soil test values of K at panicle initiation (PI) and post-harvest stages (PH) at Jagtial site



and fertilizer N (0.609 **) and P (0.455 **), plant uptake of N (0.835 **), P (0.704 **) and K (0.772 **), and straw yield (0.667 **). Significant correlations were also found to exist between uptake of N and fertilizer N (0.722 **), uptake of P and fertilizer P (0.364 *), uptake of K and fertilizer K (0.35 *), and fertilizer N and $KMnO_4$ - N (-0.421 *). No significant relations between grain yield and soil test values were found to exist at Jagtial centre except $KMnO_4$ N (0.549 **). The estimates of correlation between different variables alongwith significances are given in Table 23.

The mean organic carbon (%) as observed at panicle initiation and post-harvest stages in each treatment are given in Fig.6(a). Similarly, the amounts of soil N based on $KMnO_4$ and $Ca(OH)_2$ methods as observed at panicle initiation and post-harvest stages are given in Fig.7(a) and 8(a). The mean soil test values of P and K as observed under different treatments at panicle initiation and post-harvest stages are given in Fig.9(a) and 10(a).

4.2.3.2. **WARANGAL CENTRE :**

Estimates of correlation have also been worked out between the different soil, plant, applied fertilizer nutrients and grain and straw yields from the experimental data of Warangal centre. It was found that significant

Table 23. Estimates of correlation between yield, plant uptake, soil and fertilizer nutrients at Jagtial and Warangal

Variables	Jagtial	Warangal
GY , Organic carbon (%)	0.216	0.326 *
GY , Soil N ($KMno_4$)	0.549 **	0.492 **
GY , Soil N ($Ca(OH)_2$)	0.249	0.255
GY , Soil P (Olsen)	- 0.074	- 0.169
GY , Soil K (Amm.Acetate)	- 0.200	0.488 **
GY , Fertilizer N	0.609 **	0.473 **
GY , Fertilizer P	0.455 **	0.235
GY , Fertilizer K	0.173	0.014
GY , Uptake N	0.835 **	0.603 **
GY , Uptake P	0.704 **	0.663 **
GY , Uptake K	0.772 **	0.415 **
GY , Panicle length	0.180	0.171
GY , Plant height	0.238	0.730 **
GY , Straw yield	0.667 **	0.424 **
UN , Organic carbon (%)	0.294	0.215
UN , Soil N ($KMnO_4$)	0.359 *	0.308
UN , Soil ($Ca(OH)_2$)	0.161	0.201
UN , Fertilizer N	0.722 **	0.314 *
UP , Soil P (Olsen)	0.219	0.268
UP , FP	0.364 *	0.294
UK , Soil K (Amm.Acetate)	0.153	0.320 *
UK , Fertilizer K	0.350 *	0.169
FN , Organic carbon (%)	-0.311	-0.324 *
FN , Soil N ($KMnO_4$)	-0.421 *	-0.394 *
FN , Soil N ($Ca(OH)_2$)	-0.256	-0.235
FP , Soil P (Olsen)	-0.291	-0.317
FK , Soil K (Amm.Acetate)	-0.192	-0.225

GY is grain yield (kg ha^{-1})
UN is uptake nitrogen (kg ha^{-1})
UP is uptake phosphorus (kg ha^{-1})
UK is uptake potassium (kg ha^{-1})
* : significant at 5 % level of significance
** : significant at 1 % level of significance

Fig.6(b). Soil test values of organic carbon at panicle initiation and post-harvest stages at Warangal site

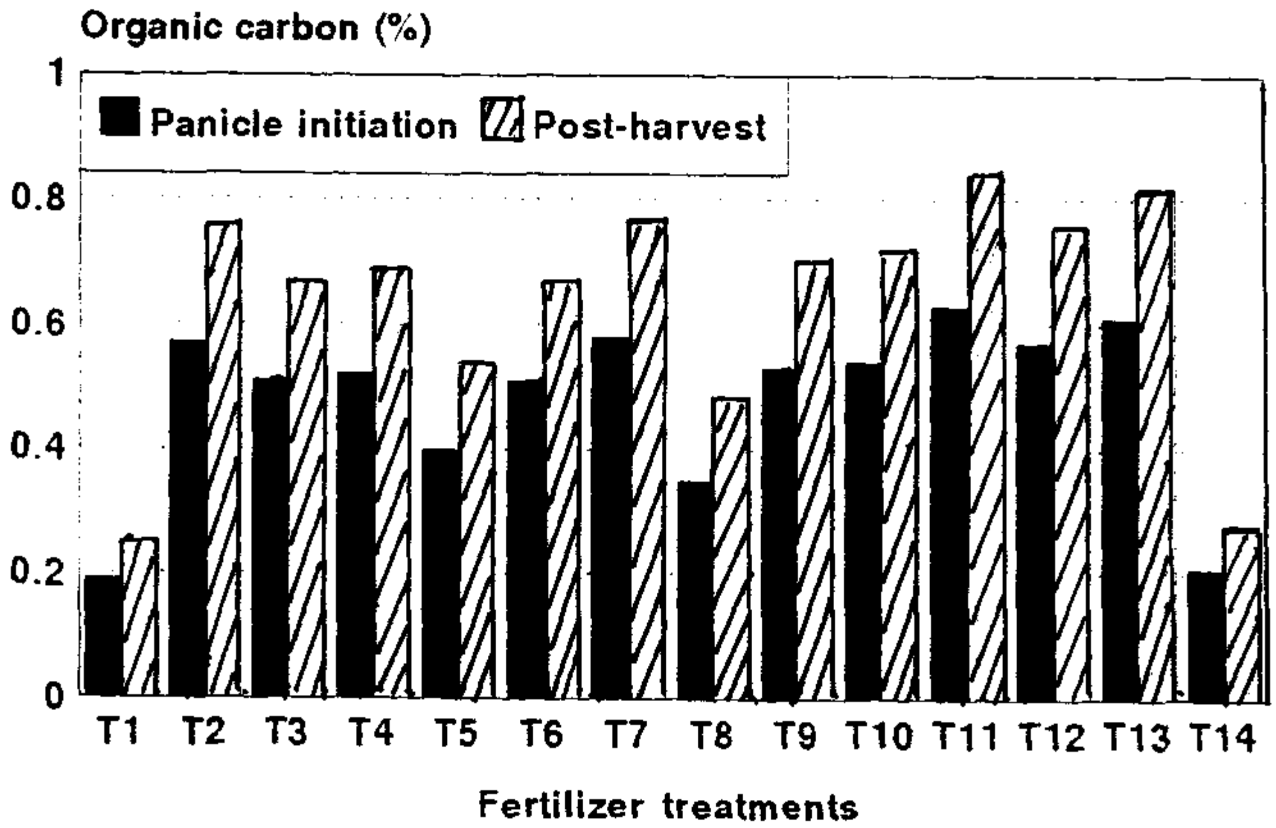


Fig.7(b). Soil test values of N at panicle initiation and post-harvest stages at Warangal site

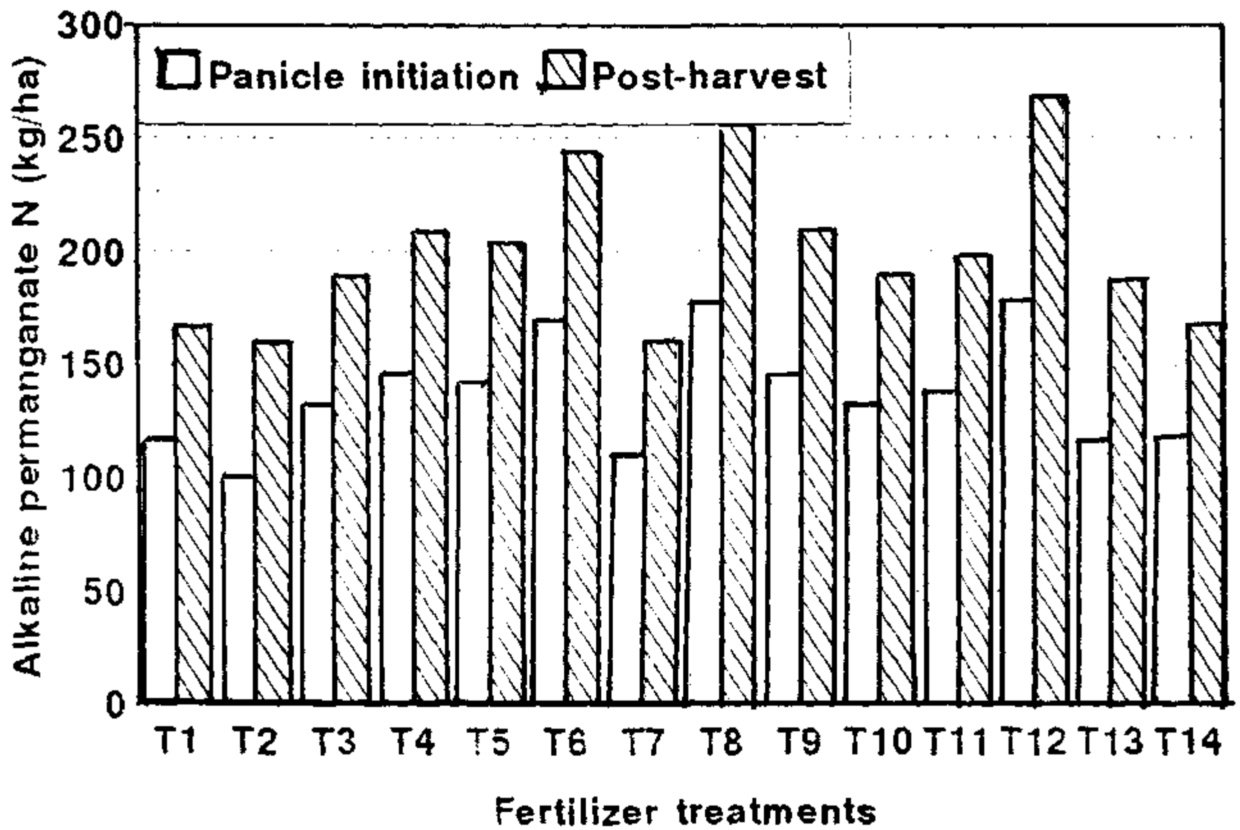


Fig.8(b). Soil test values of N at panicle initiation and post-harvest stages at Warangal site

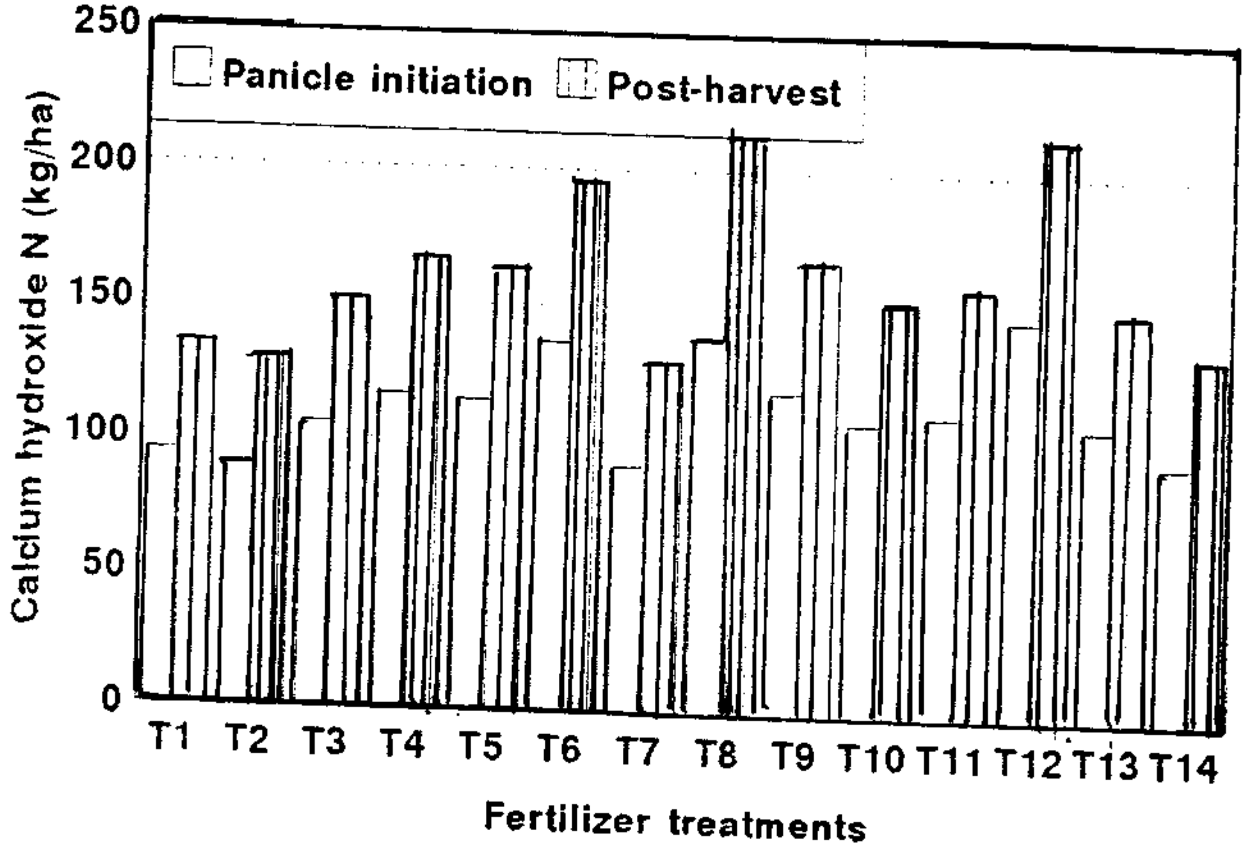


Fig.9(b). Soil test values of P at panicle initiation and post-harvest stages at Warangal site

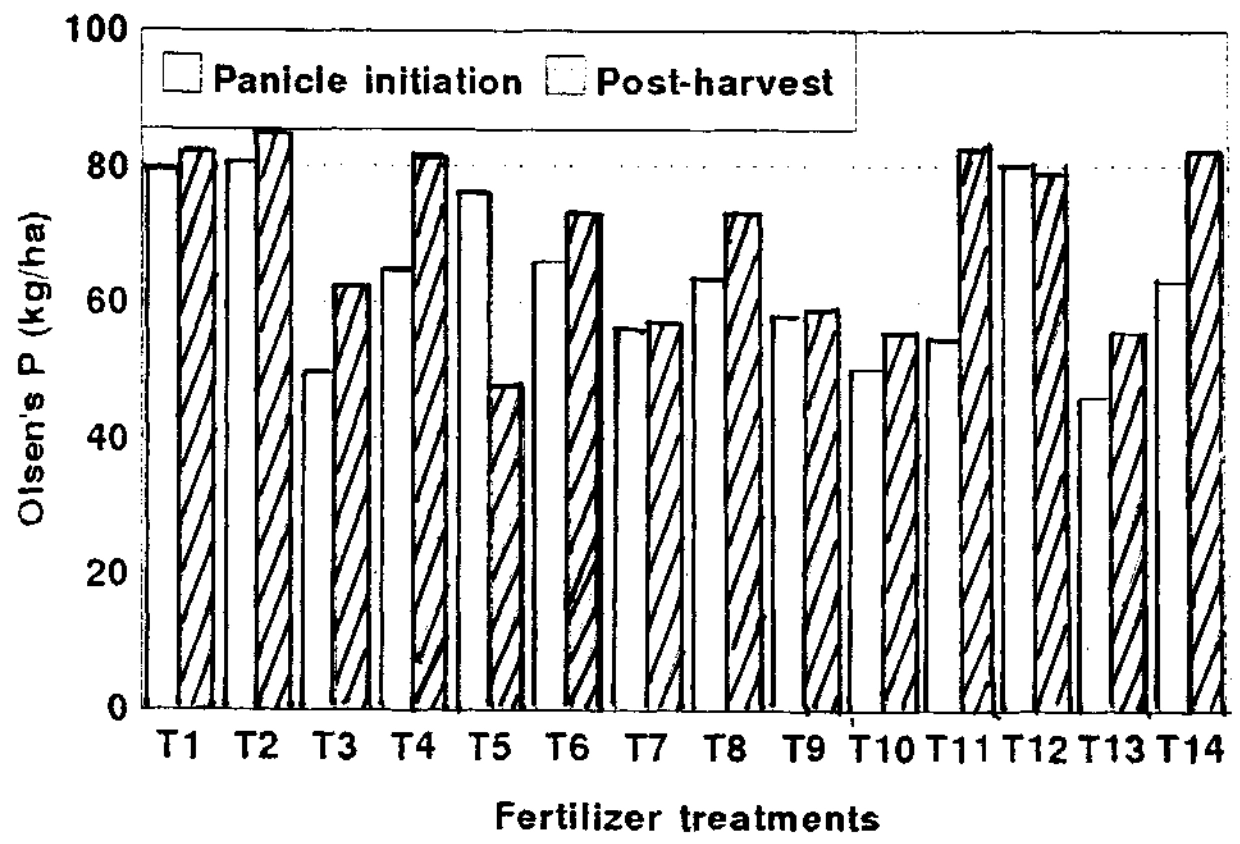
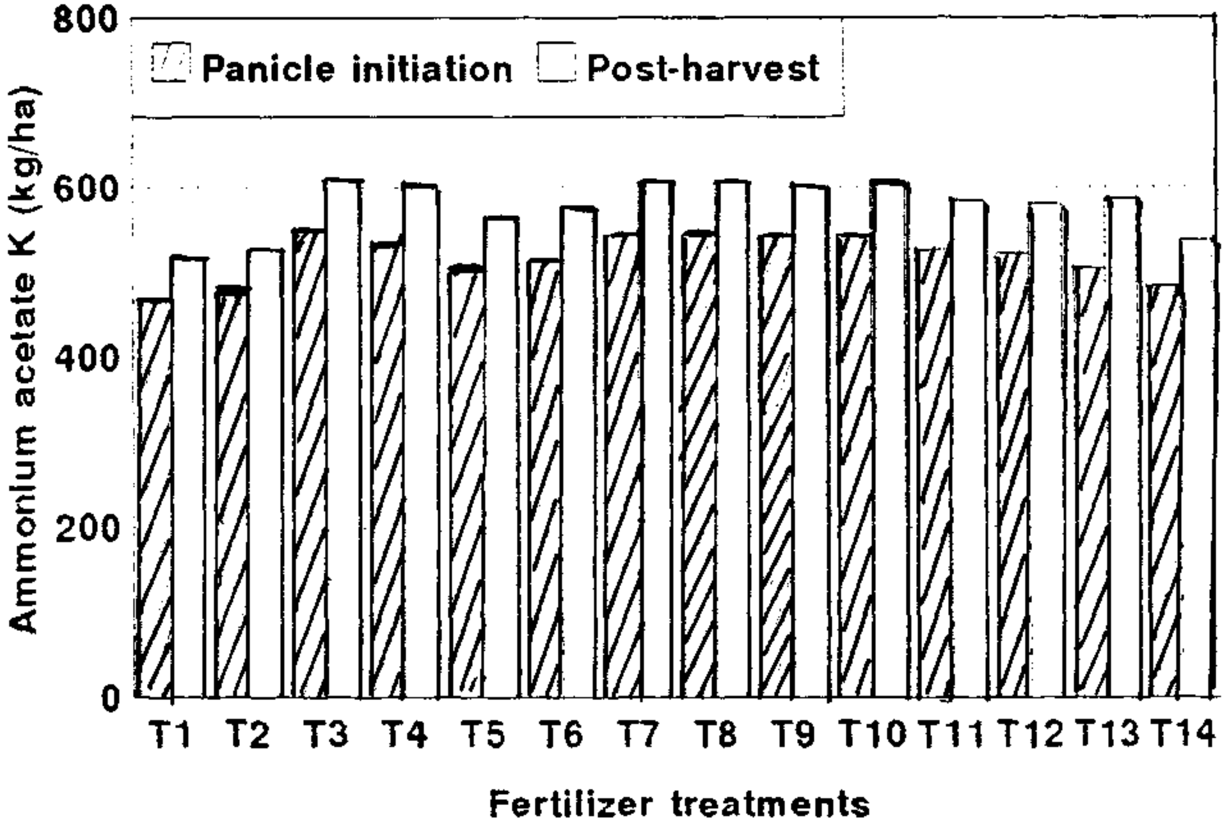


Fig.10(b). Soil test values of K at panicle initiation and post-harvest stages at Warangal site



correlations were existing between grain yield and fertilizer N (0.473 **), plant uptake of N (0.603 **), P (0.663 **) and K (0.415 **), soil K (0.488 *), straw yield (0.424 **) and plant height (0.73 **). Significant correlations were also found to exist between uptake of N and fertilizer N (0.314 *), uptake of K and soil K (0.32 *), fertilizer N and organic carbon (-0.324 *), fertilizer N and $KMnO_4$ N (-0.394 *). The estimates of correlation between different variables alongwith their significances are given in Table 23.

The mean organic carbon (%) as observed at panicle initiation and post-harvest stages in each treatment are given in Fig.6(b). Similarly, the amounts of soil N based on $KMnO_4$ and $Ca(OH)_2$ methods as observed at panicle initiation and post-harvest stages are given in Fig.7(b) and 8(b). The mean soil test values of P and K as observed under different treatments at panicle initiation and post-harvest stages are given in Fig.9(b) and 10(b).

4.2.4. RESPONSE OF RICE TO APPLICATION OF FERTILIZER NUTRIENTS

Significant responses to application of N, P and K fertilizers were observed at both Jagtial and Warangal locations. At Jagtial, Nitrogen was found to give response upto 180 kg/ha. The response ratios (kg grain/kgfertilizer)

Table 24. Response of rice crop to applied N, P and K fertilizers at Jagtial during kharif 1996

Tratments compared		Dose	Rep-1	Rep-1	Rep-2	Rep-2	Rep-3	Rep-3	Diff-1	Diff-2	Diff-3	Mean	RR
A. Nitrogen													
120-60-0	80-60-0	40	2866	2599	2807	2365	1806	3080	266	442	-1273	-188	-4.7
60-60-50	0-60-50	60	1832	1365	1988	2560	2216	949	468	-572	1267	388	6.5
120-60-50	60-60-50	60	2599	1832	2469	1988	2287	2216	767	481	72	440	7.3
180-60-50	120-60-50	60	3424	2599	2927	2469	2718	2287	825	458	431	571	9.5
120-60-50	0-60-50	120	3424	1365	2927	2560	2718	949	2060	367	1769	1399	11.7
180-60-50	60-60-50	120	3424	1832	2927	1988	2718	2216	1592	939	502	1011	8.4
B. Phosphorus													
120-60-50	120-30-50	30	3424	2469	2927	2079	2718	2586	955	848	132	645	21.5
120-90-50	120-60-50	30	3138	1365	3002	2469	1962	2216	1774	533	-253	684	22.8
120-30-50	120-0-50	30	2469	2040	2079	2417	2586	1774	429	-338	812	301	10.0
120-60-50	120-0-50	60	3424	2040	2927	2417	2718	1774	1384	510	944	946	15.8
120-90-50	120-30-50	60	3138	2469	3002	2079	1962	2586	669	923	-624	323	5.4
120-90-50	120-0-50	90	3138	2040	3002	2417	1962	1774	1098	585	188	624	6.9
C. Potassium													
120-60-30	120-60-25	5	1754	2807	1183	2339	2339	2157	-1053	-1157	182	-676	-135.2
120-60-50	120-60-30	20	3424	1754	2927	1183	2718	2339	1670	1745	379	1264	63.2
120-60-50	120-60-25	25	3424	2807	2927	2339	2718	2157	617	588	561	589	23.5
120-60-75	120-60-50	25	1910	3424	1702	2927	2378	2718	-1514	-1225	-340	-1026	-41.0
120-60-25	120-60-0	25	2807	2866	2339	2807	2157	1806	-59	-468	351	-59	-2.3
120-60-30	120-60-0	30	1754	2866	1183	2807	2339	1806	-1111	-1624	533	-734	-24.5
120-60-75	120-60-30	45	1910	1754	1702	1183	2378	2339	156	520	39	238	5.3
120-60-50	120-60-0	50	3424	2866	2927	2807	2718	1806	559	120	912	530	10.6
120-60-75	120-60-25	50	1910	2807	1702	2339	2378	2157	-897	-637	221	-437	-8.7
120-60-75	120-60-0	75	1910	2866	1702	2807	2378	1806	-955	-1105	572	-496	-6.6

Diff-1, Diff-2 and *Diff-3* are differences between yields of treatments compared
RR is the response ratio (kg/kg)
Dose is the difference between the doses of the two treatments compared for a particular nutrient

Table 25. Rice response to application of fertilizers at Jagtial and Warangal in kharif 1996

		Warangal		Jagtial	
Nutrient	Dose (kg ha^{-1})	Response (kg ha^{-1})	Response Ratio (kg/kg)	Response (kg ha^{-1})	Response Ratio (kg/kg)
N	40	248.9	6.2	-188.4	-4.7
	60	179.2	3.0	466.2	7.8
	120	179.2	1.5	1204.9	10.0
P_2O_5	30	-53.1	-1.8	543.5	18.1
	60	-74.8	-1.2	634.4	10.6
	90	-159.3	-1.8	632.8	6.9
K_2O	5	151.3	30.3	-675.7	-135.1
	20	-529.7	-26.5	1264.4	63.2
	25	-82.9	-3.3	-165.3	-6.6
	30	270.8	9.0	-734.2	-24.5
	45	-519.7	-11.5	238.2	5.3
	50	-313.6	-6.3	46.3	0.9
	75	-248.9	-3.3	-496.0	-6.6

Table 26. Response of rice crop to applied N, P and K fertilizers at Warangal during kharif 1996

Treatments compared		Dose	Rep-1	Rep-1	Rep-2	Rep-2	Rep-3	Rep-3	Diff-1	Diff-2	Diff-3	Mean	RR
A.Nitrogen													
120-60-0	80-60-0	40	4062	3554	3764	3525	3106	3106	508	239	0	249	6.2
60-60-50	0-60-50	60	3913	2569	3256	2210	3525	2360	1344	1045	1165	1185	19.7
120-60-50	60-60-50	60	3226	3913	3525	3256	3405	3525	-687	269	-120	-179	-3.0
180-60-50	120-60-50	60	3106	3226	2927	3525	2718	3405	-120	-597	-687	-468	-7.8
120-60-50	0-60-50	120	3226	2569	3525	2210	3405	2360	657	1314	1045	1006	8.4
180-60-50	60-60-50	120	3106	3913	2927	3256	2718	3525	-807	-329	-807	-647	-5.4
B.Phosphorus													
120-60-50	120-30-50	30	3226	3405	3525	3644	3405	3078	-179	-120	328	10	0.3
120-90-50	120-60-50	30	2927	3226	3883	3525	3047	3405	-299	358	-358	-100	-3.3
120-30-50	120-0-50	30	3405	3584	3644	3823	3078	2927	-179	-179	150	-69	-2.3
120-60-50	120-0-50	60	3226	3584	3525	3823	3405	2927	-358	-299	478	-60	-1.0
120-90-50	120-30-50	60	2927	3405	3883	3644	3047	3078	-478	239	-31	-90	-1.5
120-90-50	120-0-50	90	2927	3584	3883	3823	3047	2927	-657	60	120	-159	-1.8
C.Potassium													
120-60-30	120-60-25	5	4719	4002	3441	3584	3584	3704	717	-143	-120	151	30.3
120-60-50	120-60-30	20	3226	4719	3525	3441	3405	3584	-1493	84	-179	-530	-26.5
120-60-50	120-60-25	25	3226	4002	3525	3584	3405	3704	-777	-60	-299	-378	-15.1
120-60-75	120-60-50	25	3405	3226	3525	3525	3256	3405	179	0	-149	10	0.4
120-60-25	120-60-0	25	4002	4062	3584	3764	3704	3106	-60	-179	597	119	4.8
120-60-30	120-60-0	30	4719	4062	3441	3764	3584	3106	657	-323	478	271	9.0
120-60-75	120-60-30	45	3405	4719	3525	3441	3256	3584	-1314	84	-329	-520	-11.5
120-60-50	120-60-0	50	3226	4062	3525	3764	3405	3106	-836	-239	299	-259	-5.2
120-60-75	120-60-25	50	3405	4002	3525	3584	3256	3704	-597	-60	-448	-368	-7.4
120-60-75	120-60-0	75	3405	4062	3525	3764	3256	3106	-657	-239	149	-249	-3.3

Diff-1, Diff-2 and Diff-3 are differences between yields of treatments compared
RR is the response ratio (kg/kg)
Dose is the difference between the doses of the two treatments compared for a particular nutrient

Fig.22(a). Rice response to application of Nitrogen at Jagtial and Warangal kharif 1996

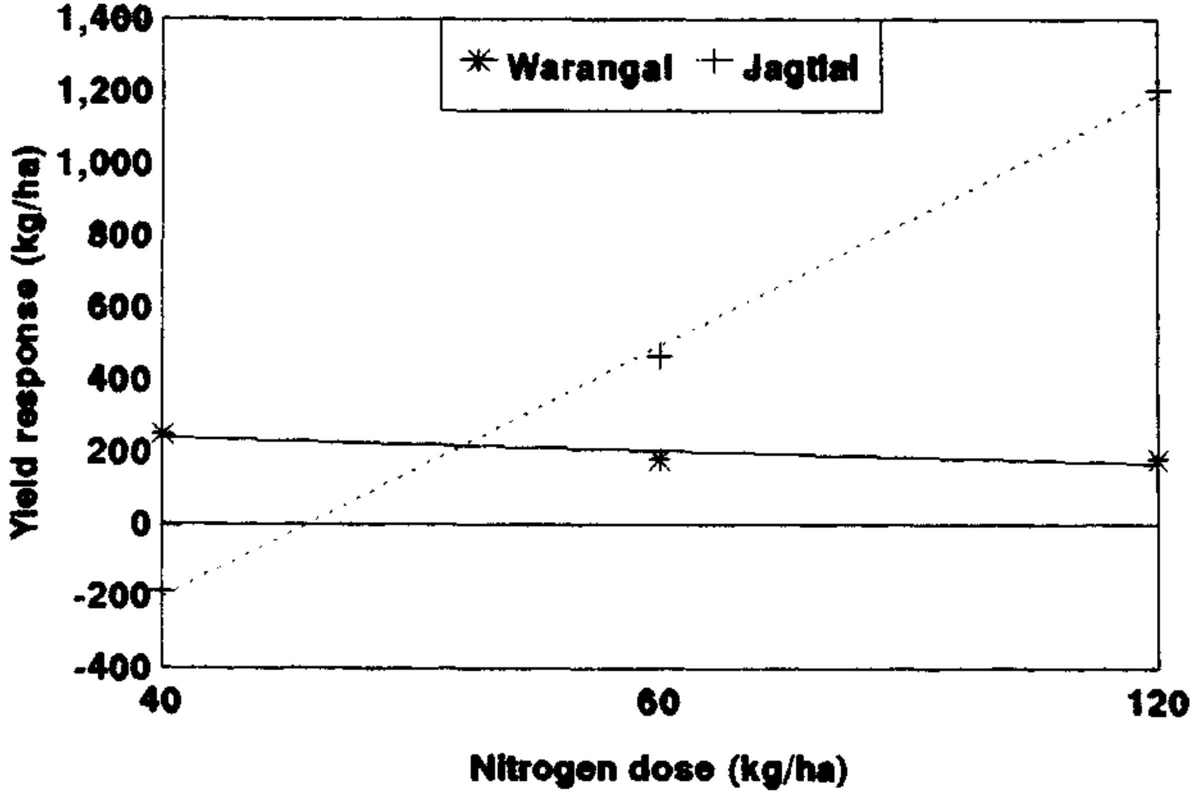


Fig.22(b). Rice response to application of Phosphorus at Jagtial and Warangal centers kharif 1996

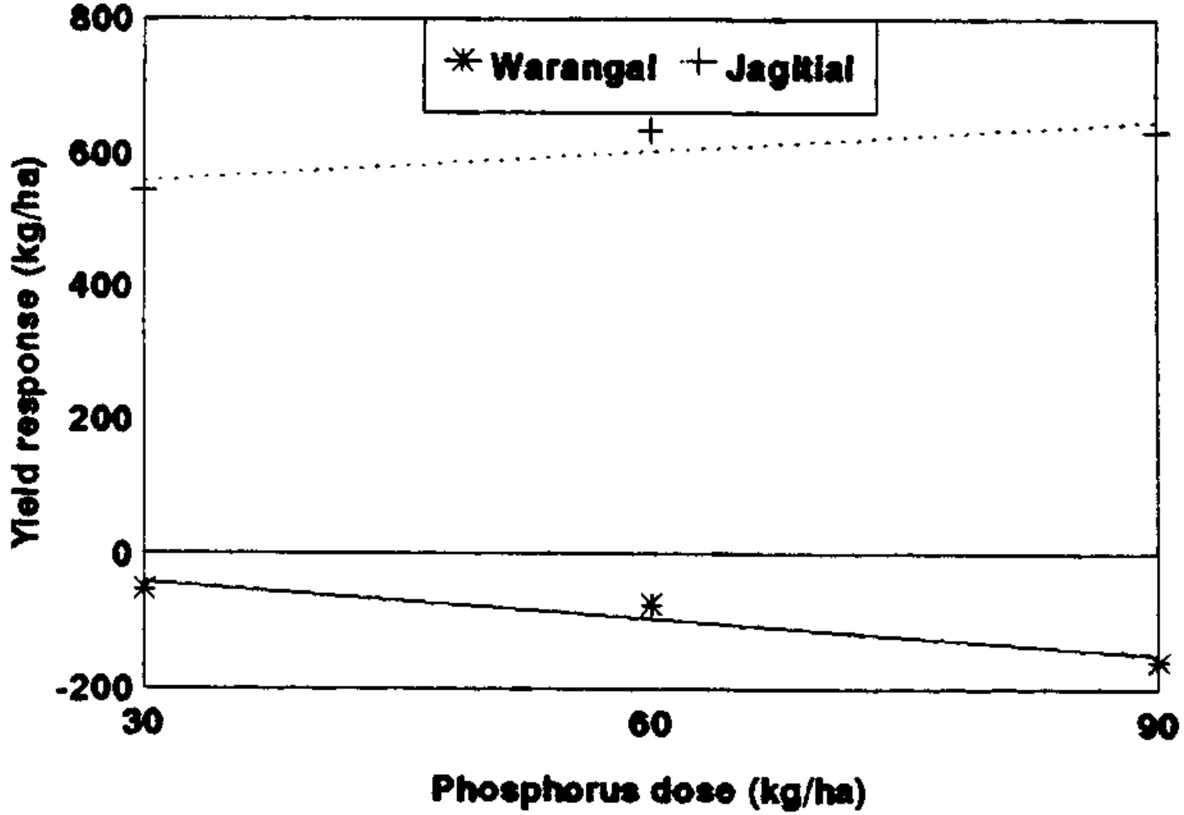
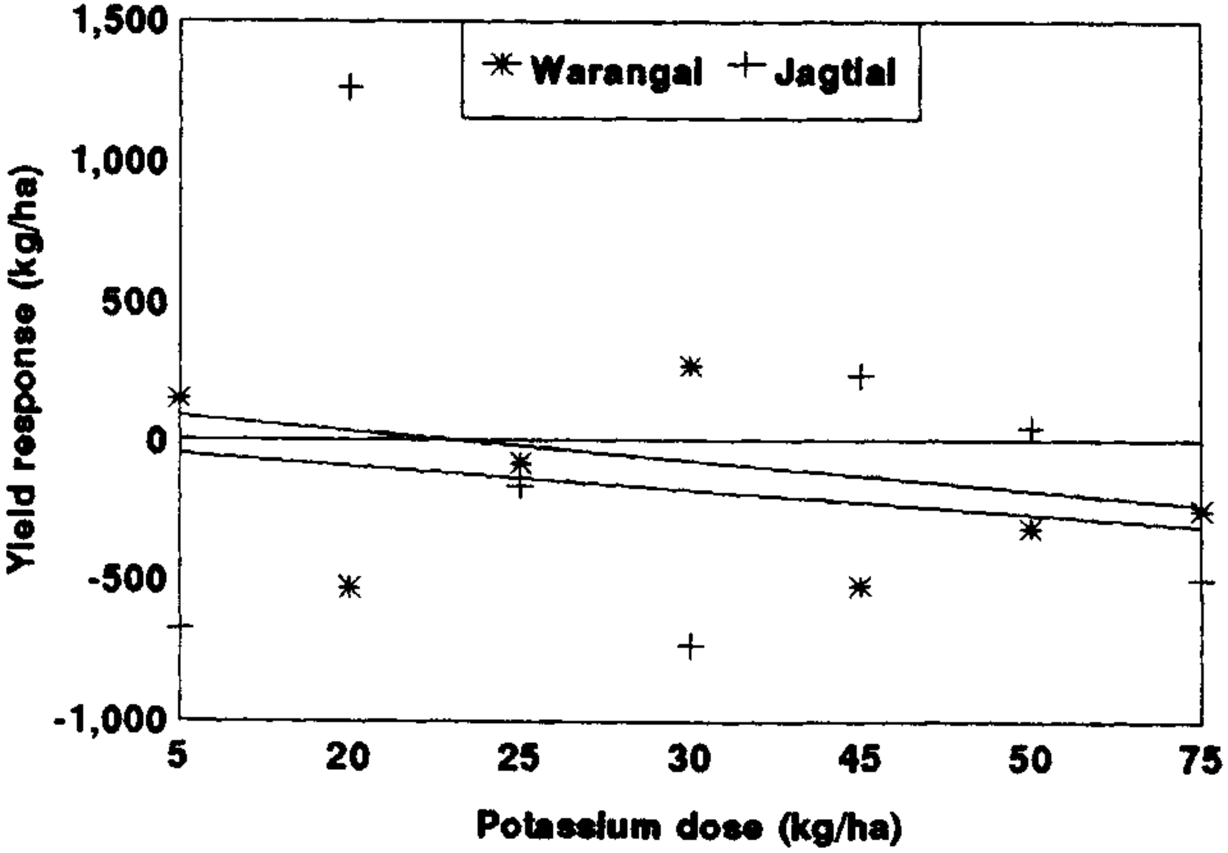


Fig.22(c). Rice response to application of Potassium at Jagtial and Warangal centers kharif 1996



were found to be 7.8 at 60 kg/ha and 10.0 at 120 kg/ha of N application. Fertilizer P was found to give response upto 90 kg/ha, with a decrease in the response ratio when compared to the responses at 30 and 60 kg/ha of P application. Although response to K was prevailing in some treatments, by and large it was negative. The actual responses and the response ratios of N, P and K nutrients are given in Tables 24 and 25.

At Warangal, response to N was observed upto 60 kg/ha only. The response ratio was of the order 6.2 at 40 kg and and 3.0 at 60 kg and 1.5 at 120 kg N/ha. The response to P was found be negative at all levels of application. However, response to K application upto 30 kg/ha was evident and was negative thereafter. The results of fertilizer responses and response ratios of N, P and K at Warangal location are given in Table 26. The mean rice response to application of N, P and K are given in Fig.22(a), 22(b) and 22(c) respectively.

4.2.5. MULTIPLE REGRESSION ANALYSIS

4.2.5.1. JAGTIAL CENTRE

The multiple regression equation of grain yield of rice through fertilizer N, P and K nutients and their square terms has been computed and is given below :

$$Y = 1120 + \overset{**}{9.29}\ FN - 0.03\ FN^2 + 4.67\ FP - 0.04\ FP^2$$
$$+ \overset{*}{11.63}\ FK - \overset{**}{0.30}\ FK^2$$

(R^2 = 0.91 ** σ = 236.9 C.V. (%) = 10.5)

The multiple regression equation of grain yield through 9 variables viz., all the 6 fertilizer terms and three terms of the soil N, P and K nutrients based on Organic carbon (%), Olsen and Ammonium acetate methods respectively was computed for making yield prediction and is given below :

$$Y = 3115 + 75.58\ SN + 1.43\ SP - \overset{**}{11.82}\ SK + \overset{*}{6.89}\ FN - 0.03\ FN^2$$
$$+ \overset{*}{10.71}\ FP - 0.07\ FP^2 + 8.29\ FK - \overset{*}{0.19}\ FK^2$$

(R^2 = 0.92 ** σ = 234.7 C.V. (%) = 10.4)

(O.C. (%), Olsen-P, Amm.ace-K)

Similarly, the multiple regression equation for predicting yield through all the above 9 variables with KMnO4 combination for soil N can be given as

$$Y = 3102 + 0.19\ SN + 1.26\ SP - \overset{**}{11.77}\ SK + \overset{*}{6.28}\ FN - \overset{*}{0.03}\ FN^2$$
$$+ 9.64\ FP - 0.06\ FP^2 + 7.34\ FK - \overset{*}{0.21}\ FK^2$$

(R^2 = 0.92 ** σ = 235.7 C.V. (%) = 10.4)

(KMnO4-N, Olsen-P, Amm.ace-K)

Similarly, the multiple regression equation with all the 9 variables with Ca(OH)2 method for soil N can be given as

$$Y = 2841 + 1.01\ SN + 4.45\ SP - \overset{**}{11.29}\ SK + \overset{*}{6.65}\ FN - \overset{*}{0.03}\ FN^2$$

$$+ 10.88\ FP - 0.07\ FP^2 + 7.32\ FK - \overset{*}{0.21}\ FK^2$$

$$(R^2 = 0.91^{**} \quad \sigma = 235.8 \quad C.V.\ (\%) = 10.4)$$

(Ca(OH)2-N, Olsen-P , Amm.Ace-K)

The multiple regression equation for predicting yield through 12 variables comprising of 6 fertiliser terms, three soil terms and three soil and fertilizer interaction variable terms has been computed for calibrating both yield prediction and fertiliser optimisation. The regression equation is as follows :

$$Y = -3700 + \overset{**}{0.5344}\ SN + 12.99\ SP + \overset{**}{23.69}\ SK + \overset{**}{25.45}\ FN - 0.01\ FN^2$$

$$+ 1.40\ FP - 0.01\ FP^2 + \overset{**}{62.62}\ FK - \overset{**}{0.47}\ FK^2$$

$$- \overset{**}{60.80}\ FN\ SN - 0.01\ FP\ SP - \overset{**}{0.61}\ FK\ SK$$

$$(R^2 = 0.93^{**} \quad \sigma = 203.9 \quad C.V.\ (\%) = 9.0)$$

(O.C. (%)-N, Olsen-P, Amm.Ace-K)

Similarly, the multiple regression equations with 12 variables based on the combinations of KMNO4-N and Ca(OH)2-N methods of soil N are as follows :

Fig.11(a). Relationship between grain yield and uptake N at Jagtial site

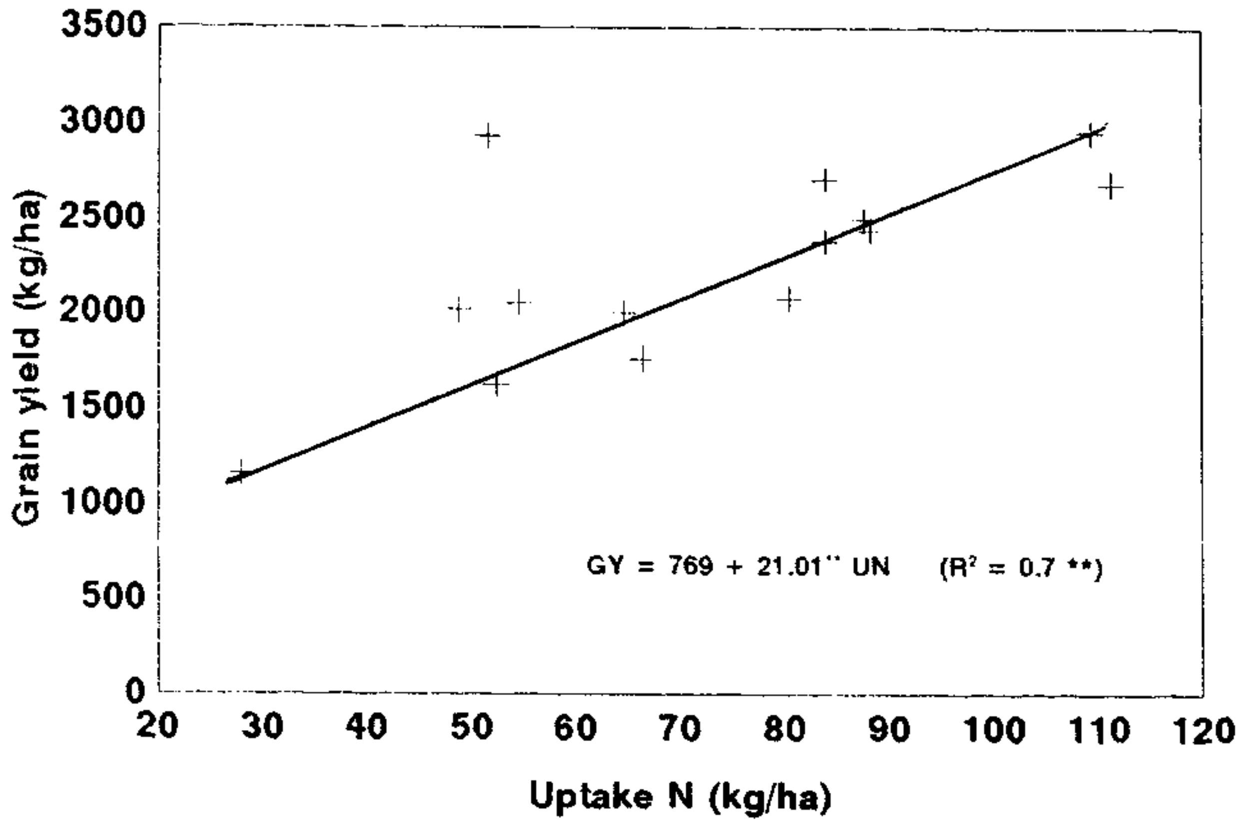


Fig.12(a). Relationship between grain yield and uptake P at Jagtial site

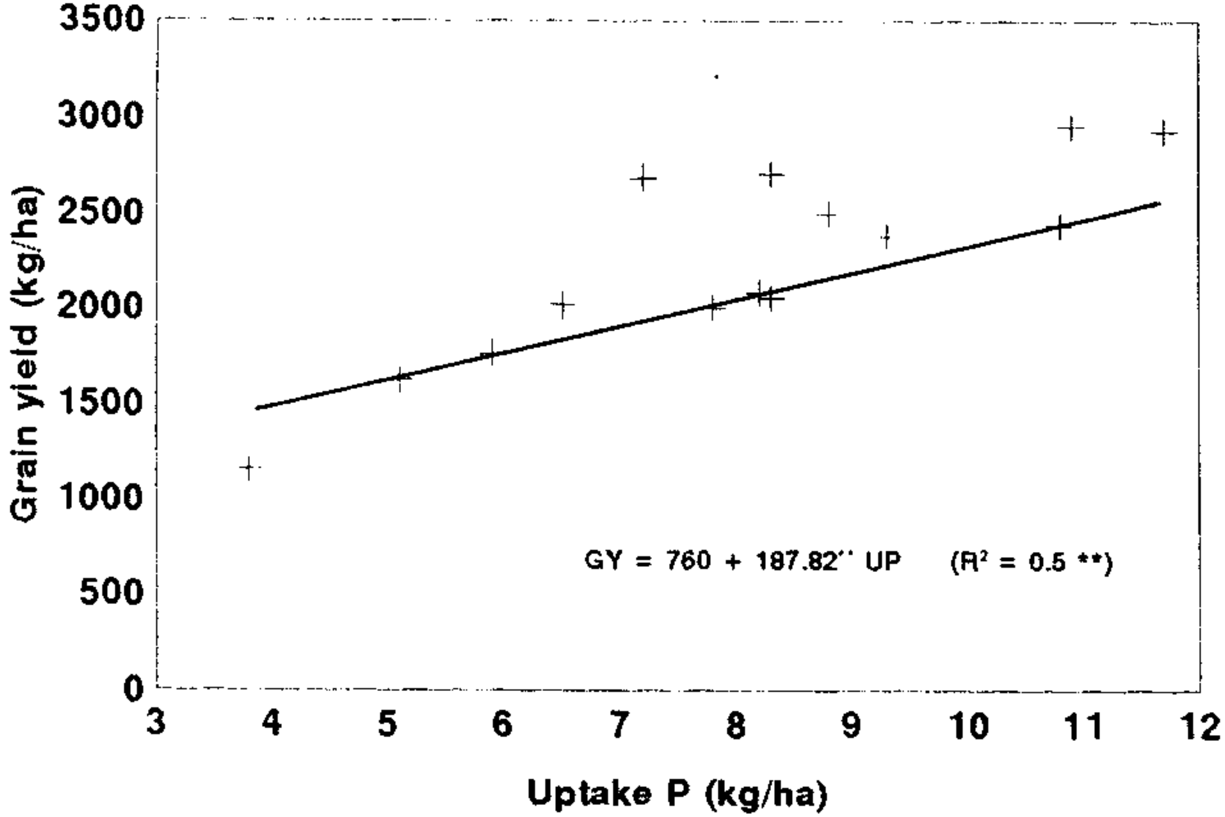
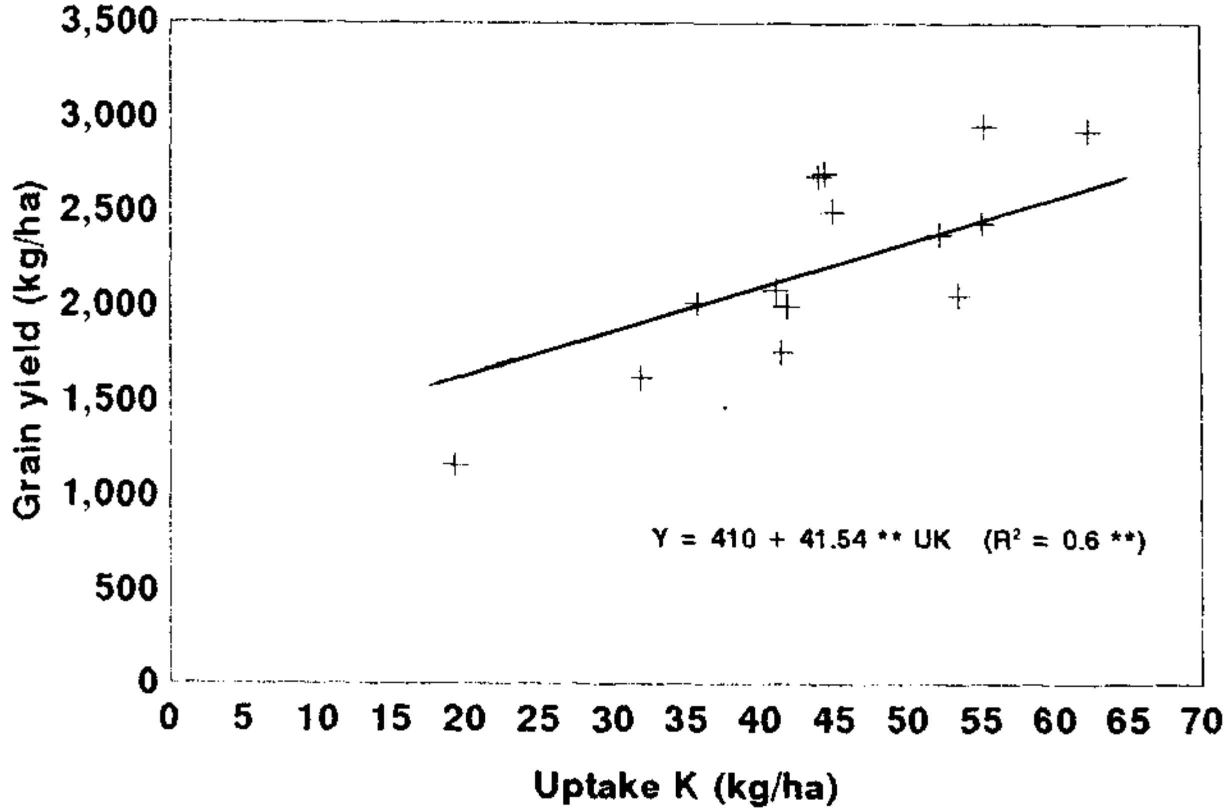


Fig.13(a). Relationship between grain yield and uptake K at Jagtial site



$$Y = 343 - 0.63\ SN + 23.67\ SP + 2.50\ SK + \overset{**}{5.17}\ FN - 0.02\ FN^2$$

$$+ \overset{**}{25.42}\ FP - 0.17\ FP^2 + \overset{**}{68.76}\ FK - 1.25\ FK^2$$

$$+ 0.02\ FN\ SN - 0.28\ FP\ SP - \overset{*}{0.48}\ FK\ SK$$

($R^2 = 0.93$ ** $\sigma = 226.6$ C.V. (%) = 10.0)

($KMnO_4$-N, Olsen-P and Amm.Ace-K)

$$Y = 530 - 1.72\ SN + 20.32\ SP + 2.64\ SK + 4.81\ FN - 0.02\ FN^2$$

$$+ \overset{*}{26.48}\ FP - 0.17\ FP^2 + \overset{*}{69.07}\ FK - 1.35\ FK^2$$

$$+ 0.03\ FN\ SN - 0.29\ FP\ SP - \overset{*}{0.49}\ FK\ SK$$

($R^2 = 0.89$ ** $\sigma = 266.2$ C.V. (%) = 11.8)

($Ca(OH)_2$-N, Olsen-P, Amm.Ace-K)

The grain yield has been regressed with plant uptake of N, P and K nutrients. It was found that high and significant yield predictions (R^2 of 0.80) can be made through plant uptake of nutrients. The regression coefficients of N and K were found to be significant for making yield prediction. The regression model of grain yield through uptake variables is given below :

$$Y = 383 + \overset{**}{14.44}\ UN + 12.33\ UP + \overset{*}{16.91}\ UK$$

($R^2 = 0.80$ ** , $\sigma = 306.9$, C.V. (%) = 13.6)

The relation between yield and plant uptake was found to be linear with a high and significant correlation of variables. The relation between yield and uptake of N , P and K nutrients is given in Fig. 11(a), 12(a) and 13(a).

Table 27. Fertilizer adjustment equations of rice at Jagtial (derived based on multiple regressions)

Regression equation	Fertilizer adjustment equation	Range of soil test values (kg ha^{-1})	Average soil test value (kg ha^{-1})	Fertilizer dose (kg ha^{-1})
Only fertilizer terms	FN = 155 - 16.67 R FP_2O_5 = 58 - 12.50 R FK_2O = 22 - 2.63 R	Not applicable	Not applicable	129 35 18
Fertilizer and soil terms (OC)	FN = 115 - 16.67 R FP_2O_5 = 77 - 7.14 R FK_2O = 22 - 2.63 R	0.06 - 0.73 11 - 50 134 - 211	0.29 23 174	89 64 20
Fertilizer and soil terms (KM)	FN = 105 - 16.67 R FP_2O_5 = 80 - 8.33 R FK_2O = 18 - 2.38 R	94 - 436 11 - 50 134 - 211	158 23 174	79 65 17
Fertilizer and soil terms (CA)	FN = 111 - 16.67 R FP_2O_5 = 78 - 7.14 R FK_2O = 17 - 2.38 R	75 - 349 11 - 50 134 - 211	126 23 174	85 65 16
Fertilizer, soil and interaction terms (OC)	FN = 318 - 760 SN - 12.50 R FP_2O_5 = 70 - 0.50 SP - 50.00 R FK_2O = 67 - 0.65 SK - 1.06 R	0.06 - 0.73 11 - 50 134 - 211	0.29 23 174	78 0 0
Fertilizer, soil and interaction terms (KM)	FN = 129 - 0.50 SN - 25.00 R FP_2O_5 = 75 - 0.82 SP - 2.94 R FK_2O = 28 - 0.19 SK - 0.40 R	94 - 436 11 - 50 134 - 211	158 23 174	11 51 0
Fertilizer, soil and interaction terms (CA)	FN = 120 - 0.75 SN - 25.00 R FP_2O_5 = 78 - 0.85 SP - 2.94 R FK_2O = 26 - 0.18 SK - 0.37 R	75 - 349 11 - 50 134 - 211	126 23 174	0 53 0

R is the ratio of 1 kg of fertilizer and 1 kg of paddy
OC : Organic carbon (%)
KM : Alkaline permonganate-N (kg ha^{-1})
CA : Calcium hydoxide-N (kg ha^{-1})
SN, SP, SK are soil N, P and K nutrients (kg ha^{-1})

Table 28. Ready reckoners of fertilizer doses based on soil test values for maximum yield, maximum profit and a desired rate of return

Equation No.	Maximum yield (kg/ha)			Maximum profit (Rs/ha)			Desired return (1 : 2)		
	N	P	K	N	P	K	N	P	K
A : WARANGAL									
1	102	36	31	95	32	27	88	27	24
2	100	32	16	93	28	0	87	23	0
3	133	80	340	122	0	324	111	0	308
4	122	16	52	112	11	48	102	5	45
B : JAGITYAL									
	N	P	K	N	P	K	N	P	K
1	155	58	22	129	37	20	103	15	19
2	115	77	22	89	65	20	63	53	19
3	105	80	18	79	66	16	53	51	15
4	111	78	17	85	66	15	59	54	14

Equation 1 : Only fertilizer terms
Equation 2 : Fertilizer and soil terms (Organic carbon, Olsen-P, Am.Ac-K)
Equation 3 : Fertilizer and soil terms ($KMnO_4$-N, Olsen-P, Am.Ac-K)
Equation 4 : Fertilizer and soil terms (Calcium hydroxide-N, Olsen-P, Am.Ac-K)

4.2.5.1.1. FERTILIZER ADJUSTMENT EQUATIONS BASED ON REGRESSIONS

Since the fertiliser response type was found to be (+ - -) for all the three nutrients based on the multiple regression analysis and the equations as described above, and the regression equations are providing a high value of R^2 (above 0.67), the fertilizer adjustment equations have been derived under each regression equation by partially differentiating grain yield 'Y' with respect to FN, FP and FK variables, and are provided in Table 27. The fertilizer adjustment equations for both the maximum yield, maximum profit and for desired rate of return, alongwith the ranges of soil test values for which they are applicable are given in the Table 28.

4.2.5.1.2. READY RECKONERS OF FERTILIZER DOSES FOR VARYING SOIL TEST VALUES

Using the fertilizer adjustment equations as described in Table 27, optimum fertilizer doses for varying soil test values have been computed within the range of soil test values as observed for the Jagtial location. The ready reckoners of fertilizer N, P and K doses for varing soil test values of all the three nutrients for both maximum yield,

Table 29(a). Ready reckoner of fertilizer doses based on soil test values for maximum yield, maximum profit and a desired rate of return

A. Jagtial : Rice (Using Equation 5 of fertilizer adjustment equations)

Soil test values			Optimum fertilizer doses (kg/ha) for attaining								
			Maximum yield			Maximum profit			DRR		
OC-N	OL-P	AM-K	N	P	K	N	P	K	N	P	K
0.05	5	100	280	68	2	260	59	1	241	50	1
0.15	10	110	204	65	0	184	56	0	165	48	0
0.25	15	120	128	63		108	54		89	45	
0.35	20	130	52	60		32	51		13	43	
0.45	25	140	0	58		0	49		0	40	
0.55	30	150		55			46			38	
0.65	35	160		53			44			35	
0.75	40	170		50			41			33	
0.85	45	180		48			39			30	
0.85	50	190		45			36			28	
0.95	55	200		43			34			25	
1.05	60	210		40			31			23	

Maximum yield (kg/ha)
Maximum profit (Rs/ha)
DRR : Desired rate of return (DRR = 1:2)

OC-N : Organic carbon (%)
OL-P : Olsen's P (kg/ha)
AM-K : Ammonium acetate K (kg/ha)

Fertlizer adjustment equations :

FN = 318 - 760 SN - 12.50 R
FP2O5 = 70 - 0.50 SP - 5.00 R
FK2O = 67 - 0.65 SP - 0.65 R

Table 29(b). Ready reckoner of fertilizer doses based on soil test values for maximum yield, maximum profit and a desired rate of return

A. Jagtial : Rice (Using Equation 6 of fertilizer adjustment equations)

Soil test values			Optimum fertilizer doses (kg/ha) for attaining								
			Maximum yield			Maximum profit			DRR		
KM-N	OL-P	AM-K	N	P	K	N	P	K	N	P	K
90	5	100	84	71	9	80	66	9	76	61	8
120	10	110	69	67	7	65	62	7	61	57	7
150	15	120	54	63	5	50	58	5	46	53	5
180	20	130	39	59	3	35	54	3	31	49	3
210	25	140	24	55	1	20	49	1	16	44	1
240	30	150	9	50	0	5	45	0	1	40	0
270	35	160	0	46		0	41		0	36	
300	40	170		42			37			32	
330	45	180		38			33			28	
360	50	190		34			29			24	
390	55	200		30			25			20	
420	60	210		26			21			16	

Maximum yield (kg/ha) KM-N : Alkaline permanaganate N (kg/ha)
Maximum profit (Rs/ha) OL-P : Olsen's P (kg/ha)
DRR : Desired rate of return (DRR = 1:2) AM-K : Ammonium acetate K (kg/ha)

Fertlizer adjustment equations :

FN = 129 - 0.50 SN - 2.50 R
FP2O5 = 75 - 0.82 SP - 2.94 R
FK2O = 28 - 0.19 SP - 0.40 R

Table 29(c). Ready reckoner of fertilizer doses based on soil test values for maximum yield, maximum profit and a desired rate of return

A : Jagtial : Rice (Using Equation 7 of fertilizer adjustment equations)

Soil test values			Optimum fertilizer doses (kg/ha) for attaining								
			Maximum yield			Maximum profit			DRR		
CA-N	OL-P	AM-K	N	P	K	N	P	K	N	P	K
100	5	400	45	74	0	41	69	0	37	64	0
115	10	430	34	70		28	22		18	19	
130	15	460	23	65		12	16		3	14	
145	20	490	11	61		0	11		0	8	
160	25	520	0	57			5			3	
175	30	550		53			0			0	
190	35	580		48							
205	40	610		44							
220	45	640		40							
235	50	670		36							
250	55	700		31							

Maximum yield (kg/ha)
Maximum profit (Rs/ha)
DRR : Desired rate of return (DRR = 1:2)

CA-N : Calicium hydroxide N (kg/ha)
OL-P : Olsen's P (kg/ha)
AM-K : Ammonium acetate K (kg/ha)

Fertlizer adjustment equations :

$FN = 120 - 0.75\ SN - 2.50\ R$
$FP2O5 = 78 - 0.85\ SP - 2.91\ R$
$FK2O = 26 - 0.18\ SP - 0.37\ R$

maximum profit and a desired rate of return are given in Table 29 (a), 29(b) and 29(c).

4.2.5.2. WARANGAL CENTRE

The multiple regression equation of grain yield of rice through fertilizer N, P and K nutients and their quadratic terms has been computed and is given below :

$$Y = 2415 + \overset{**}{22.39}\ FN - \overset{**}{0.11}\ FN^2 + \overset{**}{14.23}\ FP - \overset{**}{0.20}\ FP^2 + 5.58\ FK - 0.09\ FK^2$$

($R^2 = 0.87$ ** $\sigma = 186.3$ C.V. (%) = 5.7)

The multiple regression equation of grain yield through 9 variables viz., all the 6 fertilizer terms and three terms of the soil N, P and K nutrients based on Organic carbon (%), Olsen and Ammonium acetate methods respectively was computed for making yield prediction and is given below :

$$Y = 3636 - 115.51\ SN + 6.22\ SP - 1.29\ SK + \overset{**}{24.09}\ FN - \overset{**}{0.12}\ FN^2 + \overset{*}{12.64}\ FP - \overset{*}{0.20}\ FP^2 + 0.62\ FK - 0.02\ FK^2$$

($R^2 = 0.92$ ** $\sigma = 162.1$ C.V. (%) = 4.9)

(O.C. (%), Olsen-P, Amm.ace-K)

Similarly, the multiple regression equation for predicting yield through all the above 9 variables with KMNO4 combination for soil N can be given as

$$Y = 1629 - \overset{**}{5.58}\ SN + 4.37\ SP + 2.61\ SK + \overset{**}{18.68}\ FN - \overset{*}{0.07}\ FN^2$$

$$+ 1.59\ FP - 0.11\ FP^2 + \overset{**}{13.59}\ FK - 0.02\ FK^2$$

$(R^2 = 0.91^{**} \quad \sigma = 174.9 \quad C.V.\ (\%) = 5.3)$

(KMnO4-N, Olsen-P, Amm.ace-K)

Similarly, the multiple regression equation with all the 9 variables with Ca(OH)2 method for soil N can be given as

$$Y = 2385 - \overset{**}{7.78}\ SN + 0.99\ SP + 1.82\ SK + \overset{**}{19.49}\ FN - \overset{**}{0.08}\ FN^2$$

$$+ 5.16\ FP - 0.16\ FP^2 + \overset{*}{9.31}\ FK - \overset{*}{0.09}\ FK^2$$

$(R^2 = 0.87^{**} \quad \sigma = 210.1 \quad C.V.\ (\%) = 6.4)$

(Ca(OH)2-N, Olsen-P , Amm.Ace-K)

The multiple regression equation for predicting yield through 12 variables comprising of 6 fertiliser terms, three soil terms and three soil and fertilizer interaction variable terms has been computed for calibrating both yield prediction and fertiliser optimisation. The regression equation is as follows :

$$Y = -4008 - \overset{*}{906.25}\ SN - 11.95\ SP + \overset{**}{14.73}\ SK + \overset{**}{9.87}\ FN$$

$$- \overset{**}{0.04}\ FN^2 + \overset{**}{29.06}\ FP - 0.21\ FP^2 + \overset{**}{114.38}\ FK - \overset{**}{2.21}\ FK^2$$

$$- 3.29\ FN\ SN - \overset{**}{0.42}\ FP\ SP - \overset{**}{0.23}\ FK\ SK$$

$(R^2 = 0.96^{**} \quad \sigma = 107.6 \quad C.V.\ (\%) = 3.3)$

(O.C. (%)-N, Olsen-P, Amm.Ace-K)

Fig.11(b). Relationship between grain yield and uptake N at Warangal site

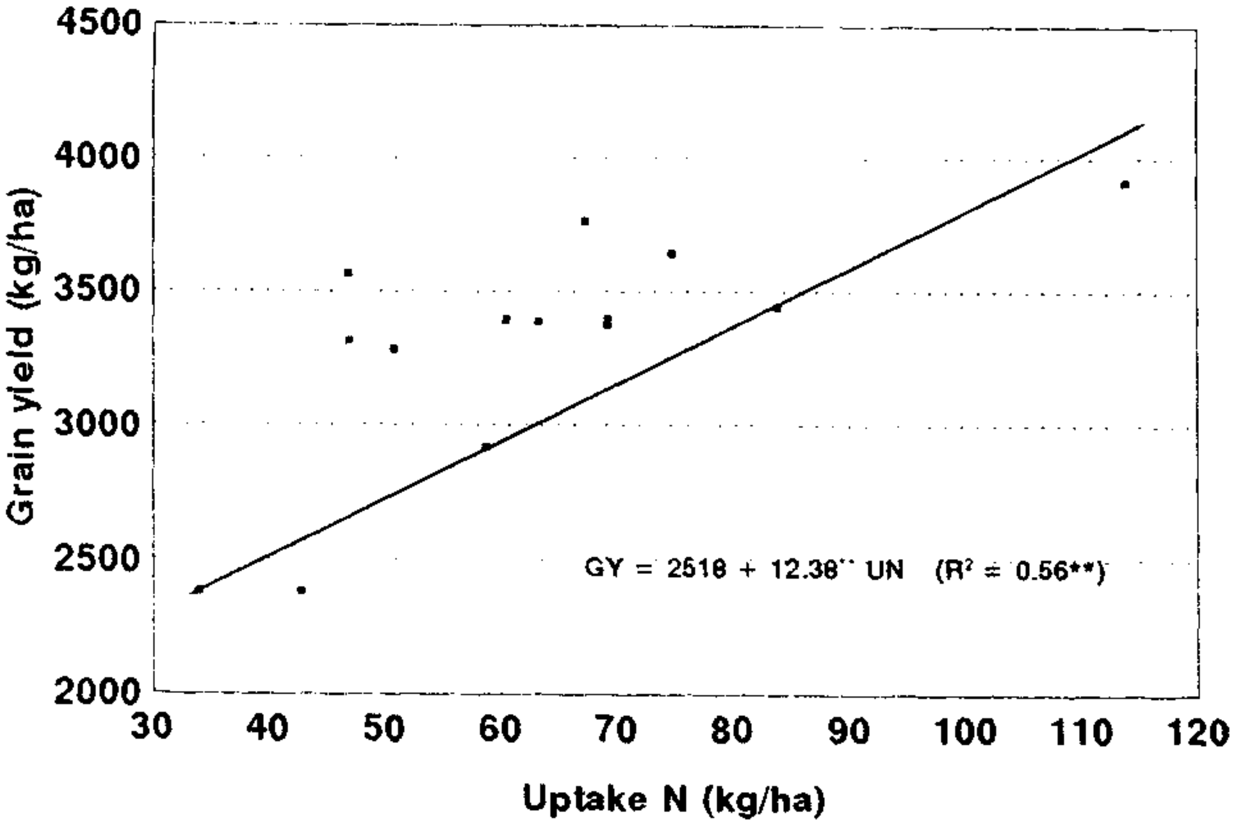


Fig.12(b). Relationship between grain yield and uptake P at Warangal site

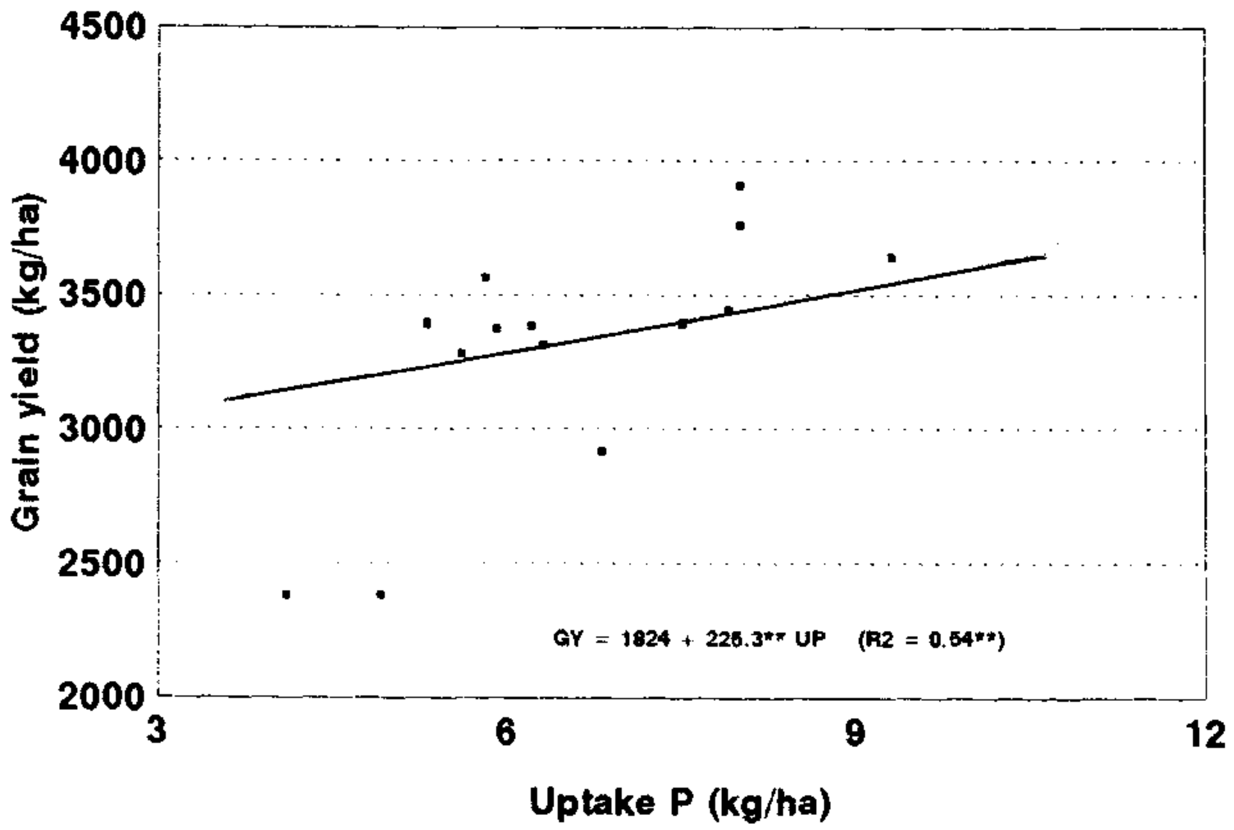
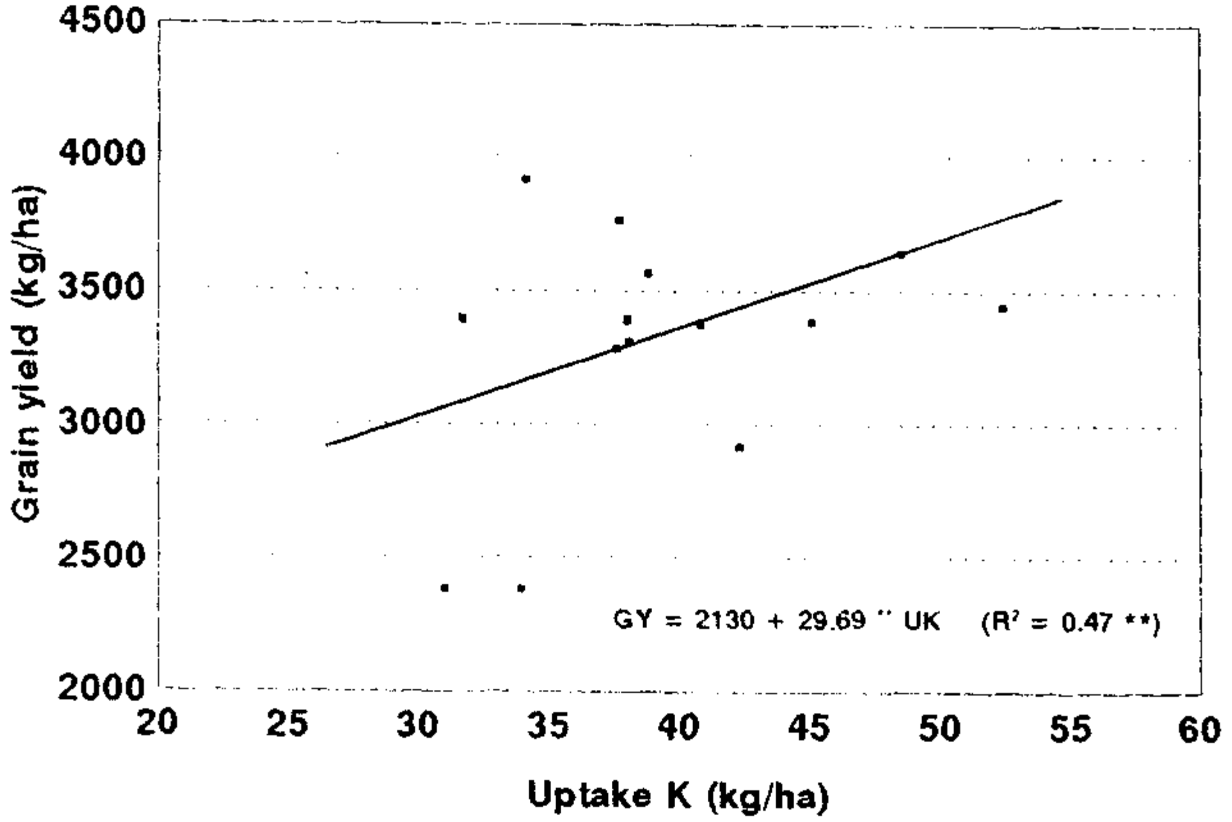


Fig.13(b). Relationship between grain yield and uptake K at Warangal site



Similarly, the multiple regression equations with 12 variables based on the combinations of KMnO4-N and Ca(OH)2-N methods of soil N are as follows :

$$Y = 81 - \overset{**}{24.46}\ SN + \overset{*}{38.77}\ SP + 6.28\ SK + 9.33\ FN - \overset{**}{0.07}\ FN^2$$
$$+ 26.27\ FP - \overset{**}{0.35}\ FP^2 + \overset{**}{102.29}\ FK - 1.29\ FK^2$$
$$- \overset{**}{0.14}\ FN\ SN - \overset{**}{0.78}\ FP\ SP - \overset{**}{0.16}\ FK\ SK$$

(R^2 = 0.91 ** σ = 168.15 C.V. (%) = 5.1)

(KMnO4-N, Olsen-P and Amm.Ace-K)

$$Y = 103 - \overset{**}{30.21}\ SN + 37.77\ SP + 6.30\ SK + 9.63\ FN - \overset{**}{0.08}\ FN^2$$
$$+ 24.65\ FP - \overset{**}{0.35}\ FP^2 + \overset{*}{102.01}\ FK - 2.01\ FK^2$$
$$- \overset{*}{0.17}\ FN\ SN - \overset{*}{0.76}\ FP\ SP - \overset{*}{0.16}\ FK\ SK$$

(R^2 = 0.85 ** σ = 221.6 C.V. (%) = 6.7)

(Ca(OH)2-N, Olsen-P, Amm.Ace-K)

The grain yield has been regressed with data on plant uptake N, P and K. It was found that high and significant yield predictions (R^2 of 0.86) can be made through plant uptake of nutrients. The regression coefficients of N and P were found to be significant for making yield prediction. The regression model of grain yield through uptake variables is given below :

$$Y = 1239 + \overset{**}{5.57}\ UN + \overset{**}{179.84}\ UP + 7.92\ UK$$

(R^2 = 0.86 ** , σ = 205.2 , C.V. (%) = 6.2)

Table 30. Fertilizer adjustment equations of rice at Warangal (derived based on multiple regressions)

Regression equation	Fertilizer adjustment equation	Range of soil test values (kg ha^{-1})	Average soil test value (kg ha^{-1})	Fertilizer dose (kg ha^{-1})
Only fertilizer terms	FN = 102 - 4.54 R FP2O5 = 36 - 2.50 R FK2O = 31 - 5.56 R	Not applicable	Not applicable	95 31 27
Fertilizer and soil terms (OC)	FN = 100 - 4.17 R FP2O5 = 32 - 2.50 R FK2O = 16 - 25.00 R	0.12 - 1.05 44 - 87 496 - 628	0.64 70 578	93 27 0
Fertilizer and soil terms (KM)	FN = 133 - 7.14 R FP2O5 = 80 - 50.00 R FK2O = 340 - 25.0 R	142 - 351 44 - 87 496 - 628	202 70 578	122 0 324
Fertilizer and soil terms (CA)	FN = 122 - 6.25 R FP2O5 = 16 - 3.13 R FK2O = 52 - 5.56 R	115 - 281 44 - 87 496 - 628	162 70 578	112 10 48
Fertilizer, soil and interaction terms (OC)	FN = 123 - 41.1 SN - 12.00 R FP2O5 = 69 - 1.00 SP - 2.38 R FK2O = 26 - 0.05 SK - 0.23 R	0.12 - 1.05 44 - 87 496 - 628	0.64 70 578	77 0 0
Fertilizer, soil and interaction terms (KM)	FN = 66 - 1.00 SN - 7.14 R FP2O5 = 38 - 1.11 SP - 1.43 R FK2O = 40 - 0.06 SK - 0.39 R	142 - 351 44 - 87 496 - 628	202 70 578	0 0 5
Fertilizer, soil and interaction terms (CA)	FN = 60 - 1.06 SN - 6.25 R FP2O5 = 35 - 1.09 SP - 1.43 R FK2O = 25 - 0.04 SK - 0.25 R	115 - 281 44 - 87 496 - 628	162 70 578	0 0 2

R is ratio of 1 kg fertilizer and 1 kg of value of crop
OC : Organic carbon (%)
KM : Alkaline permonganate-N (kg ha^{-1})
CA : Calcium hydroxide-N (kg ha^{-1})

Table 31(a). Ready reckoner of fertilizer doses based on soil test values for maximum yield, maximum profit and a desired rate of return

A : Warangal : Rice (Using Equation 5 of fertilizer adjustment equations)

Soil test values			Optimum fertilizer doses (kg/ha) for attaining								
			Maximum yield			Maximum profit			DRR		
OC-N	OL-P	AM-K	N	P	K	N	P	K	N	P	K
0.1	5	400	119	64	6	100	60	6	81	56	6
0.2	10	430	115	59	5	96	55	4	77	51	4
0.3	15	460	111	54	3	92	50	3	73	46	3
0.4	20	490	107	49	2	88	45	1	69	41	1
0.5	25	520	102	44	0	84	40	0	65	36	0
0.6	30	550	98	39		79	35		61	31	
0.7	35	580	94	34		75	30		57	26	
0.8	40	610	90	29		71	25		52	21	
0.9	45	640	86	24		67	20		48	16	
1.0	50	670	82	19		63	15		44	11	
1.1	55	700	78	14		59	10		40	6	

Maximum yield (kg/ha)
Maximum profit (Rs/ha)
DRR : Desired rate of return (DRR = 1:2)

OC-N : Organic carbon (%)
OL-P : Olsen's P (kg/ha)
AM-K : Ammonium acetate K (kg/ha)

Fertilizer adjustment equations :

FN = 123 - 41.10 SN - 12.00 R
FP2O5 = 69 - 1.00 SP - 2.38 R
FK2O = 26 - 0.05 SK - 0.23 R

Table 31(b). Ready reckoner of fertilizer doses based on soil test values for maximum yield, maximum profit and a desired rate of return

A : Warangal : Rice (Using Equation 6 of fertilizer adjustment equations)

			Optimum fertilizer doses (kg/ha) for attaining								
Soil test values			Maximum yield			Maximum profit			DRR		
KM-N	OL-P	AM-K	N	P	K	N	P	K	N	P	K
100	5	400	66	32	16	55	30	16	44	28	15
130	10	430	36	27	14	25	24	14	14	22	14
160	15	460	6	21	12	0	19	12	0	16	12
190	20	490	0	16	11		13	10		11	10
220	25	520		10	9		8	9		5	8
250	30	550		5	7		2	7		0	6
280	35	580		0	5		0	5			5
310	40	610			3			3			3
340	45	640			2			1			1
370	50	670			0			0			0
400	55	700									

Maximum yield (kg/ha)
Maximum profit (Rs/ha)
DRR : Desired rate of return (DRR = 1:2)

KM-N : Alkaline permanaganate N (kg/ha)
OL-P : Olsen's P (kg/ha)
AM-K : Ammonium acetate K (kg/ha)

Fertilizer adjustment equations :

$FN = 166 - 1.00\ SN - 7.14\ R$
$FP2O5 = 38 - 1.11\ SP - 1.43\ R$
$FK2O = 40 - 0.06\ SK - 0.39\ R$

Table 31(c). Ready reckoner of fertilizer doses based on soil test values for maximum yield, maximum profit and a desired rate of return

A : Warangal : Rice (Using Equation 7 of fertilizer adjustment equations)

Soil test values			Optimum fertilizer doses (kg/ha) for attaining								
			Maximum yield			Maximum profit			DRR		
CA-N	OL-P	AM-K	N	P	K	N	P	K	N	P	K
100	5	400	54	30	9	44	27	9	34	25	9
120	10	430	33	24	8	23	22	8	13	19	7
140	15	460	12	19	7	2	16	6	0	14	6
160	20	490	0	13	5	0	11	5		8	5
180	25	520		8	4		5	4		3	4
200	30	550		2	3		0	3		0	3
220	35	580		0	2			2			1
240	40	610			1			0			0
260	45	640			0						
280	50	670									
300	55	700									

Maximum yield (kg/ha)
Maximum profit (Rs/ha)
DRR : Desired rate of return (DRR = 1:2)

CA-N : Calicium hydroxide N (kg/ha)
OL-P : Olsen's P (kg/ha)
AM-K : Ammonium acetate K (kg/ha)

Fertilizer adjustment equations :

$$FN = 160 - 1.06\ SN - 6.25\ R$$
$$FP2O5 = 35 - 1.09\ SP - 1.43\ R$$
$$FK2O = 25 - 0.04\ SK - 0.25\ R$$

The relation between yield and plant uptake was found to be linear with a high and significant correlation of variables. The relation between yield and uptake of N , P and K nutrients is given in Fig.11(b), 12(b) and 13(b) respectively.

4.2.5.2.1. FERTILIZER ADJUSTMENT EQUATIONS BASED ON REGRESSIONS

The fertiliser response type was found to be (+ - -) for all the three nutrients based on the multiple regression analysis and the equations as described above for the Warangal site. Further, the regression equations were found to have a high value of R^2 (above 0.67), the fertilizer adjustment equations have been derived under each regression equation by partially differentiating grain yield 'Y' with respect to FN, FP and FK variables as shown in Table 30. The fertilizer adjustment equations for both the maximum yield, maximum profit and for desired rate of return, along with the ranges of soil test values for which they are applicable for soils of Warangal are given in the Table 31(a), 31(b) and 31(c).

Table 32. Nutrient requirement of rice, soil and fertiliser contributions in soils of Jagtial (kharif 1996)

Method		Basic data			Targetted yield equation	Response ratio
		NR	CS	CF		
Conventional (WF)	N	3.21	22.4	35.4	FN = 9.08 T - 0.63 SN	5.8
	P	0.81	17.5	17.9	FP = 4.51 T - 2.31 SP	
	K	2.43	12.0	64.1	FK = 3.79 T - 0.23 SK	
Conventional (YM)	N	2.92	22.4	49.2	FN = 5.93 T - 0.46 SN	7.9
	P	0.72	18.0	20.8	FP = 3.46 T - 1.98 SP	
	K	2.09	12.0	63.6	FK = 3.29 T - 0.23 SK	
Simultaneous (WF)	N	3.10	27.2	46.7	FN = 6.65 T - 0.58 SN	6.7
	P	0.35	32.8	15.1	FP = 2.33 T - 2.17 SP	
	K	1.97	26.3	33.2	FK = 5.93 T - 0.79 SK	
Simultaneous (YM)	N	2.91	27.2	46.7	FN = 6.22 T - 0.58 SN	8.4
	P	0.35	32.8	15.1	FP = 2.32 T - 2.17 SP	
	K	1.91	26.3	33.2	FK = 5.75 T - 0.79 SK	

N, P and K are abbreviated for N, P_2O_5 and K_2O
FN, FP and FK are fertilizer N, P_2O_5 and K_2O doses (kg ha^{-1})
SN, SP and SK are soil N, P and K nutrients (kg ha^{-1})
T is yield target (q ha^{-1})
WF is whole field data
YM is yield maximum data
Response ratio is measured as kg/kg

4.2.5.2.2. READY RECKONERS OF FERTILIZER DOSES FOR VARYING SOIL TEST VALUES

Using the fertilizer adjustment equations as described in Tables 27 and 30, optimum fertilizer doses for varying soil test values have been computed with in the range of soil test values as observed for the Jagtial location. The ready reckoners of fertilizer N, P and K doses for varing soil test values of all the three nutrients for both maximum yield, maximum profit and a desired rate of return indicate that the doses are meaningful for attaining different levels of yield.

4.2.6. BASIC DATA AND TARGETTED YIELD EQUATIONS

The basic data viz., nutrient requirement (NR), contribution from soil (CS) and fertiliser (CF) have been derived for both Jagtial and Warangal centres using the procedures as described under Materials and Methods chapter.

4.2.6.1. JAGTIAL CENTRE

The basic data viz., estimates of NR, CS and CF have been derived under both Conventional and Simultaneous estimation procedures and are given in the Table 32. The estimates have been derived from the data obtained from 42 plots (whole field) under the Conventional procedure, and 14 plots (means of 3 replications) under the Simultaneous

Table 33. Nutrient requirement of rice, soil and fertiliser contributions in soils of Warangal (kharif 1996)

Method		Basic data			Targetted yield equation	Response ratio
		NR	CS	CF		
Conventional (WF)	N	1.82	44.4	143.7	FN = 10.32 T - 1.28 SN	4.5
	P	0.22	4.8	5.6	FP = 3.62 T - 0.89 SP	
	K	0.18	12.3	16.9	FK = 8.51 T - 0.40 SK	
Conventional (YM)	N	1.61	39.6	123.6	FN = 8.45 T - 1.18 SN	5.2
	P	0.22	4.8	5.6	FP = 3.79 T - 1.04 SP	
	K	0.19	10.5	17.6	FK = 7.04 T - 0.38 SK	
Simultaneous (WF)	N	1.89	27.0	34.2	FN = 5.52 T - 0.79 SN	6.8
	P	0.20	14.0	12.4	FP = 1.60 T - 1.13 SP	
	K	1.21	8.5	15.9	FK = 7.59 T - 0.54 SK	
Simultaneous (YM)	N	1.79	27.0	34.2	FN = 5.23 T - 0.79 SN	7.8
	P	0.19	14.0	12.4	FP = 1.55 T - 1.13 SP	
	K	1.20	8.5	15.9	FK = 7.57 T - 0.54 SK	

N, P and K are abbreviated for N, P_2O_5 and K_2O
FN, FP and FK are fertilizer N, P_2O_5 and K_2O doses (kg ha^{-1})
SN, SP and SK are soil N, P and K nutrients (kg ha^{-1})
T is yield target (q ha^{-1})
WF is whole field data
YM is yield maximum data
Response ratio is measured as kg/kg

estimation procedure. The basic data indicates that NR of N is around 3.0, while P_2O_5 and K_2O are around 0.75 and 2.0 respectively. While the fertilizer efficiencies of all the three nutrients were more under Simultaneous estimation procedure, the estimates of soil efficiency were high under the Conventional procedure. The targetted yield equations have been derived with the basic data under both procedures, and the response ratios have been derived under each set of equations.

The results were found to agree with the published information for the soils of Jagtial region. The response ratios were found to be higher under the Simultaneous estimation procedure (6.7 to 8.4) when compared to those derived under the Conventional procedure (5.8 to 7.9).

4.2.6.2. WARANGAL CENTRE

The estimates of NR, CS and CF have been derived under both Conventional and Simultaneous estimation procedures and are given in the Table 33. The estimates have been derived from the whole field data (with 42 plots) under conventional procedure, and only 14 plots (means of 3 replications) under Simultaneous estimation procedure. The basic data indicates that NR of N is around 1.8, while P_2O_5 and K_2O are around 0.22 and 1.2 respectively. While the soil and fertilizer efficiencies of N and K were high under

Table 34. Ready reckoner for making fertiliser recommendation for different yield targets of rice based on soil test values Jagtial soils

Soil test values (kg/ha)			Fertilizer doses (kg/ha)					
			T=30 (q/ha)			T=35 (q/ha)		
KMnO4-N	OLSEN-P	AMAC-K	FN	FP	FK	FN	FP	FK
WHOLE FIELD (Conventional)								
90	10	100	216	112	91	261	135	110
140	15	120	184	101	86	230	123	105
190	20	140	153	89	82	198	112	100
240	25	160	121	78	77	167	100	96
290	30	180	90	66	72	135	89	91
340	35	200	58	54	68	104	77	87
390	40	220	27	43	63	72	65	82
440	45	240	0	31	58	41	54	77
YIELD MAXIMUM (Conventional)								
90	10	100	137	84	76	166	101	92
140	15	120	113	74	71	143	91	88
190	20	140	90	64	67	120	82	83
240	25	160	67	54	62	97	72	78
290	30	180	44	44	57	74	62	74
340	35	200	21	35	53	51	52	69
390	40	220	0	25	48	28	42	65
440	45	240		15	43	5	32	60
WHOLE FIELD (Simultaneous)								
90	10	100	147	48	99	181	60	129
140	15	120	118	37	83	152	49	113
190	20	140	89	26	67	123	38	97
240	25	160	60	16	51	94	27	81
290	30	180	31	5	36	65	16	65
340	35	200	2	0	20	36	6	50
390	40	220	0		4	7	0	34
440	45	240			0	0		18
YIELD MAXIMUM (Simultaneous)								
90	10	100	134	48	94	166	59	122
140	15	120	105	37	78	137	49	106
190	20	140	76	26	62	108	38	91
240	25	160	47	15	46	79	27	75
290	30	180	18	4	30	50	16	59
340	35	200	0	0	15	21	5	43
390	40	220			0	0	0	27
440	45	240						12

Table 35. Ready reckoner for making fertilizer recommendation for different yield targets of rice based on soil test values for Warangal soils

Soil test values (kg/ha)			T=35 (q/ha)			T=45 (q/ha)		
			Fertilizer doses (kg/ha)					
KMnO4-N	OLSEN-P	AMAC-K	FN	FP	FK	FN	FP	FK
WHOLE FIELD (Conventional procedure)								
100	10	300	233	118	178	336	154	263
140	20	350	182	109	158	285	145	243
180	30	400	131	100	138	234	136	223
220	40	450	80	91	118	183	127	203
260	50	500	28	82	98	132	118	183
300	60	550	0	73	78	80	110	163
340	70	600		64	58	29	101	143
380	80	650		56	38	0	92	123
YIELD MAXIMUM (Conventional procedure)								
100	10	300	178	122	132	262	160	203
140	20	350	131	112	113	215	150	184
180	30	400	83	101	94	168	139	165
220	40	450	36	91	75	121	129	146
260	50	500	0	81	56	73	119	127
300	60	550		70	37	26	108	108
340	70	600		60	18	0	98	89
380	80	650		49	0		87	70
WHOLE FIELD (Simultaneous procedure)								
100	10	300	114	45	104	169	61	180
140	20	350	83	33	77	138	49	153
180	30	400	51	22	50	106	38	126
220	40	450	19	11	23	75	27	99
260	50	500	0	0	0	43	16	72
300	60	550				11	4	45
340	70	600				0	0	18
380	80	650						0
YIELD MAXIMUM (Simultaneous procedure)								
100	10	300	104	43	103	156	58	179
140	20	350	72	32	76	125	47	152
180	30	400	41	20	49	93	36	125
220	40	450	9	9	22	62	25	98
260	50	500	0	0	0	30	13	71
300	60	550				0	2	44
340	70	600					0	17
380	80	650						0

conventional, the values for P were more under simultaneous estimation procedure.

The targetted yield equations have been derived with the basic data under both procedures, and the response ratios have been worked out under each set of equations. The results were found to agree with the published data available for the soils of Warangal region. The response ratios were found to be higher under the Simultaneous estimation procedure (6.8 to 7.8) when compared to those derived under the Conventional procedure (4.5 to 5.2).

4.2.7. READY RECKONERS FOR PRESCRIBING SOIL TEST BASED FERTILIZER DOSES FOR DIFFERENT YIELD TARGETS

Using the targetted yield equations, an attempt has been made to compute the ready reckoners of optimum fertilizer doses for varying soil test values for attaining desired yield targets under the established ranges of soil fertility for the two regions viz., Jagtial and Warangal. The fertilizer doses were found to confirm with the already published data and results of different workers. The ready reckoners are given in Table 34 for the Jagtial soils and Table 35 for the Warangal soils. The ready reckoners indicate that the optimum fertilizer doses are well within the experimented doses of N, P and K, and are found to be meaningful for attaining the grain yields that have been derived. Further, these results also are valid for the farmer's field conditions under the Sreeramsagar Project Command area, since the soil fertility status and test values are converging with those of the experimental stations.

4.2.8. COMPARISON OF SOIL TEST METHODS FOR ESTIMATION OF NITROGEN

In the experiments at both Jagtial and Warangal, soil nitrogen has been estimated by three methods viz., based on organic carbon, alkaline permanganate method, and calcium hydroxide method. Estimates of correlation of the soil test values as analysed under these methods and grain yield have been determined, which indicated that alkaline permanganate method is comparitively a more reliable method for estimating soil nitrogen since it had a higher and significant correlation with yield for both alfisols and inceptisols of Jagtial (r=0.549 **) and vertisols of Warangal (r=0.492 **).

With the multiple regression analysis also, the same result has been observed, since the regression models with the combination of soil N as estimated by permanganate method were found to have a higher predictability (R^2 value) when compared to the regression models with other combinations of variables of soil N. This is evident from the different regression equations described for both the locations in the section 4.2.5.

DISCUSSION & CONCLUSIONS

CHAPTER - V

5.DISCUSSION

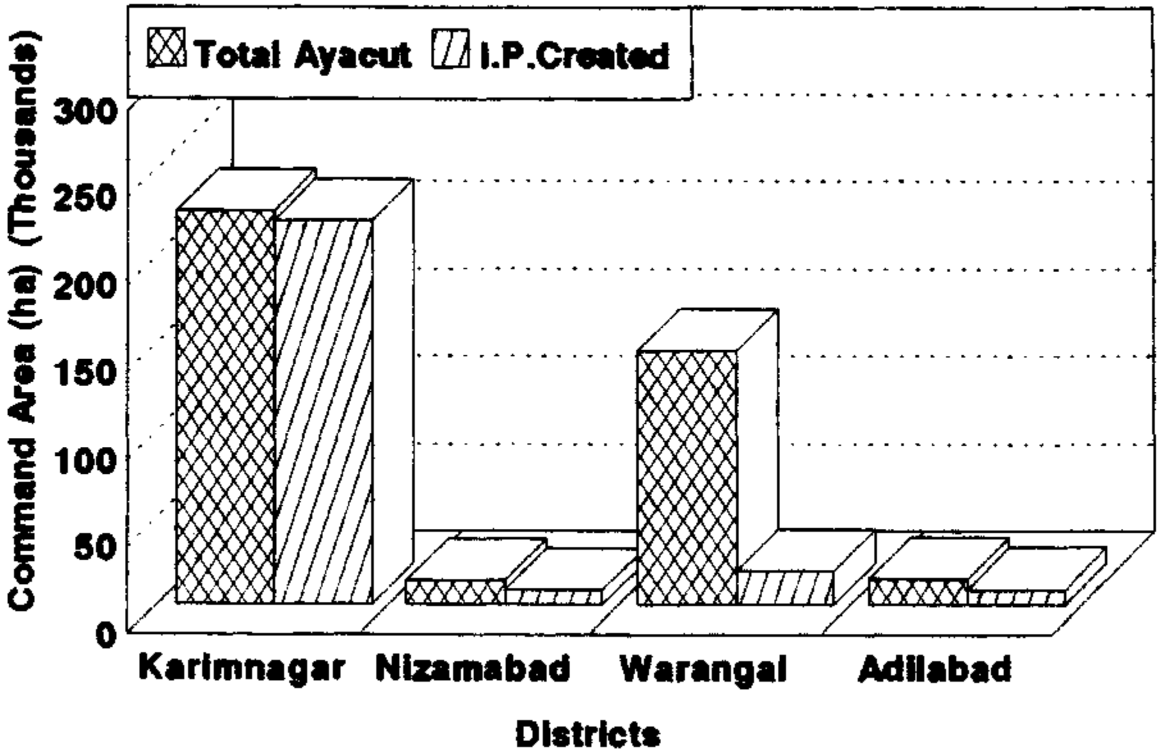
Andhra Pradesh is considered as the rice bowl of the country. Nitrogen is the major nutrient limiting crop productivity in Indian soils and crops need nitrogen in large amounts. The large increase in nitrogen fertilizer usage in recent years has led to recognition of the need for the reliable methods of measuring nitrogen supplying capacity of soils and predicting their individual nitrogen fertilizer requirements. Site specific fertilizer recommendations for targetted yields of paddy are today's prime concern which is dependent on the N supplying capacity of paddy soils. Nitrogen is a vital input in Indian agriculture. Based on soil test values, soil test based fertilizer recommendations have to be evolved so as to make full use of native soil fertility. Fertilizer recommendation for efficient and economic crop production is based on soil testing as one of the essential factors.

Many biological and chemical laboratory methods of testing the soil for available N have been proposed for predicting soil nitrogen availability (Bremner, 1965; Chang, 1978; and Sahrawat, 1983). The present investigation has attempted a fertilizer N recommendation for the farming areas for irrigated rice of Sreeramsagar Project command. The investigation has also attempted to evaluate the three different soil test procedures for available N to elucidate appropriate method that can be adopted by the soil testing laboratories. The appropriate method of soil testing to determine the available soil nitrogen found suitable, if adopted by the soil testing laboratories, can enhance the value of soil test data and help rationalise the use of fertilizer N (Dubey et al. 1972). Velayutham (1984) stressed that the key to increase the fertilizer use efficiency lies in the application of fertilizer nutrients based on soil testing to meet the crop requirements.

5.1. SREERAMSAGAR PROJECT COMMAND AREA

Sreeramsagar project reservoir is constructed across the Godavari river near Pochampad village of Nizamabad district in the northern Telangana zone of Andhra Pradesh. It is proposed to utilise 200 tmc of Godavari waters through this project to irrigate an area of 8.48 lakh hectares under its command spread over in the districts of Adilabad, Nizamabad, Karimnagar, Warangal, Khammam and Nalgonda under the three canal systems viz., Kakatiya, Saraswathi and Laxmi canals. Out of which four districts viz., Karimnagar, Warangal, Adilabad and Nizamabad were chosen as they

Fig.24 District-wise Ayacut/Irrigation potential created in Sri Ram Sagar Project Command Area (Stage-1)



are the main beneficiaries of the project command accounting to 2.55 lakh hectares of land area irrigated by the project out of the total command of 3.97 lakh hectares currently irrigated which is shown in Appendix 1(b) and Fig.24. The topography of the command area is rolling type with undulating physical features. The slope of the land ranged from 1 to 3 per cent. The nature of the soils are diversified ranging from red chalka soils to black clayey soils. The climate of command area is semi-arid with dry hot summer and fairly severe winter (Minimum temperatures recorded 9-10° C). The average annual rainfall is 944 mm.

5.2. SOIL FERTILITY SURVEY OF SREERAMSAGAR PROJECT COMMAND AREA

An extensive survey was conducted during 1993 and 1994 in command area of Sreeramsagar Project (SRSP), also popularly called as Pochampad Project with the help of SRSP command area maps and toposheets of Adilabad, Karimnagar, Warangal and Nizamabad districts for earmarking road maps as well as index map showing the wet cultivated area of distribution under two canals studied viz., Saraswathi canal and Kakatiya canal of the project. A total of 21 units have been identified from grid locations using toposheets and 60 villages were selected covering four districts of command area. The 60 villages which have been chosen are depicted in the Map at M-1. A questionnaire was prepared for collecting the information from 300 farmers spread over 60 villages of the four districts. Soil samples were collected from the selected fields initially before the rice crop was transplanted. Subsequently samples of the soil were collected at the panicle initiation and post-harvest stages of the crop. Supporting information on cultivation practices, manurial schedules, history of holdings, farmer's practice of fertilizer application, and the yield obtained in the fields have been collected through the questionnaire as given in Appendix 1.

5.2.1. FERTILITY STATUS OF THE SOILS OF SREERAMSAGAR PROJECT COMMAND AREA

These command area soils were found to be red (alfisols and inceptisols) and black soils (vertisols). The red soils which comprise of 65 % of the area were sandy loam to loamy sand in texture. The black soils which comprise of 35 % of the area were found to be clay loam to silty clay in texture. The surveyed area were mostly concentrated in Karimnagar district as it occupies the major chunk of irrigated paddy areas of the Sreeramsagar project.

Initial soil samples were collected from rice farmer's plots from 0-15 cm soil depth. The pH of the soils analysed indicated that majority of soils are moderately alkaline to slightly acidic in soil reaction with pH ranging from 5.14 to 8.85 in Karimnagar, 6.45 to 7.91 in Nizamabad, 6.02 to 8.96 in Warangal and 5.61 to 8.16 in Adilabad districts. The total number of soils collected from farmer's fields in the four districts were 230 in Karimnagar, 15 in Nizamabad, 25 in Warangal, and 30 in Adilabad, thus totalling to 300 from as many farm holdings. Initial soil samples were collected at the rate of 5 samples from each village using quartering method. The names of farmers, initial soil test values, applied fertilizer doses are shown in Appendix 2. The mandal-wise distribution of villages alongwith the distributories allotted and attached to the villages are given in Table 1. EC values were found to range from 0.10 to 0.68 in Karimnagar, 0.03 to 0.4 in Nizamabad, 0.06 to 0.46 in Warangal, and 0.09 to 0.68 $dS\ m^{-1}$ in Adilabad districts. Organic carbon (%) status as shown in Appendix 2 ranged from 0.28 to 1.97 percent in Karimnagar, 0.67 to 1.68 in Nizamabad, 0.31 to 2.02 in Warangal , and 0.47 to 1.92 in Adilabad districts. Olsen's P was found to range from 6 to 55, 18 to 46, 7 to 35, and 8 to 56 kg/ha in the soils of Karimnagar, Nizamabad, Warangal and Adilabad districts respectively. Exchangeable soil K by ammonium acetate method ranged from 96 to 528, 189 to 645, 110 to 382 and from 102 to 502 kg/ha in the soils of Karimnagar, Nizamabad, Warangal and Adilabad districts respectively.

5.2.1.1. CATEGORISATION OF SOILS BASED ON NUTRIENT AVAILABILITY

The soils of these four districts were classified into 'Low', 'Medium' and 'High' categories with respect to nutrient status and are given in Tables 9 and 10 for initial and panicle initiation stages respectively. Based on organic carbon (%) status, it was found that 25 (8.3 %) soils were low when compared to 49 (16.3 %) under medium and 226 (75.3 %) under high soil fertility categories in all the four districts. Using the data obtained for estimating the available nitrogen by adopting alkaline permanganate method, the soils were found to be 288 samples (96 %) tested Low, 11 (3.7 %) Medium and only 1 (0.3 %) under High spread over all the four districts.

It is observed from Tables 9 and 10 that the soils of Karimnagar, Nizamabad and Adilabad were having a high nutrient index, while a medium nutrient index was evident for Warangal soils (2.0) based on organic carbon determined initially on soil samples collected before rice transplantation. However, based on KMnO4 method, the soils were found to be low since they have a nutrient index which is lower than 1.5. The mean nutrient index over all the four districts of the survey soils was found to be high (2.67) based on organic carbon estimation, while it was low (1.04) with alkaline permanganate method for available N.

At panicle initiation stage, the nutrient indices based on the organic carbon (%) indicated that the soils were falling under high category at Karimnagar (2.74), Nizamabad (2.87) and Adilabad (2.77), whereas at Warangal it was found to be medium (2.44). The nutrient indices based on KMnO4 method were found to be low in all the four districts, with 285 (95 %) under low, 13 (4.3 %) under medium and 2 (0.7 %) under high categories for soil N in the four districts.

5.2.1.2. CATEGORISATION OF SOILS BASED ON TEXTURAL CLASSES AND NUTRIENT AVAILABILITY

5.2.1.2.1. CLASSIFICATION BASED ON INITIAL SOIL N

The soils have been classified into different textural classes within a district and categorised the soil N fertility into low (L), medium (M) and high (H) groups based on organic carbon content and available N status (alkaline permanganate extraction) and are given in Table 11. The number of samples falling in each textural class were delineated and the data have been utilised for predicting the post-harvest soil test values through initial soil test values. Based on the initial soil test values, the results of Karimnagar district indicated that maximum number of soils pertained to sandy clay loam (9 L, 14 M and 104 H), followed by clay loam (3 L, 12 M and 37 H), sandy loam (2 L, 7 M and 31 H), silt loam (3 M and 3 H), clayey (2 M and 1 H) and loamy sand (2 M) out of 14 L (6.1 %), 40 M (17.4 %), and 176 H (76.5 %) with organic carbon estimates. The ratings based on $KMnO_4$ method for available N under different soil textures were found to be sandy clay loam (124 L, 1 M and 1 H), followed by clay loam (50 L and 6 M), sandy loam (36 L and 1 M), silt loam (7 L), clayey (2 L) and loamy sand (2 L) out of 221 L (96.1 %), 8 M (3.5 %) and 1 H (0.4 %). The values of nutrient index based on organic carbon method have indicated that the soils of textures sandy clay loam (2.75), sandy loam (2.73), clay loam (2.65) fell under high category, while clayey (2.33) and loamy sand (2.00) fell under medium category. The dominant soil textures in other districts were found to be clay loam (11 out of 25) in Warangal with an index of 2.36, sandy clay loam (5 out of 15) in Nizamabad with a nutrient index of 3.0, and clay loam (22 out of 30) in Adilabad with a nutrient index of 2.91 with organic carbon method. Similarly, the categorisation of soils in different textures based on alkaline permanganate method indicated that 14 (93.3 %) out of 15 soils in Nizamabad, all the 25 soils in Warangal, and 28 (93.3 %) out of 30 soils in Adilabad were found to be having low N soil fertility status. The nutrient index values have also indicated that the soils of all the districts surveyed were having a low soil N fertility status based on the alkaline permanganate method.

5.2.1.2.2. CLASSIFICATION BASED ON SOIL N AT PANICLE INITIATION STAGE

Similar categorisation of soil test values at panicle initiation stage into low, medium and high based on the organic carbon content of the soils given in Table 12 indicated that it was high in 185 (80.4 %) soils, medium in 33 (14.3 %) soils, and low in 12 (5.2 %) with a high nutrient index of 2.75 over different soil textures of Karimnagar district. The predominant soil textural class was found to be sandy clay loam with 101 (82.1 %) in high, 17 in medium (13.8 %) and 5 low (4.1 %). Based on $KMnO_4$ method, it was found that 219 (95.2 %) soils were low, 7 (3.0 %) were medium, and 4 (1.7 %) were high in Karimnagar district with a low nutrient index of 1.07 over different textures.

In Nizamabad district 12 (80 %) were found to be high, 2 (13.3 %) were found to be medium, and 1 (6.7 %) was found to be low based on organic carbon method with a high nutrient index of 2.73 over different soil textures. Except silt clay loam with a medium nutrient index of 2.4, all the other soil textures were found to be having a high nutrient index (>2.5). Based on $KMnO_4$ method, it was observed that all the soils were in the category Low with a low nutrient index.

In Warangal district, the predominant soil texture was sandy clay loam with 9 (60 %) soils under high, 4 (26.7) under medium, 2 (13.3 %) under low categories with a Medium nutrient index of 2.47 using organic carbon method. With $KMnO_4$ method, 14 (93.3 %) soils were found to be low and 1 (6.7 %) was medium under this soil texture with a low nutrient index of 1.07.

In Adilabad district, it was observed that 26 (86.7 %) soils were high, 2 (6.7 %) each under low and medium categories based on organic carbon method with a high nutrient index of 2.80. Using $KMnO_4$ method, it was observed that 28 (93.3 %) soils were low, 2 (6.7 %) were medium over different textures with a low nutrient index of 1.07. The predominant soil texture was clay loam in this district with 19 (90.5 %) soils having high organic carbon content with a nutrient index of 2.86, and low soil N in 20 (95.2) soils with a low nutrient index of 1.05 out of 21 soils in this texture.

5.2.1.2.3. CLASSIFICATION BASED ON SOIL N, P AND K AT POST-HARVEST STAGE

Based on the soil textural classification made with the data of soil N as observed at post-harvest stage and given in Table 13, it was found that soil fertility with respect to N was predominantly low in all textures with 129 (97.7 %) in Karimnagar, 23 (92 %) in Warangal, and 18 (100 %) in Adilabad districts. At Nizamabad the soil fertility was found to be medium in 7 (58.3 %) soils. The nutrient indices over all textures were found to be 1.03 for Karimnagar, 1.64 for Nizamabad, 1.08 for Warangal, and 1.00 for Adilabad districts.

The texture wise classification of soils based on Olsen's P and ammonium acetate K methods for the four districts are given in Table-13(a). In Karimnagar district, soil P was found to be medium in 53 (40.2 %) and high in 73 (55.3 %), and low in 6 (4.5 %) soils with a nutrient index of 2.51 over different textures. Sandy clay loam texture was dominant in 25 M (35.7 %) and 41 H (58.6 %) categories. In Nizamabad district, the soil P was high in 8 (72.7 %) and medium in 3 (27.3 %) soils with a nutrient index of 2.73 over different textures. Out of 25 soils in Warangal, 18 (72 %) were high, 6 (24 %) were medium and 1 (4 %) was low based on soil P categorisation over different textures with a nutrient index of 2.68. The dominant soil texture was sandy clay loam in 11 (73.3 %) under high, and 3 (20 %) under medium categories with a nutrient index of 2.67. Based on the textural classification in Adilabad district with soil P data, it was observed that 13 (72.2 %) soils are high, and 5 (27.8 %) soils are medium with a nutrient index of 2.72.

The textural classification of soils based on ammonium acetate K method indicated that the soils of Karimnagar were medium in 67 (50.8 %) and high in 62 (47 %) with a nutrient index of 2.45 over different textures. The predominant soil texture was sandy clay loam which was medium in 37 (52.9 %) and high in 32 (45.7 %) soils with a nutrient index of 2.44. In Nizamabad, 7 (63.6 %) soils belonging to different textures were under high, and 4 (36.4 %) under medium soil fertility categories with a nutrient index of 2.64. In Warangal, 18 (72 %) were medium and 5 (20 %) were high with a nutrient index of 2.12, the leading soil texture being sandy clay loam which was low in 1 (6.7 %), medium in 12 (80 %) and 2 (13.3 %) soils with a nutrient index of 2.07. In Adilabad district, 6 (33.3 %) were low, 9 (50 %) were medium, and 3 (16.7 %) soils were high with a nutrient index of 1.83.

5.2.2. RELATIONSHIP BETWEEN SOIL TEST VALUES AND PLANT N CONTENT

During the second visit of survey, soil samples were collected at panicle initiation stage for estimation of available N by organic carbon and $KMnO_4$ methods. Plant samples of rice from 3rd leaf from top were also collected for determination of N content in plants. A wide range in plant N content was observed in the four surveyed districts. The mean plant N (C.V. %) was found to be 1.77 (31.4 %) in Karimnagar, 1.75 (20.7 %) in Nizamabad, 1.94 (34.9 %) in Warangal and 2.14 (33.2 %) in Adilabad districts as given in Appendix 3. A positive and significant correlation of plant N content was observed with organic carbon content in Karimnagar (0.51 **), $KMnO_4$ N in Karimnagar (0.59 **), Warangal (0.46 **) and Adilabad (0.49 **) soils at panicle initiation stage. The correlations of plant N with soil test values of both methods at Nizamabad, and with organic carbon at Warangal and Adilabad though positive were nonsignificant. The estimates of correlation are given in Table 5. The correlations indicated that $KMnO_4$ method of soil N was better related with plant N content than organic carbon method.

5.2.3. RELATIONSHIP BETWEEN PLANT N CONTENT AND YIELD OF RICE CROP

Estimates of correlation between plant N content and grain yield in farmer's fields have been worked out and are given in Table 5. The correlations have indicated that a positive and significant relationship existed between these two variables in all the four districts. The correlations were 0.52 ** at Karimnagar, 0.61 * at Nizamabad, 0.41 * at Warangal, and 0.50 * at Adilabad districts. The correlations indicate that farmers can obtain high yields of rice only if suitable rice cultivars which provide a high plant N content are cultivated. This is indicative of the fact that either the plant should have inherent capacity to absorb actively soil N and the conditions for active absorption of soil N by rice plant should be ensured through proper dose, placement, weed control and irrigation practices.

5.2.4. RELATIONSHIP BETWEEN SOIL FERTILITY AND YIELD OF RICE CROP

The relationship between grain yield and initial soil test values of N, P and K have been computed and are given in Table 5. The correlations have indicated that a negative and significant relationship existed between grain yield and soil P (-0.33 **) and soil K (-0.25 **) in

Karimnagar, organic carbon (-0.61 *) and soil P (-0.60 *) at Nizamabad, soil P (-0.41 *) and soil K (0.40 *) in Warangal districts. The correlations of all other variables were nonsignificant. The correlations were found to be negative which may be due to soil heterogenity in different textures and improper management practices adopted currently by the farmers. The other main reason could be unregulated water supply and improper irrigation management.

5.2.5. RELATIONSHIP BETWEEN FERTILIZER USE AND CROP YIELD OF RICE

The relationships between fertilizer N, P and K and grain yield of each of the four survey districts have been computed and are given in Table 5. The correlations were found to be significant in Karimnagar for fertilizer N (0.39 **), fertilizer P (0.21 *) and fertilizer K (0.46 **) nutrients. The relation between fertilizer K and grain yield alone was found to be significant in Warangal district (0.39 *). The relationship of grain yield with fertilizer N was 0.49 * and with fertilizer K was 0.48 * in Adilabad district. All the other correlations were found to be nonsignificant, which may be due to non-judicious application of fertilizers without resorting to soil test data. The significant positive correlations have also indicated that the chemical fertilizers have provided a good yield response in most of the surveyed soils, and hence can form the basis for developing a proper fertilization schedules for optimising yields taking into consideration soil test data.

5.2.5.1. RELATIONSHIP BETWEEN SOIL TEST VALUES AND FERTILIZER DOSES

The correlations of soil test values and fertilizer doses as given in Table 5 have indicated that there is a negative correlation between soil K and fertilizer K (-0.24) in Karimnagar, organic carbon and fertilizer N (-0.38) and soil N and fertilizer N (-0.39) in Nizamabad districts. Similarly, the relations of soil K and fertilizer K (-0.30) in Warangal, organic carbon and fertilizer N (-0.31), soil N and fertilizer N (-0.35), soil P and fertilizer P (-0.36), and soil K and fertilizer K (-0.31) in Adilabad district were also found to be negative. These correlations indicate that the soil and fertilizer variables are useful for developing a basis of fertilizer adjustment using soil test values for these districts.

5.2.6. PREDICTION OF POST-HARVEST SOIL TEST VALUES

The multiple regression equations for predicting post-harvest soil test values based on initial soil test values, applied fertilizer doses and harvested grain yield

Fig.23(a). Changes in soil fertility of N from initial to post harvest stages in different surveyed districts

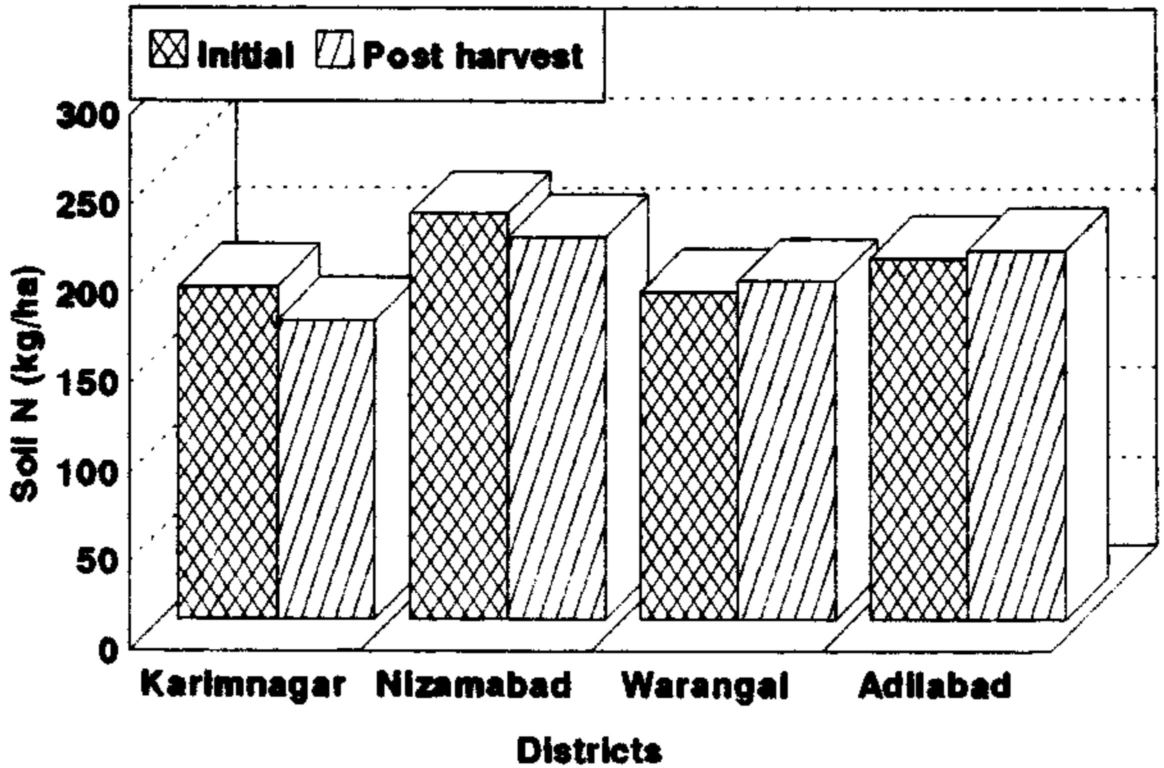


Fig.23(b). Changes in soil fertility of P from initial to post harvest stages in different surveyed districts

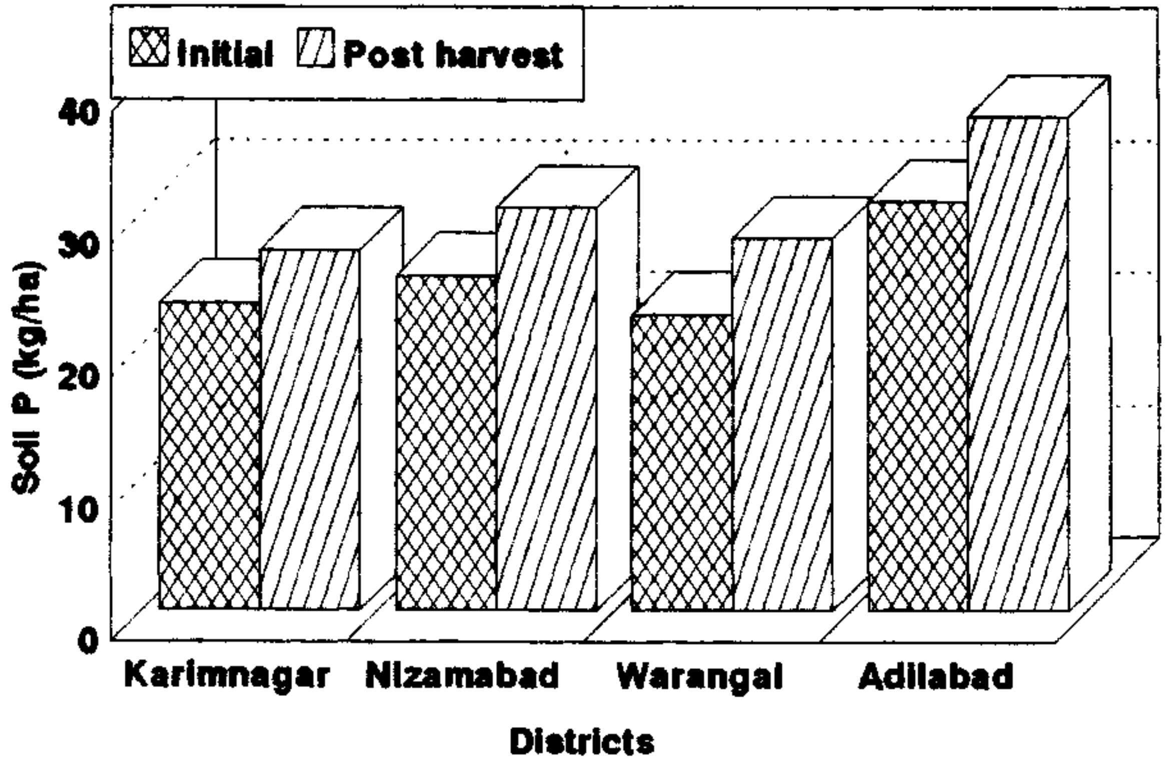
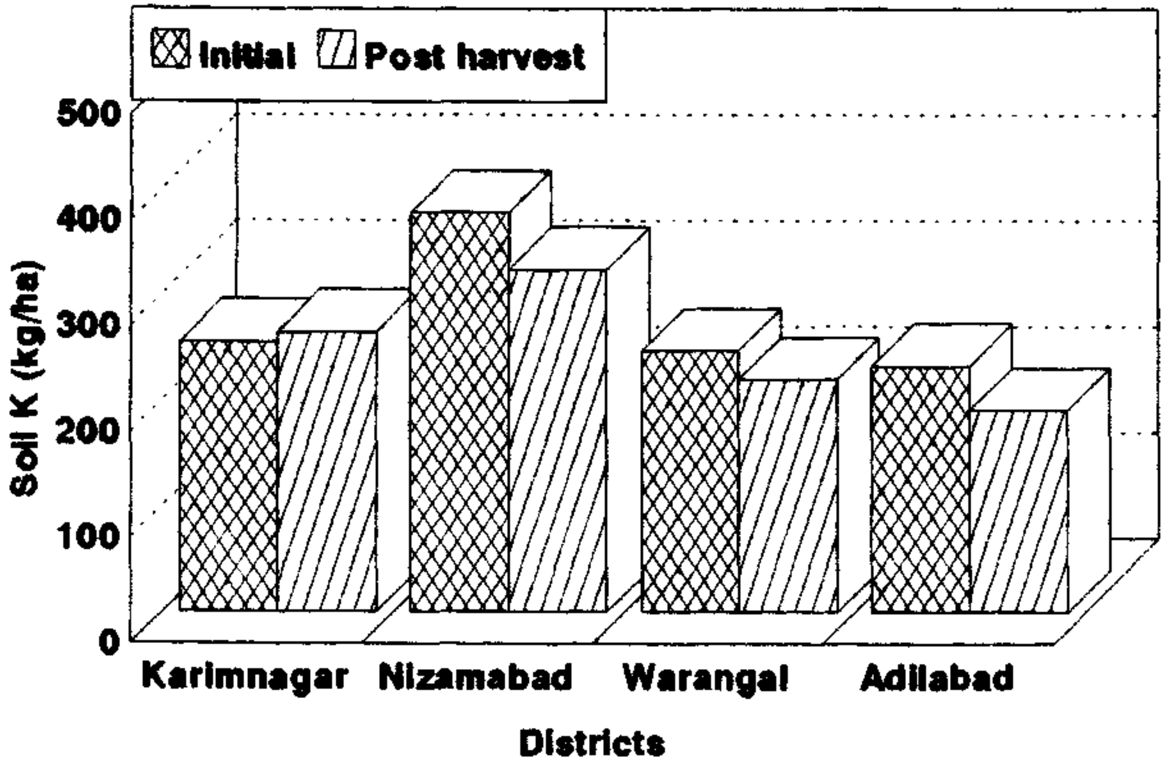


Fig.23(c). Changes in soil fertility of K from initial to post harvest stages in different surveyed districts



for each district are given in Table 6. From the regression equations it is observed that the post-harvest soil test values can be predicted with a high and significant predictability in all the four districts covering the area surveyed. The soil N prediction values were found to be 0.69 ** for Karimnagar, 0.82 ** for Nizamabad, 0.84 ** for Warangal, and 0.54 ** for Adilabad districts. Highly significant R^2 values of soil P for the above four districts were found to be 0.62 **, 0.66 **, 0.77 ** and 0.85 ** respectively. The predictability of soil K was found to be 0.52 ** for Karimnagar, 0.48 * for Nizamabad, 0.63 ** for Warangal, and 0.88 ** for Adilabad districts. The regression coefficients of initial soil N, P and K nutrients were highly significant (at 1 % level of significance) for the three nutrients in all districts except soil P in Karimnagar, and soil K in Nizamabad and Warangal districts. The fertilizer N, P and K variables and grain yield in surveyed soils were found to be nonsignificant for predicting post-harvest soil test values of all the three nutrients. Fig. 23(a), 23(b) and 23(c) indicate the changes in soil fertility of N, P and K from initial to post-harvest stages in each district, showing a depletion of soil N and build up of soil P and K in Karimnagar, depletion of soil N and K, and build up of soil P in Nizamabad, build up of soil N and P and depletion of soil

K in Warangal, and build up of soil N and P and depletion of soil K in Adilabad districts.

5.2.7. PREDICTION OF AVAILABLE N STATUS FROM ORGANIC CARBON CONTENT OF SOILS

A significant correlation was found to exist between organic carbon and alkaline permanganate N in different textural groups of Karimnagar soils. High predictability (R^2 more than 0.6 **) was found to exist for predicting KMnO4-N through organic carbon content in clay loam (0.62 **) and sandy clay loam (0.69 **) soil textures. The predictability was about 0.57 ** in sandy loam 0.59 ** in silt loam textures for soil N. The prediction equations have been calibrated and are given below for different soil textures of Karimnagar district as shown in Table 8.

Texture	Prediction equation	R^2 value
Clay loam	$KMnO_4\text{-}N = 159 + 39.9^{**}\ OC\ (\%)$	0.62 **
Sandy clay loam	$KMnO_4\text{-}N = 168 + 21.7^{**}\ OC\ (\%)$	0.69 **
Sandy loam	$KMnO_4\text{-}N = 148 + 44.3^{**}\ OC\ (\%)$	0.57 **
Silt loam	$KMnO_4\text{-}N = 78 + 145.8^{**}\ OC\ (\%)$	0.59 **

(OC : Organic carbon (%)

(KMnO4-N : Available equivalent N)

Using the above equations, it is possible to predict the available N content of soils of various textural classes which can be used by the soil testing laboratories. This would improve the efficiency of soil testing services and enable the laboratories to provide fertilizer recommendations in time for rice. These findings have also been confirmed with the work carried out in the Soil Test Crop Response Correlation Project (Velayutham et al, 1984).

The prediction equations of soil N through organic carbon content of the four districts over all soil textures are given below :

District	Prediction equation	R^2 value
Karimnagar	KMnO4-N = 152 + 12.78** OC	0.66 **
Nizamabad	KMnO4-N = 288 - 59.81** OC	0.60 **
Warangal	KMnO4-N = 174 + 12.25** OC	0.61 **
Adilabad	KMnO4-N = 125 + 38.99** OC	0.71 **

OC : Organic carbon (%)

KMnO4-N : Available equivalent N

A ready reckoner showing the predicted soil N based on KMnO4 method through organic carbon (%) content of each district is given in Table 7. The predicted soil N was found to range between 153 to 179 kg/ha in Karimnagar, 162 to 282 kg/ha in Nizamabad, 175 to 200 kg/ha in Warangal, and 132 to

270 kg/ha in Adilabad districts for a varying organic carbon content of 0.1 to 2.1 percent in these soils. The predicted values of soil N indicate that the values are highly and significantly predictable and are within the ranges of soil N as observed in the farmer's fields of different districts.

5.2.8. QUICK SOIL TESTS

5.2.8.1. QUICK SOIL TESTS OF SOIL N WITH ORGANIC CARBON

Based on 150 samples collected from farmer's fields of four districts, quick soil tests were adopted for assessing the fertility of the soils. The classification of soils under different textures falling under Low, Medium and High categories with the quick soil test for N as determined by organic carbon content using colour comparator is given in Table 14. From these results, it was observed that 107 (89.2 %) soils were low, 5 (4.2 %) were medium and 8 (6.7 %) were high in Karimnagar district over different textures with a low nutrient index of 1.17. In Nizamabad and Warangal districts, all the 8 samples studied in each district have fallen under the low soil fertility category. In Adilabad district, 10 (71.4 %) soils were found to be low, and 4 soils (28.6 %) were medium with a nutrient index of 1.29.

5.2.8.2. COMPARISON OF ROUTINE SOIL TESTS WITH QUICK SOIL TESTS

Soil testing laboratories in the state recommend fertilizer N based on crop response data with less emphasis on soil test value. Since organic carbon is an index of soil N, it is being followed by the laboratories. As a quick test procedure soil organic carbon content soil organic carbon content is determined as an approximation using colour comparator method. Based on determination of organic carbon content of soils by Walkley and Black (1934) titrimetric method, the 150 soils selected from the area surveyed in the four districts were categorised as Low, Medium and High and are given in Table 14(a). Based on organic carbon (%) status, it was found that 9 (7.5 %) soils were low when compared to 20 (16.7 %) under medium and 91 (75.8 %) under high soil fertility categories in Karimnagar. Similarly, all the 8 samples under high category (100 %) in Nizamabad, 6 (75 %) under low and 2 (25 %) under high categories in Warangal and all the 14 samples (100 %) under high were observed in Adilabad district. A critical examination of the three methods of nitrogen between STL and university methods revealed interesting trends. With alkaline permanganate N method (Subbiah and Asija, 1956), the soils were assessed to be 114 (95 %) samples were Low, 6 (5 %) were Medium in

Karimnagar district as against all the 8 under high category in Nizamabad and Warangal, and 13 (92.9 %) as low, and 1 (7.1 %) as medium in Adilabad district. Thus the three methods viz., visual colour comparitive method, titrimetric method of OC and alkaline permanganate method of N were assessed and their relative performance was judged with mean nutrient indices as given in the Table 14(a). Based on quick soil tests done using qualitative colour comparison for organic carbon, it is observed that 107 (89.2 %) soils were low, 5 (4.2 %) were medium, and 8 (6.7 %) were high in Karimnagar district. All the 8 soils each in Nizamabad and Warangal were found to be low using quick soil tests. In Adilabad district, 10 (71.4 %) soils were low, and 4 (28.6 %) soils were found to be medium based on quick soil tests of organic carbon.

It is observed from Table 14(b) that the soils of Karimnagar, Nizamabad and Adilabad were having a high nutrient index (> 2.5), while a medium nutrient index was existing for Warangal soils (1.5) based on organic carbon at initial soil fertility. However, based on KMnO4 method, these soils were found to be low since they have a nutrient index of less than 1.5. The mean nutrient index over all the four districts was found to be high (2.68) with organic carbon method, while it was low (1.05) with alkaline permanganate method. The nutrient index was found to be 1.17 for

Karimnagar, 1.0 each at Nizamabad and Warangal, and 1.29 at Adilabad based on the classification made with the quick soil test method of organic carbon in the surveyed districts. It was observed that more than 50 % of the cases based on quick tests were not reliable as an index of soil fertility and fertilizer recommendation.

5.3. FIELD VERIFICATION STUDIES

Based on the results of survey of farmers fields in the command area of SRSP, and to confirm the recommendation of fertilizer N based on soil test values as these farmers have been using different doses of N, P and K which may either be in excess of actual needs or insufficient, two field verification trials were conducted one each in Karimnagar and Warangal districts namely at Jagtial and Warangal itself. The soils on which the experiment was laid out were representative of the soils of two districts, texturally.

5.3.1. DETAILS OF FIELD EXPERIMENTS

5.3.1.1. JAGTIAL CENTRE :

The field experiment was laid out with Rice variety IR-64 as the test crop during kharif 1996 at Regional Agricultural Research Station, Jagtial. A perusal of data of initial soil data reveals that the pH of the soil was 8.09

and the EC value was 0.289 dS m^{-1}. The soil had an organic carbon content of 0.31 percent , total N of 845 kg/ha and CEC of 6.44 C. mol $(P+)kg^{-1}$. The KMnO4 oxidizable N was 124.2 kg/ha and the Ca(OH)2 extractable N was 96 kg/ha. Texturally the soil was characterised as red sandy loam with 16% clay, 9.1 % silt and 75 % sand fractions. P fixation and recovery were found to be 45 and 55 percent respectively. The critical level of soil P was estimated to be 34 kg/ha. The data of different soil characteristics are presented in the Table 2(d) in "Materials and Methods". Twelve treatments as recommended by the International Soil Fertility Evaluation procedure of Waugh and Fitts (1961) were included in the experimentation. In addition a treatment representing the farmer's fertilization practice and the recommended level of application of fertilizers were also included in the layout thus totalling 14 treatments as detailed in Table 2(b) under "Materials and Methods".

5.2.1.2. **WARANGAL CENTRE**

At this centre also the different fertilization treatments included were similar to those employed at Jagtial centre and the layout details of the treatments is given in Table 2(c) under "Material and Methods". The rice variety employed selected was WGL-20471 (Erramallelu), a popular variety grown in the area. The soil texture was black clayey with 47.5 % clay, 15 % silt and 37.5 % sand. The pH and E.C. of the soil were 8.64 and 0.808 dSm^{-1} respectively. The soil contained 0.53 % organic carbon and KMnO4 available N of 184.6 kg/ha and Ca(OH)2 extractable N of 110 kg/ha. The total N content was 1204 kg/ha. The soil available P was found to be 29.4 kg/ha with a critical value of 40 kg/ha. P fixation and recovery were found to be be 65 and 35 percent respectively. The soil K was found to be 512 kg/ha. The CEC of the soil was 14.95 C mol $(P+)kgP^{-1}$. The initial soil characterisation of the centre is given in Table 2(e) under "Material and Methods".

5.3.2. **EVALUATION OF SOIL TEST METHODS FOR NITROGEN**

Three soil test methods or indices have been evaluated in the field experimentation at Jagtial and Warangal viz.,

i) Organic carbon (Walkley & Black, 1934) ;

ii) Alkaline permanganate method (Subbiah and Asija,1956) ; and

iii) Hot calcium hydroxide distillation method (Prasad, 1966).

These three methods have been correlated with different parameters like grain yield, drymatter, plant uptake of N, P and K nutrients, plant height, panicle length, applied fertilizer nutrients and inferences about the suitabilty of a soil test method have been drawn. These are found to be in confirmity with the work of Bajaj et al (1967), Subbiah and Bajaj (1968), Subbiah and Asija (1956), Prasad (1965) who obtained significant correlations with paddy and wheat yields using soil N estimation methods. At Jagtial, the organic carbon (%) was found to range between 0.06 and 0.73 with a mean of 0.26. The soil N based on KMnO4 method was found to range from 94 and 436 kg/ha with a mean of 158 kg/ha. Similarly, the soil N based on calcium hydroxide method was found to vary between 75 and 349 kg/ha with a mean of 126 kg/ha. The descriptive statistics of different parameters are given in the Table 18.

At Warangal, the organic carbon (%) was found to range between 0.12 and 1.05 with a mean of 0.64. The soil N based on KMnO4 method was found to be between 141 and 351 kg/ha with a mean of 202 kg/ha. Similarly, the soil N based on calcium hydroxide method was found to vary between 115 and 281 kg/ha with a mean of 162 kg/ha. The descriptive statistics of different parameters are given in the Table 18.

The correlations of different methods of soil N with grain yield are given in Table 23. Soil N based on alkaline permanganate method was found to have a high and significant correlation with grain yield at both Jagtial (0.549 **) and Warangal (0.492 **). The correlations of organic carbon method with grain yield were found to be 0.216 at Jagtial and 0.326 * at Warangal. Similarly, the relations of soil N based on calcium hydroxide method with grain yield were found to be nonsignificant and were 0.249 at Jagtial and 0.255 at Warangal. These correlations indicate that alkaline permanganate method of soil N is a better method over the other two methods since it is highly and significantly correlated with yield than the other two methods. Similar significant correlations with N uptake and drymatter of rice was found by Sahrawat (1982a).

The correlations of soil N based on KMnO4 method with plant uptake N were found to be higher at Jagtial (0.359 *) when compared to those of soil N based on organic carbon method (0.294) and calcium hydroxide method (0.161). Similarly, at Warangal the correlation of soil N based on KMnO4 (0.308) was higher than those based on organic carbon method (0.215) and calcium hydroxide method (0.201). The correlations of soil N with fertilizer N were found to be negative and significant for KMnO4 with fertilizer N at both Jagtial (-0.421 *) and Warangal (-0.394 *), and organic carbon and fertilizer N at Warangal (-0.324 *). All the other correlations of soil N with fertilizer N were found to be nonsignificant. Further, the coefficient of variation was found to be larger in organic carbon (53.2 and 35.8 %) than $KMnO_4$ (47.7 and 20.3 %) and $Ca(OH)_2$ (47.6 and 20.2%) at Jagtial and Warangal respectively as given in Table 18.

Thus the correlations of soil N with grain yield, plant uptake and fertilizer N have clearly indicated the superiority of alkaline permanganate method of soil N both at Jagtial and Warangal. The quick soil tests done in survey soils will only be a qualitative measure of nutrient index which cannot be matched with regular methods of soil N estimation as done in the laboratories of universities for fertilizer recommendation.

5.3.3. RELATIONSHIP BETWEEN GRAIN YIELD AND APPLIED FERTILIZERS

When soil available nutrients are not adequate to meet the crop requirements, additions of nutrients through fertilizers are essential for which relationships between grain yield and different fertilizer variables for optimisation of fertilizer nutrients have been worked out through experimentation.

5.3.3.1. JAGTIAL CENTRE :

The mean grain yield obtained was 2260 kg/ha with a range of 1759 to 3691 kg/ha. The drymatter was highest (5030 kg/ha in the treatment T12 (180-90-75) of N-P-K combination, followed by T10 (120-60-25) i.e., 4776 kg/ha. The grain yield was found to have a high and significant correlation with post-harvest soil test values of N based on $KMnO_4$ method (r=0.55 **). The correlations of grain yield with the organic carbon (%) and available N based on calcium hydroxide method were found to be positive but nonsignificant. However, significant correlations with both grain and straw yields with applied fertilizer N and P were observed. The replicated data of different fertilizer treatments are given in Appendix 6. A coefficient of variation of 28.9 % was obtained for grain yield attained at different fertilizer treatments. Similarly, the coefficient of variation of plant uptake of N, P and K were found to be 36.6, 30.6 and 27.1 % over different fertilizer treatments respectively. Pathak et al.(1976) and Reddy et al (1987) have also obtained similar relationship between grain yield and applied fertilizer nutrients.

High and Significant correlations of grain yield with fertilizer N and P nutrients were found at this centre. The correlations were 0.609 (**) and 0.455 (**) for N and P respectively. The correlation of fertilizer K with grain yield was 0.173 and nonsignificant. The correlations indicate that fertilizer nutrients would significantly influence the changes in grain yield which can be predicted through standard Soil Test Crop Response model and optimise the fertilizer nutrients (Velayutham et al, 1979, Maruthi Sankar, 1986).

Since the survey results have clearly shown that at the field level the fertilization practices and yields of rice are varying, there is a need to evolve proper fertilization schedules particularly for N to realise optimum yield of rice. The different fertilization schedules adopted in the field study coupled with the information obtained from the field survey, if collated will provide information on the proper fertilization practices which can be recommended to the farmers in the Sreeramsagar Project Command. The analysis of grain yield data of Jagtial centre indicated that application of 180-60-50 (treatment 5) gave the highest yield of 2952 kg/ha followed by T12 (180-90-75) which gave a grain yield of 2928 kg/ha. The two schedules were however on par with each other. The grain yield was minimum at 1155 kg/ha in the unfertilized experimental control. The farmer's fertilization practice (80-60-0) has given a yield of 2681 kg/ha, the yield based on the general recommended dose (120-60-30) was found to be 1759 kg/ha. The average 'Total N' in this soil was found to be 972.9 kg/ha with a coefficient of variation of 15.8 %. The analysis of variance of grain yield, plant uptake and soil N, P and K nutrients, and 'Total N' are

Table 36. Means of yield, soil test values and plant uptake of nutrients at different levels of N application at Jagtial
A.NITROGEN

FN	FP	FK	GY	OC(PI)	KM(PI)	CA(PI)	OL(PI)	AM(PI)	OC(PH)	KM(PH)	CA(PH)	OL(PH)	AM(PH)	Total N	UN	UP	UK
0	0	0	1059	0.06	81	65	16	279	0.10	116	93	21	170	870	24	4.0	20
0	60	50	949	0.19	70	55	24	310	0.26	100	80	46	189	962	29	3.7	17
0	0	0	1053	0.07	104	91	16	280	0.09	163	130	21	172	1026	27	3.7	17
0	60	50	2560	0.22	120	89	30	324	0.29	160	128	48	196	1006	79	7.4	50
0	0	0	1345	0.07	94	76	14	284	0.10	135	108	20	172	928	32	3.7	22
0	60	50	1364	0.17	103	83	35	315	0.22	147	118	50	193	958	50	4.1	29
Mean			1388	0.13	95	77	23	299	0.18	137	110	34	182	958	40	4.4	26
60	60	50	1988	0.31	112	91	15	279	0.42	160	130	16	169	1040	50	6.1	39
60	60	50	1832	0.19	231	168	13	282	0.26	332	266	18	176	1419	45	6.6	35
60	60	50	2216	0.25	164	127	16	282	0.33	246	197	20	172	1205	51	6.9	34
Mean			2012	0.25	169	129	15	281	0.34	246	198	18	172	1221	49	6.5	36
80	60	0	2365	0.21	77	61	12	264	0.29	110	88	15	160	705	59	6.9	46
80	60	0	3080	0.15	79	63	10	261	0.20	113	90	11	158	684	76	8.3	43
80	60	0	2599	0.08	81	65	11	256	0.11	116	93	13	155	760	65	6.6	43
Mean			2681	0.15	79	63	11	260	0.20	113	90	13	158	716	67	7.3	44
120	60	50	2287	0.15	100	80	13	296	0.20	143	114	19	179	927	50	8.5	50
120	60	30	1183	0.24	86	68	15	284	0.32	122	98	15	172	868	42	4.0	24
120	60	25	2339	0.54	77	62	26	225	0.73	110	88	26	211	706	65	10.2	57
120	0	50	1774	0.28	195	161	13	307	0.37	287	229	18	186	1124	73	7.9	43
120	30	50	2586	0.08	80	64	17	302	0.11	114	92	29	171	870	87	11.1	54
120	30	60	1962	0.25	78	60	41	282	0.33	111	89	41	142	805	70	9.4	45
120	60	0	1806	0.11	91	75	18	244	0.14	133	107	19	142	898	63	10.7	43
120	60	25	2157	0.39	89	71	24	234	0.53	127	102	24	205	846	52	13.3	54
120	60	75	2378	0.42	101	81	17	339	0.56	144	115	18	192	1128	57	9.5	43
120	60	75	1702	0.43	92	74	15	348	0.57	132	105	16	190	1011	41	6.9	39
120	30	50	2079	0.06	66	53	16	281	0.06	94	75	25	184	624	73	7.8	49
120	30	50	3002	0.17	75	62	31	304	0.22	110	88	42	138	706	90	6.7	36
120	60	30	2339	0.29	88	70	16	282	0.38	125	100	16	171	905	79	7.5	47
120	60	50	2599	0.14	110	88	12	298	0.19	157	125	17	181	975	61	9.1	59
120	0	50	2040	0.19	274	214	12	305	0.26	436	349	17	185	1384	80	9.1	38
120	30	50	2469	0.12	94	76	19	291	0.16	135	108	27	176	876	91	9.1	53
120	30	50	3138	0.33	79	63	38	291	0.45	113	90	40	134	788	103	8.9	52
120	60	0	2865	0.12	95	77	21	222	0.16	138	110	23	147	908	105	7.4	49
120	60	25	2807	0.24	101	81	29	230	0.32	144	115	30	202	946	76	8.7	55
120	60	0	2807	0.10	90	72	16	228	0.13	129	103	17	136	840	96	8.2	43
120	60	75	1910	0.41	110	87	18	333	0.54	157	125	19	189	1020	57	7.0	43
120	60	30	1754	0.34	90	72	14	284	0.45	129	103	17	172	840	78	6.2	53
120	60	50	2469	0.14	90	72	11	299	0.19	129	103	15	181	892	53	7.4	52
120	0	50	2417	0.36	97	77	13	280	0.48	138	110	18	170	1086	88	7.5	42
Mean			2286	0.25	102	82	19	283	0.33	148	118	23	173	916	72	8.4	47
180	90	75	2651	0.23	177	131	26	317	0.30	253	202	26	201	1487	107	11.0	62
180	90	75	2716	0.26	83	67	20	314	0.35	119	95	21	186	986	101	10.8	60
180	60	50	1741	0.30	94	76	11	289	0.42	135	108	16	175	896	82	7.5	48
180	60	50	3424	0.12	99	76	9	270	0.16	141	113	13	164	946	127	10.4	60
180	90	75	3417	0.19	271	199	25	312	0.26	387	309	27	193	2104	126	13.3	65
180	60	50	3691	0.21	97	76	11	271	0.28	138	110	15	166	905	119	12.3	58
Mean			2940	0.22	137	104	17	296	0.29	196	156	20	181	1221	110	10.9	59

PI : Panicle initiation stage
PH : Post-harvest stage
GY : Grain yield (kg/ha)
OC : Organic carbon (%)
KM : Alkaline permanganate N (kg/ha)
CA : Calcium hydroxide N (kg/ha)
OL : Olsen's P (kg/ha)
AM : Ammonium acetate K (kg/ha)
SY : Straw yield
UN : Uptake N (kg/ha)
UP : Uptake P (kg/ha)
UK : Uptake K (kg/ha)

Table 36. Means of yield, soil test values and plant uptake of nutrients at different levels of P application at Jagtial
B. PHOSPHORUS

FN	FP	FK	GY	OC(PI)	KN(PI)	CA(PI)	OL(PI)	AN(PI)	OC(PH)	KN(PH)	CA(PH)	OL(PH)	AN(PH)	Total N	UN	UP	UK
0	0	0	1346	0.07	94	76	14	284	0.10	135	108	20	172	928	32	3.7	22
0	0	0	1053	0.07	104	91	16	280	0.09	163	130	21	172	1026	27	3.7	17
120	0	50	1774	0.28	195	161	13	307	0.37	287	229	18	188	1124	73	7.9	43
120	0	50	2040	0.19	274	214	12	305	0.26	436	349	17	185	1384	80	9.1	38
0	0	0	1059	0.06	81	65	16	279	0.10	116	93	21	170	870	24	4.0	20
120	0	50	2417	0.36	97	77	13	280	0.48	138	110	18	170	1086	88	7.5	42
		Mean	1615	0.17	141	114	14	289	0.23	213	170	19	176	1070	54	6.0	30
120	30	50	1962	0.25	78	60	41	282	0.33	111	89	41	142	805	70	9.4	45
120	30	50	2586	0.08	80	64	17	302	0.11	114	92	29	171	870	87	11.1	54
120	30	50	3002	0.17	75	62	31	304	0.22	110	88	42	138	706	90	6.7	36
120	30	50	2079	0.06	66	53	16	281	0.08	94	75	25	184	624	73	7.8	49
120	30	50	2469	0.12	94	76	19	291	0.16	135	108	27	176	876	91	9.1	53
120	30	50	3138	0.33	79	63	38	291	0.45	113	90	40	134	788	103	8.9	52
		Mean	2539	0.17	79	63	27	292	0.22	113	90	34	158	778	86	8.8	48
180	60	50	3424	0.12	99	76	9	270	0.16	141	113	13	164	946	127	10.4	60
0	60	50	949	0.19	70	55	24	310	0.26	100	80	46	189	962	29	3.7	17
60	60	50	2216	0.25	164	127	16	282	0.33	246	197	20	172	1205	51	6.9	34
120	60	50	2287	0.15	100	80	13	296	0.20	143	114	19	179	927	50	8.5	50
180	60	50	3691	0.21	97	76	11	271	0.28	138	110	15	166	905	119	12.3	58
120	60	30	1183	0.24	86	68	15	284	0.32	122	98	15	172	868	42	4.0	24
120	60	30	2339	0.29	88	70	16	282	0.38	125	100	16	171	905	79	7.5	47
60	60	50	1832	0.19	231	168	13	282	0.26	332	266	18	176	1419	45	6.6	35
120	60	0	1806	0.11	91	75	18	244	0.14	133	107	19	142	898	63	10.7	43
120	60	25	2157	0.39	89	71	24	234	0.53	127	102	24	205	846	52	13.3	54
120	60	75	2378	0.42	101	81	17	339	0.56	144	115	18	192	1128	57	9.5	43
80	60	0	3080	0.15	79	63	10	261	0.20	113	90	11	158	684	76	8.3	43
120	60	50	2599	0.14	110	88	12	298	0.19	157	125	17	181	975	61	9.1	59
120	60	75	1910	0.41	110	87	18	333	0.54	157	125	19	189	1020	57	7.0	43
80	60	0	2365	0.21	77	61	12	264	0.29	110	88	15	160	705	59	6.9	46
120	60	75	1702	0.43	92	74	15	348	0.57	132	105	16	190	1011	41	6.9	39
120	60	0	2865	0.12	96	77	21	222	0.16	138	110	23	147	908	105	7.4	49
120	60	25	2807	0.24	101	81	29	230	0.32	144	115	30	202	946	76	8.7	55
0	60	50	2560	0.22	120	89	30	324	0.29	160	128	48	196	1006	79	7.4	50
60	60	50	1988	0.31	112	91	15	279	0.42	160	130	16	169	1040	50	6.1	39
80	60	0	2599	0.06	81	65	11	256	0.11	116	93	13	155	760	65	6.6	43
180	60	50	1741	0.30	94	76	11	289	0.42	135	108	16	175	896	82	7.5	48
120	60	50	2469	0.14	90	72	11	299	0.19	129	103	15	181	892	53	7.4	52
0	60	50	1364	0.17	103	83	35	315	0.22	147	118	50	193	958	50	4.1	29
120	60	0	2807	0.10	90	72	16	228	0.13	129	103	17	136	840	96	8.2	43
120	60	25	2339	0.54	77	62	26	225	0.73	110	88	26	211	706	65	10.2	57
120	60	30	1754	0.34	90	72	14	284	0.45	129	103	17	172	840	78	6.2	53
		Mean	2267	0.24	101	80	17	280	0.32	145	116	21	176	933	67	7.8	45
180	90	75	3417	0.19	271	199	25	312	0.26	387	309	27	193	2104	126	13.3	65
180	90	75	2651	0.23	177	131	26	317	0.30	253	202	26	201	1487	107	11.0	62
180	90	75	2716	0.26	83	67	20	314	0.35	119	95	21	186	986	101	10.8	60
		Mean	2928	0.23	177	132	24	314	0.30	253	202	25	193	1526	111	11.7	62

PI : Panicle initiation stage
PH : Post-harvest stage
GY : Grain yield (kg/ha)
OC : Organic carbon (%)
KN : Alkaline permanganate N (kg/ha)
CA : Calcium hydroxide N (kg/ha)
OL : Olsen's P (kg/ha)
AN : Ammonium acetate K (kg/ha)
SY : Straw yield
UN : Uptake N (kg/ha)
UP : Uptake P (kg/ha)
UK : Uptake K (kg/ha)

Table 36. Means of yield, soil test values and plant uptake of nutrients at different levels of K application at Jagtial
C.POTASSIUM

FN	FP	FK	GY	OC(PI)	KM(PI)	CA(PI)	OL(PI)	AM(PI)	OC(PH)	KM(PH)	CA(PH)	OL(PH)	AM(PH)	Total N	UN	UP	UK
0	0	0	1053	0.07	104	91	16	280	0.09	163	130	21	172	1026	27	3.7	17
80	60	0	2599	0.08	81	65	11	256	0.11	116	93	13	155	760	65	6.6	43
120	60	0	2807	0.10	90	72	16	228	0.13	129	103	17	136	840	96	8.2	43
120	60	0	2865	0.12	95	77	21	222	0.16	138	110	23	147	908	105	7.4	49
80	60	0	2365	0.21	77	61	12	264	0.29	110	88	15	160	705	59	6.9	46
0	0	0	1345	0.07	94	76	14	284	0.10	135	108	20	172	928	32	3.7	22
0	0	0	1059	0.06	81	65	16	279	0.10	116	93	21	170	870	24	4.0	20
120	60	0	1806	0.11	91	75	18	244	0.14	133	107	19	142	898	63	10.7	43
80	60	0	3080	0.15	79	63	10	261	0.20	113	90	11	158	684	76	8.3	43
		Mean	2109	0.11	88	72	15	258	0.15	128	102	18	157	847	61	6.6	36
120	60	25	2157	0.39	89	71	24	234	0.53	127	102	24	205	846	52	13.3	54
120	60	25	2807	0.24	101	81	29	230	0.32	144	115	30	202	946	76	8.7	55
120	60	25	2339	0.54	77	62	26	225	0.73	110	88	26	211	706	65	10.2	57
		Mean	2434	0.39	89	71	26	230	0.53	127	102	27	206	833	64	10.7	55
120	60	30	1183	0.24	86	68	15	284	0.32	122	98	15	172	868	42	4.0	24
120	60	30	2339	0.29	88	70	16	282	0.38	125	100	16	171	905	79	7.5	47
120	60	30	1754	0.34	90	72	14	284	0.45	129	103	17	172	840	78	6.2	53
		Mean	1759	0.29	88	70	15	283	0.38	125	100	16	172	871	66	5.9	41
120	0	50	1774	0.28	195	161	13	307	0.37	287	229	18	186	1124	73	7.9	43
120	30	50	1962	0.25	78	60	41	282	0.33	111	89	41	142	805	70	9.4	45
60	60	50	2216	0.25	164	127	16	282	0.33	246	197	20	172	1205	51	6.9	34
120	60	50	2287	0.15	100	80	13	296	0.20	143	114	19	179	927	50	8.5	50
180	60	50	3691	0.21	97	76	11	271	0.28	138	110	15	166	905	119	12.3	58
120	0	50	2040	0.19	274	214	12	305	0.26	436	349	17	185	1384	80	9.1	38
120	30	50	2586	0.08	80	64	17	302	0.11	114	92	29	171	870	87	11.1	54
180	60	50	3424	0.12	99	76	9	270	0.16	141	113	13	164	946	127	10.4	60
120	60	50	2599	0.14	110	88	12	298	0.19	157	125	17	181	975	61	9.1	59
60	60	50	1832	0.19	231	168	13	282	0.26	332	266	18	176	1419	45	6.6	35
0	60	50	949	0.19	70	55	24	310	0.26	100	80	46	189	962	29	3.7	17
120	30	50	2469	0.12	94	76	19	291	0.16	135	108	27	176	876	91	9.1	53
0	60	50	2560	0.22	120	89	30	324	0.29	160	128	48	196	1006	79	7.4	50
120	0	50	2417	0.36	97	77	13	280	0.48	138	110	18	170	1086	88	7.5	42
0	60	50	1364	0.17	103	83	35	315	0.22	147	118	50	193	958	50	4.1	29
60	60	50	1988	0.31	112	91	15	279	0.42	160	130	16	169	1040	50	6.1	39
120	60	50	2469	0.14	90	72	11	299	0.19	129	103	15	181	892	53	7.4	52
180	60	50	1741	0.30	94	76	11	289	0.42	135	108	16	175	896	82	7.5	48
120	30	50	3138	0.33	79	63	38	291	0.45	113	90	40	134	788	103	8.9	52
120	30	50	3002	0.17	75	62	31	304	0.22	110	88	42	138	706	90	6.7	36
120	30	50	2079	0.06	66	53	16	281	0.06	94	75	25	184	624	73	7.8	49
		Mean	2314	0.20	116	91	19	293	0.27	168	134	26	173	971	74	8.0	45
180	90	75	2716	0.26	83	67	20	314	0.35	119	95	21	186	986	101	10.8	60
180	90	75	3417	0.19	271	199	25	312	0.26	387	309	27	193	2104	126	13.3	65
120	60	75	1910	0.41	110	87	18	333	0.54	157	125	19	189	1020	57	7.0	43
120	60	75	2378	0.42	101	81	17	339	0.56	144	115	18	192	1128	57	9.5	43
180	90	75	2651	0.23	177	131	26	317	0.30	253	202	26	201	1487	107	11.0	62
120	60	75	1702	0.43	92	74	15	348	0.57	132	105	16	190	1011	41	6.9	39
		Mean	2462	0.32	139	107	20	327	0.43	199	159	21	192	1289	82	9.8	52

PI : Panicle initiation stage
PH : Post-harvest stage
GY : Grain yield (kg/ha)
OC : Organic carbon (%)
KM : Alkaline permanganate N (kg/ha)
CA : Calcium hydroxide N (kg/ha)
OL : Olsen's P (kg/ha)
AM : Ammonium acetate K (kg/ha)
~~SY : Straw yield~~
UN : Uptake N (kg/ha)
UP : Uptake P (kg/ha)
UK : Uptake K (kg/ha)

given in Table 21. The relation between grain and drymatter yields and applied fertilizers are shown in Fig.11(a) for N, 12(a) for P and 13(a) for K. It is obvious from the data obtained that grain and straw yields have increased linearly upto 180 kg/ha of N application. There was an increase in yields upto 30 kg followed by a plateau and response to P application. Thereafter a marginal increase upto 90 kg of P application was evident. Potassium application increased straw yield linearly upto 25 kg. The grain yield did not increase significantly due to K application. There was a negligible increase in yields beyond this dose. The means of grain and straw yields averaged at each level N, P and K application are given in Table 36.

5.3.3.1.1. OPTIMISATION OF FERTILIZERS USING MULTIPLE REGRESSION EQUATIONS

Yield is a function of soil and fertilizer N, P and K at optimum levels of other production components. Multiple regression procedures offer a scope to quantitatively evaluate the effects of production variables. The R^2 values of multiple regression equations of grain yield with soil, fertilizer and their interaction variables were found to be 0.93 (**) for equation with organic carbon, 0.93 (**) with $KMnO_4$ N, and 0.89 (**) with calcium hydroxide N combinations.

Hence, the fertilizer adjustment equations for attaining maximum yield, maximum profit, and a desired rate of return (in the present case 1:2) have been derived for estimating optimum fertilizer doses for varying soil test values. The response types of fertilizer N, P and K variables were found to be (+ - -) for their linear, quadratic and interaction terms with soil nutrient variables. The fertilizer adjustment equations for varying soil test values are given in Table 27. The fertilizer adjustment equations are valid for the range of soil test values as observed in the experiment viz., 0.06 to 0.73 percent organic carbon, 94 to 436 kg/ha $KMnO_4$ N, 75 to 349 kg/ha $Ca(OH)_2$ N, 11 to 50 kg/ha Olsen's P and 134 to 211 kg/ha ammonium acetate K. The fertilizer doses derived at an average soil test value of each nutrient were found to be meaningful and were within the doses experimented. The fertilizer adjustment equations based on the soil N with $KMnO_4$ combination were found to be having a better adjustment of fertilizer N with lower fertilizer doses for varying soil N than those derived under combinations of the other two soil N methods. These doses derived for maximum yield, maximum profit and a desired rate of return can be used for making yield prediction using a multiple regression equations.

5.3.3.2. **WARANGAL CENTRE**

The soil at Warangal location was found to be more comparitively more fertile as indicated by a higher mean grain yield of 3297 kg/ha over different fertilizer treatments with a coefficient of variation of 9.3 % with the variety 'Yerramallelu (WGL-20471)'. The highest mean grain yield was recorded in T14 treatment (120-60-30) which was 3915 kg/ha. The plant uptake of N ranged from 26.9 and 145.8 kg/ha with a mean of 63 kg/ha, while the P uptake ranged from 3.8 and 10 kg/ha, with a mean of 6.5 kg/ha. The K uptake varied from 28.3 and 60.3 kg/ha with a mean of 39.3 kg/ha. The mean plant uptake of N, P and K were found to be 62.9, 6.5 and 39.3 kg/ha with a coefficients of variation of 30.5, 12.3 and 12 % respectively. Available N by $KMnO_4$ method provided a good index of soil test value at this location with a mean of 202 kg/ha. The 'Total N' averaged over different treatments under replications was recorded as 1309.7 kg/ha with a coefficient of variation of 9.7 %. Higher yields obtained at this centre are possibly due to even rainfall distribution coupled with better native soil fertility status and heavier texture of the soil as compared to Jagtial soils which are comparitively light textured. The analysis of grain and straw yields indicated that the applied fertilizer treatments are significantly different from each

Table 37. Means of yield, soil test values and plant uptake of nutrients at different levels of N application at Warangal
A. NITROGEN

FN	FP	FK	GY	OC(PI)	KM(PI)	CA(PI)	OL(PI)	AM(PI)	OC(PH)	KM(PH)	CA(PH)	OL(PH)	AM(PH)	Total N	UN	UP	UK
0	0	0	2330	0.20	115	92	82	468	0.26	165	132	82	520	1066	38	4.0	29
0	60	50	2360	0.58	111	89	81	448	0.77	158	127	85	498	1029	46	4.9	35
0	0	0	2330	0.22	115	94	76	455	0.30	167	134	80	505	1090	37	4.5	34
0	60	50	2210	0.59	78	91	78	524	0.78	163	130	82	582	1060	32	4.6	30
0	0	0	2479	0.16	119	95	80	473	0.21	170	136	84	525	1105	27	3.8	30
0	60	50	2569	0.54	112	90	83	447	0.75	160	128	87	496	1041	50	5.4	36
	Mean		2380	0.38	108	92	80	469	0.51	164	131	83	521	1065	38	4.5	32
60	60	50	3256	0.52	134	107	45	565	0.69	191	153	56	628	1243	47	5.0	33
60	60	50	3913	0.50	132	105	54	545	0.66	188	150	68	606	1225	43	7.0	43
60	60	50	3525	0.51	132	104	50	532	0.68	189	151	62	591	1230	51	5.4	40
	Mean		3564	0.51	133	105	50	547	0.68	189	151	62	608	1233	47	5.8	39
80	60	0	3525	0.67	106	109	46	512	0.90	191	153	54	588	1242	52	5.6	32
80	60	0	3106	0.62	127	107	42	480	0.83	188	150	56	581	1223	71	5.3	29
80	60	0	3554	0.56	120	106	50	520	0.75	185	148	57	588	1203	58	5.0	34
	Mean		3395	0.62	118	107	46	504	0.83	188	150	56	586	1223	60	5.3	32
120	60	50	3405	0.52	153	124	65	516	0.69	219	175	81	599	1425	66	6.5	49
120	60	30	3441	0.34	119	95	59	488	0.45	170	136	79	548	1106	126	7.2	30
120	60	25	3584	0.40	136	109	41	555	0.54	192	154	48	617	1249	75	8.6	36
120	0	50	2927	0.51	151	123	70	470	0.68	216	173	73	541	1392	57	6.6	42
120	30	50	3078	0.75	131	107	54	530	1.00	191	153	57	589	1219	66	5.5	39
120	30	50	3047	0.35	176	135	69	549	0.48	251	201	73	610	1632	47	5.1	34
120	60	0	3106	0.53	152	126	68	544	0.71	222	177	59	605	1442	55	8.4	41
120	60	25	3704	0.54	134	108	56	530	0.72	196	157	56	598	1275	45	7.8	38
120	60	75	3256	0.63	138	116	55	523	0.84	199	159	83	581	1226	48	7.8	36
120	60	75	3525	0.63	140	111	47	540	0.84	200	160	81	599	1291	121	8.1	41
120	30	50	3644	0.43	99	81	53	555	0.57	141	115	53	616	941	80	6.5	46
120	30	50	3883	0.31	139	108	62	545	0.42	199	160	76	605	1594	53	6.3	35
120	60	30	3584	0.22	120	94	62	487	0.29	169	135	82	541	1098	69	8.2	31
120	60	50	3226	0.77	140	110	66	541	1.02	201	160	83	601	1310	74	5.9	48
120	0	50	3584	0.79	184	145	66	538	1.05	263	211	75	598	1708	100	7.6	60
120	30	50	3405	0.56	105	84	61	542	0.75	150	120	61	608	982	61	5.7	37
120	30	50	2927	0.41	217	175	60	538	0.54	351	281	70	598	2102	52	5.6	43
120	60	0	4062	0.61	138	112	66	538	0.81	201	160	68	598	1300	73	9.5	56
120	60	25	4002	0.68	129	107	54	544	0.90	182	149	83	605	1182	82	7.6	39
120	60	0	3764	0.45	146	117	50	540	0.60	206	165	50	599	1340	96	10.0	49
120	60	75	3405	0.63	136	105	62	514	0.84	194	155	84	571	1206	38	6.5	37
120	60	30	4719	0.09	116	93	68	473	0.12	166	133	85	525	1080	146	8.5	41
120	60	50	3525	0.27	144	115	63	540	0.36	206	165	79	599	1340	51	6.0	38
120	0	50	3823	0.23	176	141	62	525	0.30	251	201	71	588	1625	94	9.6	55
	Mean		3526	0.49	142	114	60	528	0.65	206	165	71	589	1336	74	7.3	42
180	90	75	3226	0.58	182	157	83	532	0.77	301	241	79	591	1956	53	7.4	37
180	90	75	3465	0.54	156	124	78	524	0.72	220	176	76	582	1435	54	5.9	41
180	60	50	2927	0.27	147	119	76	486	0.36	210	170	44	559	1366	65	8.2	49
180	60	50	3106	0.54	143	113	72	504	0.72	204	163	51	560	1326	59	6.4	40
180	90	75	3256	0.61	196	160	80	509	0.81	282	226	82	565	1826	34	5.5	36
180	60	50	2718	0.40	137	111	80	510	0.54	196	159	48	566	1276	52	5.7	39
	Mean		3116	0.49	160	131	78	511	0.65	236	189	63	571	1531	53	6.5	40

PI : Panicle initiation stage
PH : Post-harvest stage
GY : Grain yield (kg/ha)

OC : Organic carbon (%)
KM : Alkaline permanganate N (kg/ha)
CA : Calcium hydroxide N (kg/ha)

OL : Olsen's P (kg/ha)
AM : Ammonium acetate K (kg/ha)

UN : Uptake N (kg/ha)
UP : Uptake P (kg/ha)
UK : Uptake K (kg/ha)

Table 37. Means of yield, soil test values and plant uptake of nutrients at different levels of P application at Warangal
B.PHOSPHORUS

FN	FP	FK	GY	OC(PI)	KM(PI)	CA(PI)	OL(PI)	AM(PI)	OC(PH)	KM(PH)	CA(PH)	OL(PH)	AM(PH)	Total N	UN	UP	UK
0	0	0	2479	0.16	119	95	80	473	0.21	170	136	84	525	1105	27	3.8	30
0	0	0	2330	0.22	115	94	76	455	0.30	167	134	80	505	1090	37	4.5	34
120	0	50	2927	0.51	151	123	70	470	0.68	216	173	73	541	1392	57	6.6	42
120	0	50	3584	0.79	184	145	66	538	1.05	263	211	75	598	1708	100	7.6	60
0	0	0	2330	0.20	115	92	82	468	0.26	165	132	82	520	1066	38	4.0	29
120	0	50	3823	0.23	176	141	62	525	0.30	251	201	71	588	1625	94	9.6	55
Mean			2912	0.35	143	115	73	488	0.47	205	165	78	546	1331	59	6.0	42
120	30	50	3047	0.35	176	135	69	549	0.48	251	201	73	610	1632	47	5.1	34
120	30	50	3078	0.75	131	107	54	530	1.00	191	153	57	589	1219	66	5.5	39
120	30	50	3883	0.31	139	108	62	545	0.42	199	160	76	605	1594	53	6.3	35
120	30	50	3644	0.43	99	81	53	555	0.57	141	115	53	616	941	80	6.5	46
120	30	50	3405	0.58	105	84	61	542	0.75	150	120	61	608	982	61	5.7	37
120	30	50	2927	0.41	217	175	60	538	0.54	351	281	70	598	2102	52	5.6	43
Mean			3331	0.47	145	115	60	543	0.63	214	172	65	604	1412	60	5.8	39
180	60	50	3106	0.54	143	113	72	504	0.72	204	163	51	560	1326	59	6.4	40
0	60	50	2360	0.58	111	89	81	448	0.77	158	127	85	498	1029	46	4.9	35
60	60	50	3525	0.51	132	104	50	532	0.68	189	151	62	591	1230	51	5.4	40
120	60	50	3405	0.52	153	124	65	516	0.69	219	175	81	599	1425	66	6.5	49
180	60	50	2718	0.40	137	111	80	510	0.54	196	159	48	566	1276	52	5.7	39
120	60	30	3441	0.34	119	95	59	488	0.45	170	136	79	548	1106	126	7.2	30
120	60	30	3584	0.22	120	94	62	487	0.29	169	135	82	541	1098	69	8.2	31
60	60	50	3913	0.50	132	105	54	545	0.66	188	150	68	606	1225	43	7.0	43
120	60	0	3106	0.53	152	126	58	544	0.71	222	177	59	605	1442	55	8.4	41
120	60	25	3704	0.54	134	108	56	530	0.72	196	157	56	598	1275	45	7.8	38
120	60	75	3256	0.63	138	116	55	523	0.84	199	159	83	581	1226	48	7.8	36
80	60	0	3106	0.62	127	107	42	480	0.83	188	150	56	581	1223	71	5.3	29
120	60	50	3226	0.77	140	110	66	541	1.02	201	160	83	601	1310	74	5.9	48
120	60	75	3405	0.63	136	105	62	514	0.84	194	155	84	571	1206	38	6.5	37
80	60	0	3525	0.67	108	109	46	512	0.90	191	153	54	588	1242	52	5.6	32
120	60	75	3525	0.63	140	111	47	540	0.84	200	160	81	599	1291	121	8.1	41
120	60	0	4062	0.61	138	112	66	538	0.81	201	160	68	598	1300	73	9.5	56
120	60	25	4002	0.68	129	107	54	544	0.90	182	149	83	605	1182	82	7.6	39
0	60	50	2210	0.59	78	91	78	524	0.78	163	130	82	582	1060	32	4.6	30
60	60	50	3256	0.52	134	107	45	565	0.69	191	153	56	628	1243	47	5.0	33
80	60	0	3554	0.56	120	106	50	520	0.75	185	148	57	588	1203	58	5.0	34
180	60	50	2927	0.27	147	119	76	486	0.36	210	170	44	559	1366	65	8.2	49
120	60	50	3525	0.27	144	115	63	540	0.36	206	165	79	599	1340	51	6.0	38
0	60	50	2569	0.54	112	90	83	447	0.75	160	128	87	496	1041	50	5.4	36
120	60	0	3764	0.45	146	117	50	540	0.60	206	165	50	599	1340	96	10.0	49
120	60	25	3584	0.40	136	109	41	565	0.54	192	154	48	617	1249	75	8.6	36
120	60	30	4719	0.09	116	93	68	473	0.12	166	133	85	525	1080	146	8.5	41
Mean			3373	0.50	130	107	60	517	0.67	191	153	69	579	1235	66	6.9	39
180	90	75	3256	0.61	196	160	80	509	0.81	282	226	82	565	1826	34	5.5	36
180	90	75	3226	0.58	182	157	83	532	0.77	301	241	79	591	1956	53	7.4	37
180	90	75	3465	0.54	156	124	78	524	0.72	220	176	76	582	1435	54	5.9	41
Mean			3315	0.58	178	147	80	522	0.77	268	214	79	579	1739	47	6.3	38

PI : Panicle initiation stage
PH : Post-harvest stage
GY : Grain yield (kg/ha)
OC : Organic carbon (%)
KM : Alkaline permanganate N (kg/ha)
CA : Calcium hydroxide N (kg/ha)
OL : Olsen's P (kg/ha)
AM : Ammonium acetate K (kg/ha)
UN : Uptake N (kg/ha)
UP : Uptake P (kg/ha)
UK : Uptake K (kg/ha)

Table 37. Means of yield, soil test values and plant uptake of nutrients at different levels of K application at Warangal
C.POTASSIUM

FN	FP	FK	GY	OC(PI)	KM(PI)	CA(PI)	OL(PI)	AM(PI)	OC(PH)	KM(PH)	CA(PH)	OL(PH)	AM(PH)	Total N	UN	UP	UK
0	0	0	2330	0.22	115	94	76	455	0.30	167	134	80	505	1090	37	4.5	34
80	60	0	3554	0.56	120	106	50	520	0.75	185	148	57	588	1203	58	5.0	34
120	60	0	3764	0.45	146	117	50	540	0.60	206	165	50	599	1340	96	10.0	49
120	60	0	4062	0.61	138	112	66	538	0.81	201	160	68	598	1300	73	9.5	56
80	60	0	3525	0.67	106	109	46	512	0.90	191	153	54	588	1242	52	5.6	32
0	0	0	2479	0.16	119	96	80	473	0.21	170	136	64	525	1105	27	3.8	30
0	0	0	2330	0.20	115	92	82	468	0.26	165	132	82	520	1066	38	4.0	29
120	60	0	3106	0.53	152	126	58	544	0.71	222	177	59	605	1442	55	8.4	41
80	60	0	3106	0.62	127	107	42	480	0.83	188	150	56	581	1223	71	5.3	29
Mean			3140	0.45	126	106	61	503	0.60	188	151	66	568	1223	56	6.2	37
120	60	25	3704	0.54	134	108	56	530	0.72	196	157	56	598	1275	45	7.8	38
120	60	25	4002	0.68	129	107	54	544	0.90	182	149	83	605	1182	82	7.6	39
120	60	25	3584	0.40	136	109	41	555	0.54	192	154	48	617	1249	75	8.6	36
Mean			3763	0.54	133	108	50	543	0.72	190	153	62	607	1235	67	8.0	38
120	60	30	3441	0.34	119	96	59	488	0.45	170	136	79	548	1106	126	7.2	30
120	60	30	3584	0.22	120	94	62	487	0.29	169	135	82	541	1098	69	8.2	31
120	60	30	4719	0.09	116	93	68	473	0.12	166	133	85	525	1080	146	8.5	41
Mean			3915	0.22	118	94	63	483	0.29	168	135	82	538	1095	114	8.0	34
120	0	50	2927	0.51	151	123	70	470	0.68	216	173	73	541	1392	57	6.6	42
120	30	50	3047	0.35	176	135	69	549	0.48	251	201	73	610	1632	47	5.1	34
60	60	50	3525	0.51	132	104	50	532	0.68	189	151	62	591	1230	51	5.4	40
120	60	50	3405	0.52	153	124	65	516	0.69	219	175	81	599	1425	66	6.5	49
180	60	50	2718	0.40	137	111	80	510	0.54	196	159	48	566	1276	52	5.7	39
120	0	50	3584	0.79	184	146	66	538	1.05	263	211	75	598	1708	100	7.6	60
120	30	50	3078	0.75	131	107	54	530	1.00	191	153	57	589	1219	66	5.5	39
180	60	50	3106	0.54	143	113	72	504	0.72	204	163	51	560	1326	59	6.4	40
120	60	50	3226	0.77	140	110	66	541	1.02	201	160	83	601	1310	74	5.9	48
60	60	50	3913	0.50	132	105	54	545	0.66	188	150	68	606	1225	43	7.0	43
0	60	50	2360	0.58	111	89	81	448	0.77	158	127	85	498	1029	46	4.9	35
120	30	50	3405	0.56	105	84	61	542	0.75	150	120	61	608	982	61	5.7	37
0	60	50	2210	0.59	78	91	78	524	0.78	163	130	82	582	1060	32	4.6	30
120	0	50	3823	0.23	176	141	62	525	0.30	251	201	71	588	1625	94	9.6	55
0	60	50	2569	0.54	112	90	83	447	0.75	160	128	87	496	1041	50	5.4	36
60	60	50	3256	0.52	134	107	45	565	0.69	191	153	56	628	1243	47	5.0	33
120	60	50	3525	0.27	144	115	63	540	0.36	206	165	79	599	1340	51	6.0	38
180	60	50	2927	0.27	147	119	76	486	0.36	210	170	44	559	1366	65	8.2	49
120	30	50	2927	0.41	217	175	60	538	0.54	351	281	70	598	2102	52	5.6	43
120	30	50	3883	0.31	139	108	62	545	0.42	199	160	76	605	1594	53	6.3	35
120	30	50	3644	0.43	99	81	53	585	0.57	141	115	53	616	941	80	6.5	46
Mean			3193	0.49	140	113	65	521	0.66	205	164	68	583	1336	59	6.2	41
180	90	75	3465	0.54	156	124	78	524	0.72	220	176	76	582	1435	54	5.9	41
180	90	75	3256	0.61	196	160	80	509	0.81	282	226	82	565	1826	34	5.5	36
120	60	75	3405	0.63	136	105	62	514	0.84	194	155	84	571	1206	38	6.5	37
120	60	75	3256	0.63	138	116	55	523	0.84	199	159	83	581	1226	48	7.8	36
180	90	75	3226	0.58	182	157	63	532	0.77	301	241	79	591	1956	53	7.4	37
120	60	75	3525	0.63	140	111	47	540	0.84	200	160	81	599	1291	121	8.1	41
Mean			3355	0.60	158	129	68	524	0.80	233	186	81	582	1490	58	6.9	38

PI : Panicle initiation stage
PH : Post-harvest stage
GY : Grain yield (kg/ha)
OC : Organic carbon (%)
KM : Alkaline permanganate N (kg/ha)
CA : Calcium hydroxide N (kg/ha)
OL : Olsen's P (kg/ha)
AM : Ammonium acetate K (kg/ha)
UN : Uptake N (kg/ha)
UP : Uptake P (kg/ha)
UK : Uptake K (kg/ha)

other in their effects on crop yields as given in Table 22. The replicated data for grain yield and other parameters recorded at this location are given in Appendix 7.

The relation between grain and drymatter yields and applied fertilizers are depicted in Fig.11(b) for N, 12(b) for P and 13(b) for K. It is obvious that grain and straw yields increased linearly upto 180 kg/ha of N application. There was an increase in yields upto 30 kg followed a plateau for P application. Thereafter a marginal increase in grain upto 90 kg of P application was recorded. In respect of K, the straw yield increased linearly upto 25 kg of application. The grain yield did not increase significantly to application of K. There was a negligible increase in yields beyond application of 25 kg/ha. The grain and straw yields averaged at each level N, P and K application are given in Table 37.

5.3.3.2.1. PROSPECTS FOR OPTIMISATION OF FERTILIZER USE

The coefficient of predictability (R^2 values) of multiple regression equations of grain yield with soil, fertilizer and their interaction variables were observed to be 0.96 (**) for equation with organic carbon, 0.91 (**) with $KMnO_4$ N, and 0.85 (**) with calcium hydroxide N combinations. Hence, the adjustment equations of fertilizer for attaining different levels of yield viz., maximum yield, maximum profit, and a desired rate of return (say 1:2) were derived for computing optimum fertilizer doses for varying soil test values. The response types of fertilizer N, P and K variables were found to be (+ - -) for their linear, quadratic and interaction terms with soil N, P and K variables. The adjustment equations of fertilizer N, P and K for varying soil test values are given in Table 30. These equations are valid for the range of soil test values as observed in the experiment viz., 0.12 to 1.05 percent organic carbon, 142 to 351 kg/ha $KMnO_4$ N, 115 to 281 kg/ha $Ca(OH)_2$ N, 44 to 87 kg/ha Olsen's P, and 496 to 628 kg/ha ammonium acetate K. The fertilizer doses derived at an average soil test value of each nutrient and were meaningful and within the doses experimented. The fertilizer adjustment equations based on the soil N with $KMnO_4$ combination were found to be having a better adjustment of fertilizer N with lower fertilizer doses for varying soil N than those derived under combinations of the other two soil N methods.

5.3.3.3. RICE RESPONSE TO APPLICATION OF FERTILIZERS

The results have clearly indicated that the crop responded positively to the application of different doses of N and K at Warangal, and N, P and K fertilizers at Jagtial as presented in Table 25. A positive response was recorded at

Warangal for application of N upto 120 kg/ha which diminished as the fertilizer dose increased. The mean response (kg/ha) to N (response ratio (kg/kg)) was 248.9 (6.2) at 40 kg/ha, 179.2 (3.0) at 60 kg/ha and 179.2 kg/ha (1.5 kg/kg) at 120 kg/ha. The response to P was found to be negative at all levels. The response to K was found to be positive at 5 and 30 kg/ha application, which were 151.3 (30.3) and 270.8 kg/ha (9.0 kg/kg) respectively. There was no response to K at other levels of K application which may be due to inconsistent responses of K and also due to better native soil fertility status of K.

There was a positive response to N, P and K application at Jagtial centre. While there was a negative response to N application at 40 kg/ha, the response was found to be positive at 60 and 120 kg/ha which were 466.2 (7.8) and 1204.9 kg/ha (10.0 kg/kg) respectively. P responded positively at all levels viz., 30, 60 and 90 kg/ha. The responses were 543.5 (18.1), 634.4 (10.6) and 632.8 kg/ha (6.9 kg/kg) at the above three levels respectively. The response to K was not consistent, as it was positive at 20, 45 and 50 kg/ha which were 1264.4 (63.2), 238.2 (5.3) and 46.3 kg/ha (0.9 kg/kg) and negative at all other levels. However, from the field experimental data the surmises which can be drawn are that at Warangal response to K application

Fig. 19(a). Relation between Uptake of N and fertilizer N in field experiment at Jagtial

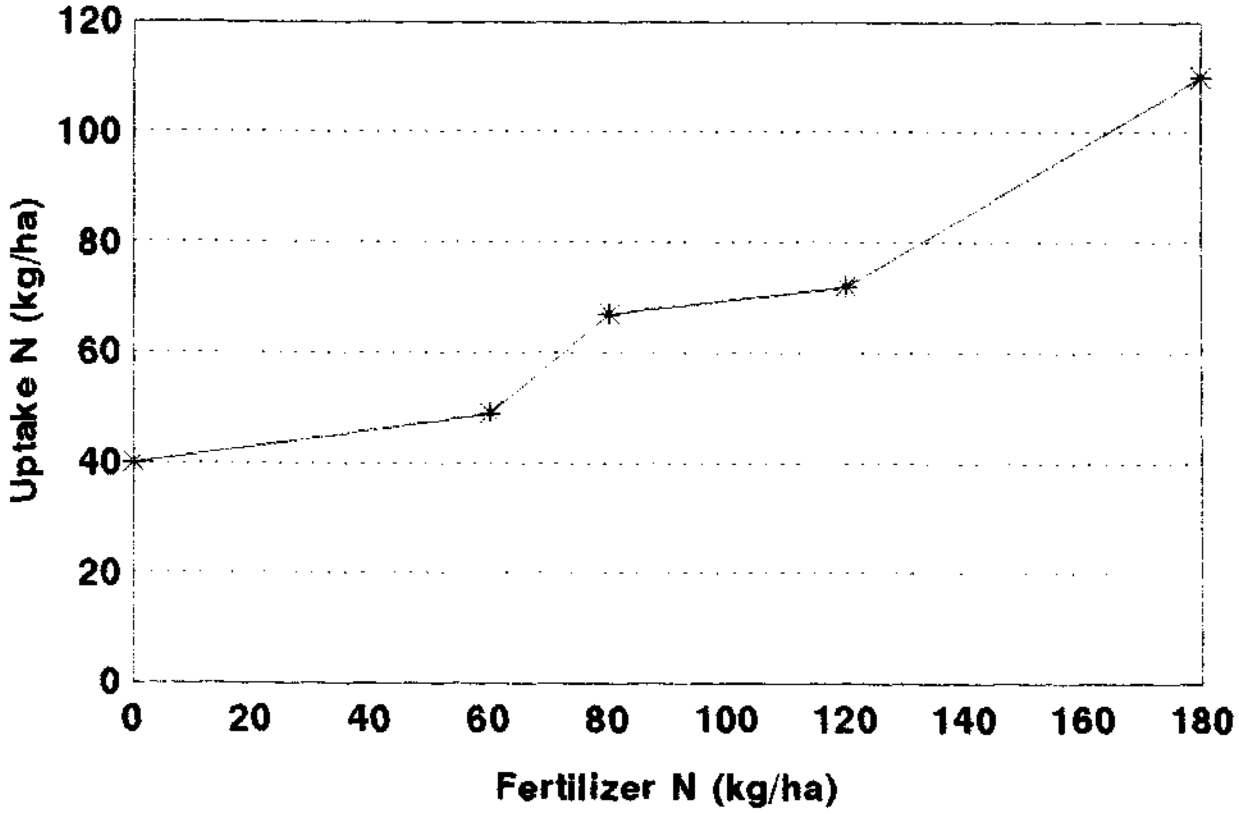


Fig.20(a). Relation between Uptake of P and fertilizer P in field experiment at Jagtial

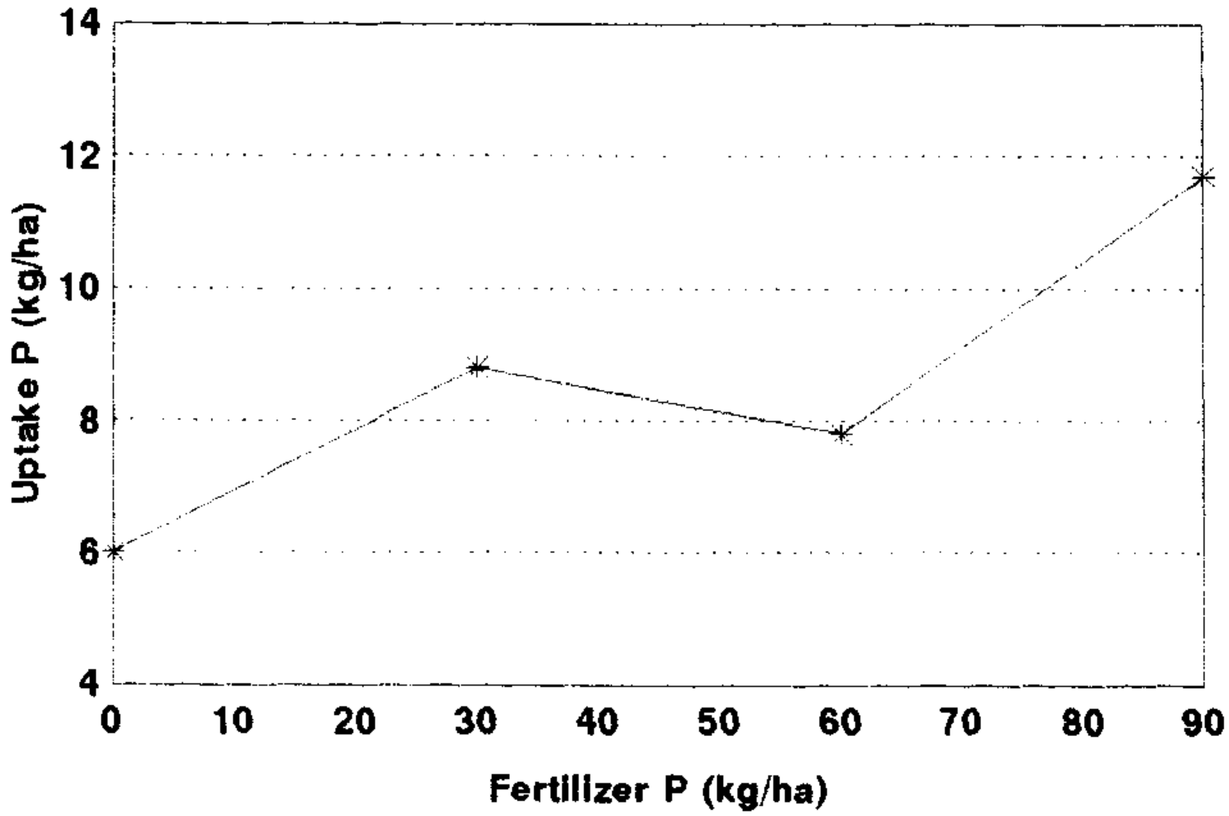
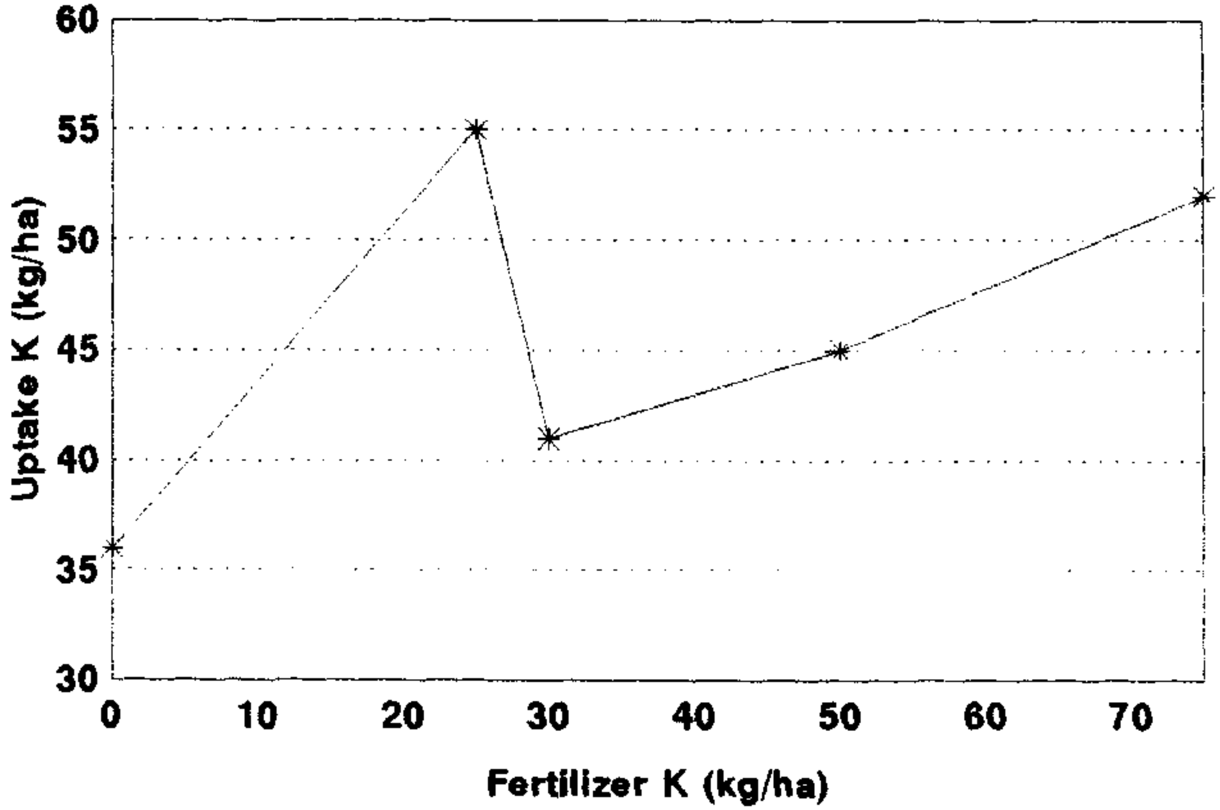


Fig.21(a). Relation between uptake of K and fertilizer K in field experiment at Jagtial



was evident upto 30 kg/ha, whereas at Jagtial upto 45 kg/ha in a few treatment combinations. The yield responses were found to be higher at Warangal than at Jagtial. The responses of rice to the application of N, P and K fertilizers are shown in Fig.22(a), 22(b) and 22(c) respectively. The figures clearly show the mean responses as discussed above using the data of yields obtained at different treatments as described in Table 24 for Jagtial and Table 26 for Warangal.

5.3.3.4. RELATIONSHIP BETWEEN PLANT UPTAKE AND FERTILIZER N, P AND K NUTRIENTS

5.3.3.4.1. JAGTIAL CENTRE

A Linear increase in plant uptake of N, P and K was observed at differnt levels of fertilizer application at both Jagtial and Warangal soils. These trends are shown in Fig.19(a), 20(a) and 21(a) for Jagtial. The mean uptake of N, P and K at each level of fertilizers are given in Table 36 separately for each nutrient. It was observed that the uptake of N ranged between 24 to 127 kg/ha (with a mean of 71 kg/ha), uptake of P from 3.7 to 13.3 kg/ha (with a mean of 8 kg/ha), and uptake of K from 16.6 to 65.1 kg/ha (with a mean of 44.5 kg/ha) at Jagtial location. The mean uptake of N at different levels of fertilizer N application were 49, 67, 72 and 110 kg/ha at 60, 80, 120 and 180 kg/ha of fertilizer N as

Fig.19(b). Relation between Uptake of N and fertilizer N in field experiment at Warangal

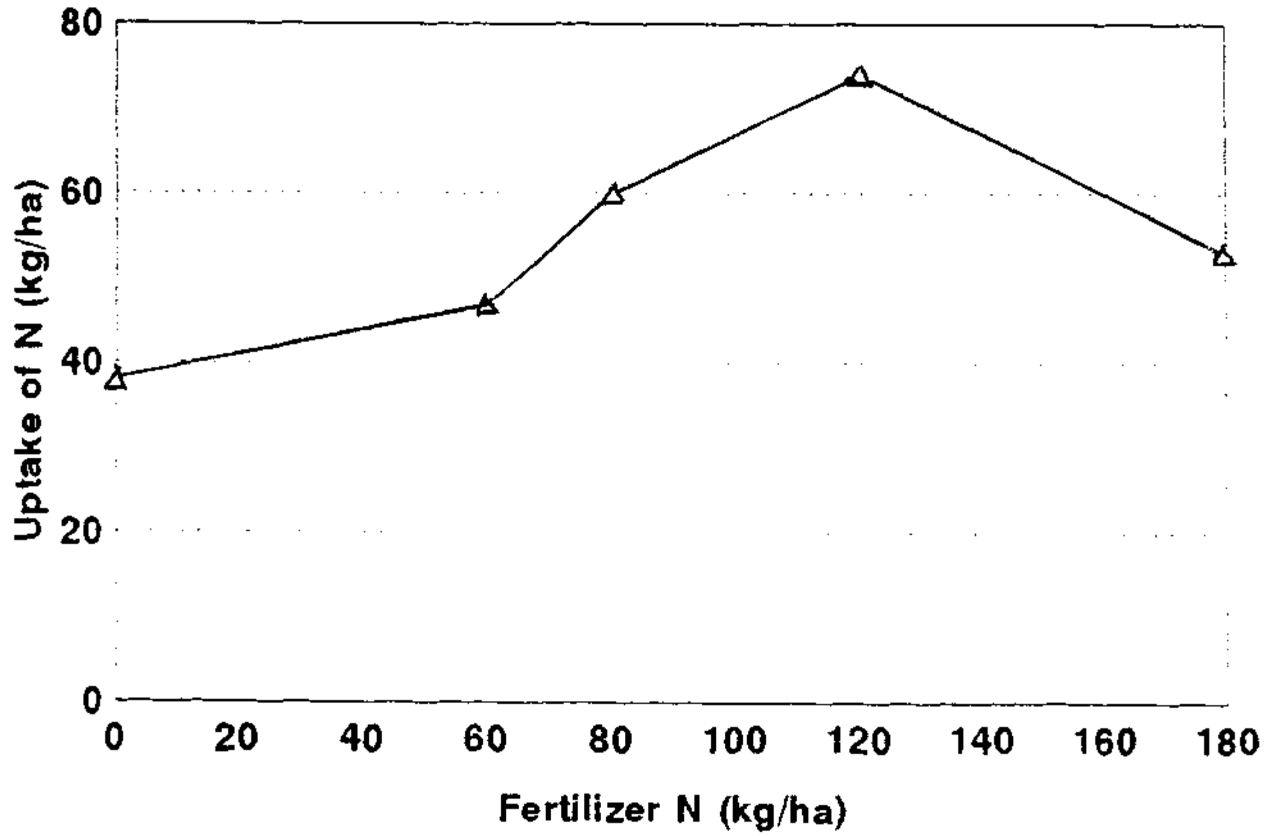


Fig.20(b). Relation between Uptake of P and fertilizer P in field experiment at Warangal

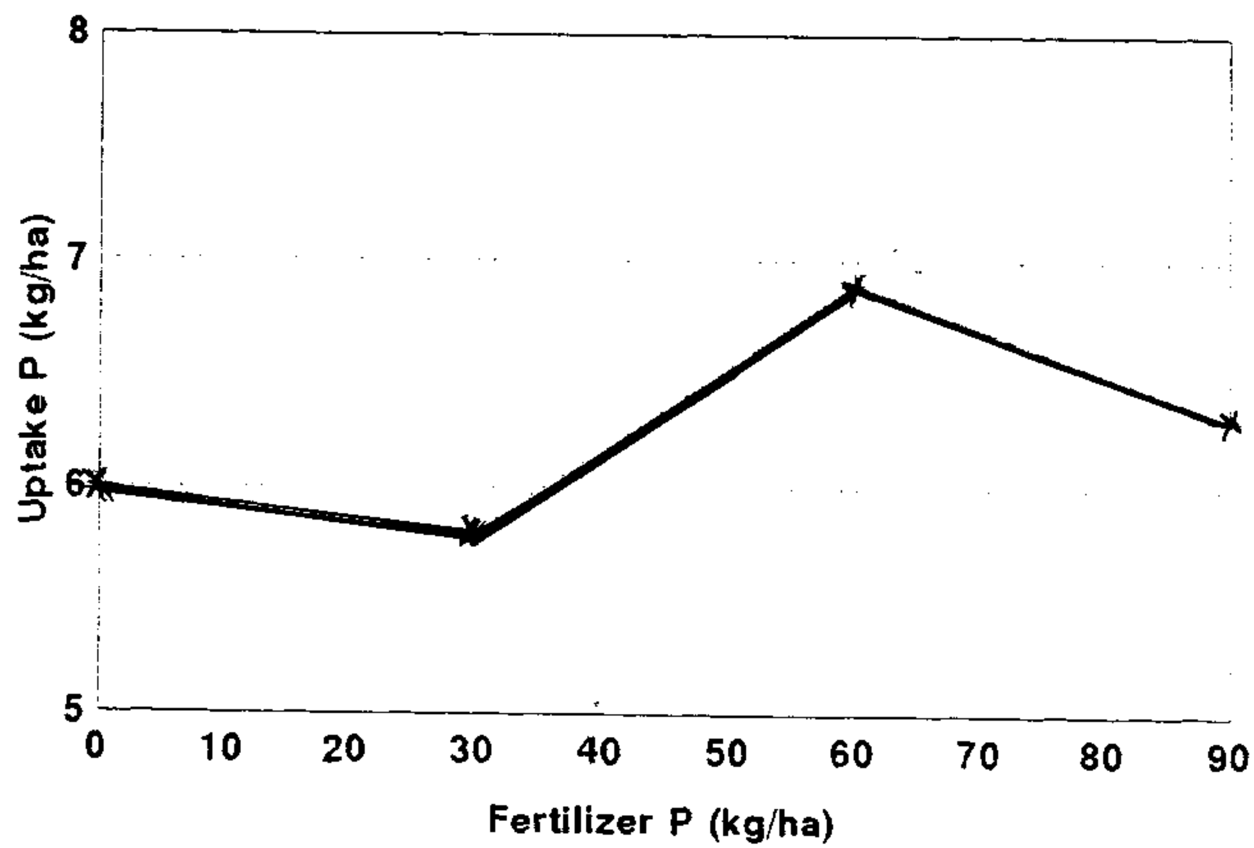
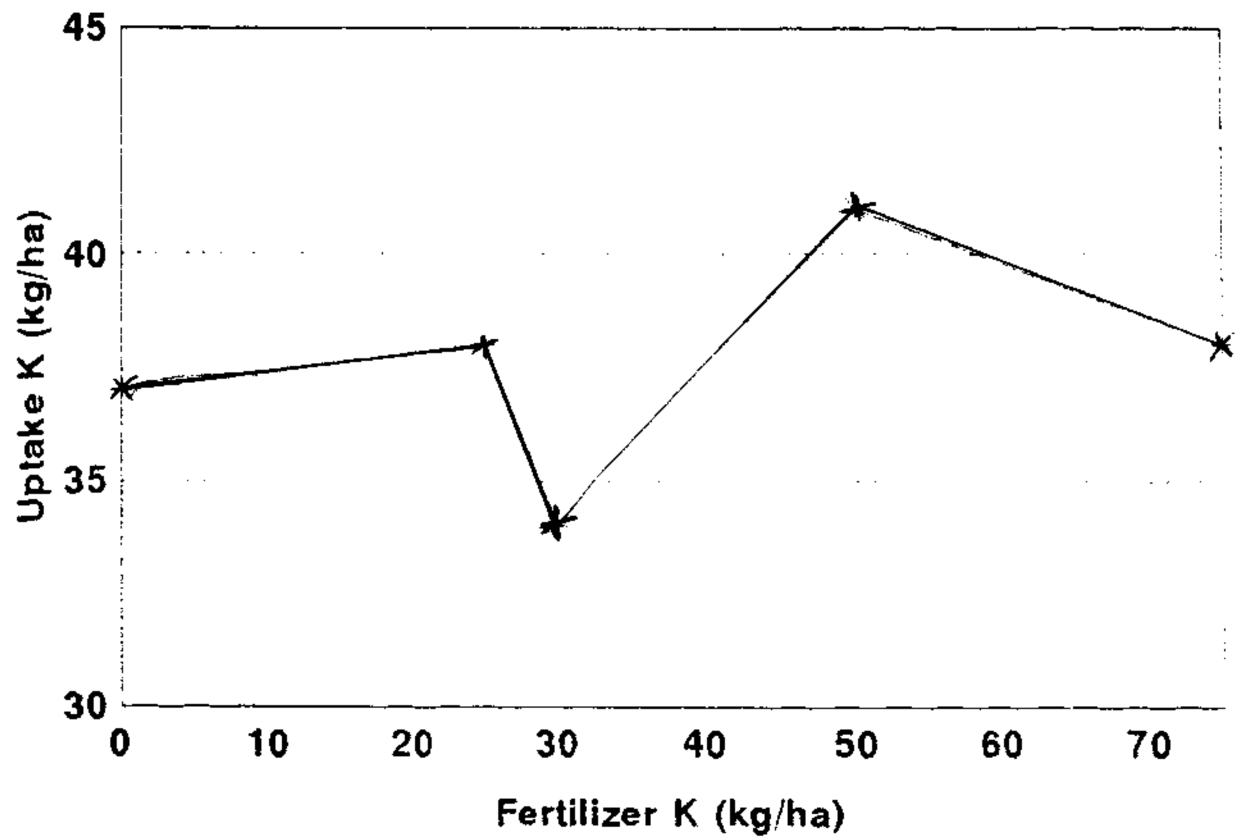


Fig.21(b). Relation between uptake K and fertilizer K in field experiment at Warangal



against the mean uptake of control plots of 40 kg/ha. The mean uptake of P was found to be 8.8, 7.8 and 11.7 kg/ha at 30, 60 and 90 kg/ha as against the control uptake of 6 kg/ha. The mean uptake of K was 55, 41, 45 and 52 kg/ha at 25, 30, 50 and 75 kg/ha as against the mean control uptake of 36 kg/ha. This is in confirmity with the work of Agarwal and Ramamurthy (1978) and Reddy et al·(1987).

5.3.3.4.2. **WARANGAL CENTRE**

A Linear increase in plant uptake of N, P and K was observed at different levels of fertilizer N, P and K application in Warangal soils. The response trends are shown in Fig.19(b), 20(b) and 21(b). The mean uptake of N, P and K at each level of fertilizers are given in Table 37 separately for N, P and K nutrients. The uptake of N was found to range between 26.9 to 145.8 kg/ha (with a mean of 62.9 kg/ha), uptake of P from 3.8 to 10 kg/ha (with a mean of 6.5 kg/ha), and uptake of K from 28.3 to 60.3 kg/ha (with a mean of 39.3 kg/ha). The mean N uptake at different levels of N application were 47, 60, 74 and 53 kg/ha at 60, 80, 120 and 180 kg/ha of fertilizer N as against the mean uptake of 38 kg/ha in control. The mean P uptake was found to be 5.8, 6.9 and 6.3 kg/ha at 30, 60 and 90 kg/ha as against the control uptake of 6 kg/ha in control. The mean uptake of K was 38, 34, 41 and 38 kg/ha at 25, 30, 50 and 75 kg/ha as against the mean control uptake of 37 kg/ha in control. The values of uptake of N, P and K nutrients have thus clearly indicated that the plant uptake can linearly and significantly be increased with an increase in application of fertilizers at both Jagtial and Warangal.

5.3.4. FERTILIZER READY RECKONERS BASED ON ADJUSTMENT EQUATIONS

Using the fertilizer adjustment equations derived from Jagtial and Warangal locations, ready reckoners have been developed for varying soil test values. The ready reckoners are given in Table 28 based on the adjustment equations derived from multiple regression equations without interaction terms, Table 29(a), Table 29(b) and Table 29(c) based on equations with interaction terms of the three combinations of soil N methods for Jagtial. Similar information of the Warangal location is given in Table 28, Table 31(a), Table 31(b) and Table 31(c) for Warangal. For Jagtial soils, the fertilizer doses were found to be with in the doses experimented in these soils. It was observed that optimum fertilizer N doses were higher with the equation using organic carbon (%) when compared to those of $KMnO_4$ and $Ca(OH)_2$ equations. The optimum P fertilizer doses were found to be almost same when derived using any of the regression equations calibrated and adjustment equations derived using OC (%) or $KMnO_4$ or $Ca(OH)_2$ combinations. The K fertilizer requirement was found to be negligible when used with any of the fertilizer adjustment equations. The N, P and K fertilizer adjustment equations are given below for Jagtial soils for varying soil test values (with KMnO4 combination) :

$$FN = 129 - 0.50\ SN - 2.50\ R$$

$$FP_2O_5 = 75 - 0.82\ SP - 2.94\ R$$

$$FK_2O = 28 - 0.19\ SK - 0.40\ R$$

For Warangal location also the same trends were observed, i.e., a higher dose based on organic carbon (%) equation when compared to $KMnO_4$ or $Ca(OH)_2$ equations. P and K fertilization were also necessary for either yield maximisation, or maximum profit or a desired rate of return.

$$FN = 166 - 1.00\ SN - 7.14\ R$$

$$FP_2O_5 = 38 - 1.11\ SP - 1.43\ R$$

$$FK_2O = 40 - 0.06\ SK - 0.39\ R$$

Using these equations fertilizer ready reckoners have been worked out for Warangal soils and are given in Tables 31(a), 31(b) and 31(c). The ready reckoners indicate that the optimal fertilizer doses were more meaningful under adjustment equations derived with KMnO4 combination than the other two methods for attaining either maximum yield, or maximum profit or a desired rate of return. This is in confirmity with the work of Renuka Rao (1990) who indicated that $KMnO_4$ oxidisable N as a better index of available N for rice in black clay loam soils of Warangal.

5.3.5. FERTILIZER RECOMMENDATIONS FOR TARGETTED YIELDS OF RICE

Soils do not contain the essential plant nutrients in adequate quantities and proportions required by many agricultural crops. Liebig 's Law of Minimum states that growth of a plant is limited by plant nutrients present in the smallest quantity, all others being present in adequate amounts. The principle of fertilizer recommendation for targetted yields based on soil testing has been enunciated and tested under the All India Coordinated Soil Test Crop Response Correlation Project by Ramamoorthy et al.. (1967). This approach which is based on the removal of definite quantities of nutrients for unit quantity of grain production, contribution of soil and fertilizer nutrients towards this removal, provide a means of working out a balance between the available nutrients in soil on the one hand and the requirement of fertilizer based on the needs of crop on the other.

The concept of yield targetting for varying soil test values was advocated by Ramamoorthy and Velayutham (1974), Bhattacharya and Rudra (1977), Dev et al. (1978), Prabhakar (1983), Bhaskaran (1983) who derived targetted yield equations for different crops. The applicability of recommending fertilizer doses for desired yield targets under different soil fertility classes in farmer's fields and its usefulness in terms of net profit over general recommended dose was demonstrated by Sekhar et al (1976), Tandon (1970), Ramamoorthy et al (1975), Dev et al (1978), Velayutham (1982) Rani Perumal et al.(1984).

5.3.5.1. BASIC DATA AND TARGETTED YIELD EQUATIONS FOR RICE

The basic data viz., nutrient requirement (NR), contribution from soil (CS) and contribution from fertilizer (CF) have been estimated from the whole field (with 42 plots), and also with the yield-maximum plots (12 plots) using the Conventional procedure as developed in the Soil Test Crop Response Correlation Project. The estimates have also been derived with the data from 14 plots (means of 3 replications) using an alternative procedure developed in the STCR Project viz., Simultaneous estimation procedure of soil and fertilizer efficiencies.

It was observed from these studies that the fertilizer quantities required to be applied for rice were lower under the Simultaneous procedure than those under the Conventional procedure for all the three nutrients. The estimates of soil and fertilizer N and K contributions or efficiencies were higher under the Conventional procedure, while for P, the estimates were found to be higher under the Simultaneous procedure at both Jagtial and Warangal centres.

The basic data and targetted yield equations using the whole field data for the two locations are as follows :

	Basic data NR	CS	CF	Targetted yield equation	Response ratio
1. Warangal : Conventional (Whole-field)					
N	1.82	44.4	143.7	$FN = 10.32\ T - 1.28\ SN$	
P	0.22	4.8	5.6	$FP_2O_5 = 3.62\ T - 0.89\ SP$	4.5
K	0.18	12.3	16.9	$FK_2O = 8.51\ T - 0.40\ SK$	
2. Warangal : Simultaneous (whole-field)					
N	1.79	27.0	34.2	$FN = 5.52\ T - 0.79\ SN$	
P	0.20	14.0	12.4	$FP_2O_5 = 1.60\ T - 1.13\ SP$	6.8
K	1.21	8.5	15.9	$FK_2O = 7.59\ T - 0.54\ SK$	
3. Jagtial : Conventional (whole-field)					
N	3.21	22.4	35.4	$FN = 9.08\ T - 0.63\ SN$	
P	0.81	17.5	17.9	$FP_2O_5 = 4.51\ T - 2.31\ SP$	5.8
K	2.43	12.0	64.1	$FK_2O = 3.79\ T - 0.23\ SK$	
4. Jagtial : Simultaneous (whole-field)					
N	3.10	27.2	46.7	$FN = 6.65\ T - 0.58\ SN$	
P	0.35	32.8	15.1	$FP_2O_5 = 2.33\ T - 2.17\ SP$	6.7
K	1.97	26.3	33.2	$FK_2O = 5.93\ T - 0.79\ SK$	

While a higher soil N efficiency was observed at Warangal, higher soil P and K efficiencies were observed at Jagtial centre. The nutrient requirements of N, P and K also were found to be higher at Jagtial location than at Warangal location as described in Tables 32 and 33. The response ratios (kg/kg) for attaining different yield targets were found to be 5.8 (whole-field) to 7.9 (yield-maximum plots) under Conventional method and 6.7 (whole-field) to 8.4 (yield-maximum plots) under Simultaneous method at Jagtial, which indicate that a high response to application of fertilizers can be obtained in these soils. Similarly, the response ratios were found to be 4.5 (whole field) to 5.2 (yield-maximum plots) under Conventional method, 6.8 (whole-field) to 7.8 (yield-maximum plots) under Simultaneous method, which indicate that a good response can be obtained by use of chemical fertilizers. The basic data and targetted yield equations were found to be converging with the results as obtained by different workers earlier for these soils, and also with those as obtained in the Soil Test Crop Response Correlation Project from time to time. Saravana Pandian and Rani Perumal (1993) obtained higher yield response with 100 kg N/ha for rice and a similar trend was reported by Biswas and Bhattacharya (1987).

5.3.5.2. READY RECKONERS FOR FERTILIZER RECOMMENDATION BASED ON SOIL TESTS FOR DIFFERENT YIELD TARGETS

Based on the ready reckoners worked out for both Warangal and Jagtial centres, it is possible to optimise soil test based fertilizer doses for attaining different yield targets of rice upto 45 q/ha in Warangal and upto 35 q/ha in Jagtial soils. These data and their analysis have indicated that to attain an yield level of 30-35 q/ha the available N content of soil as estimated by $KMnO_4$ has to be maintained at 220 kg/ha. Requirement of P fertilization through fertilizers at 40 kg/ha was identified from the studies at Warangal. Application of 40 kg P/ha is essential to obtain rice yield of 30 to 35 q/ha as determined by the Conventional procedure. However, there was no fertilizer P requirement beyond 20 kg/ha of soil P based on the equations as derived under the Simultaneous procedure. The requirement of fertilizer P application (as well as N and K) were lower with estimates employing Simultaneous procedure than those derived under Conventional procedure.

Thus, it is obvious from the above that there is a need for P fertilization to realize higher yields of rice since response to P fertilization is evident upto 60 kg/ha. The critical available P content is 20 kg/ha below which level fertilization is essential for realizing higher yields.

Fig.14(a). Relation between organic carbon and fertiliser N in rice at Jagtial during kharif 1996

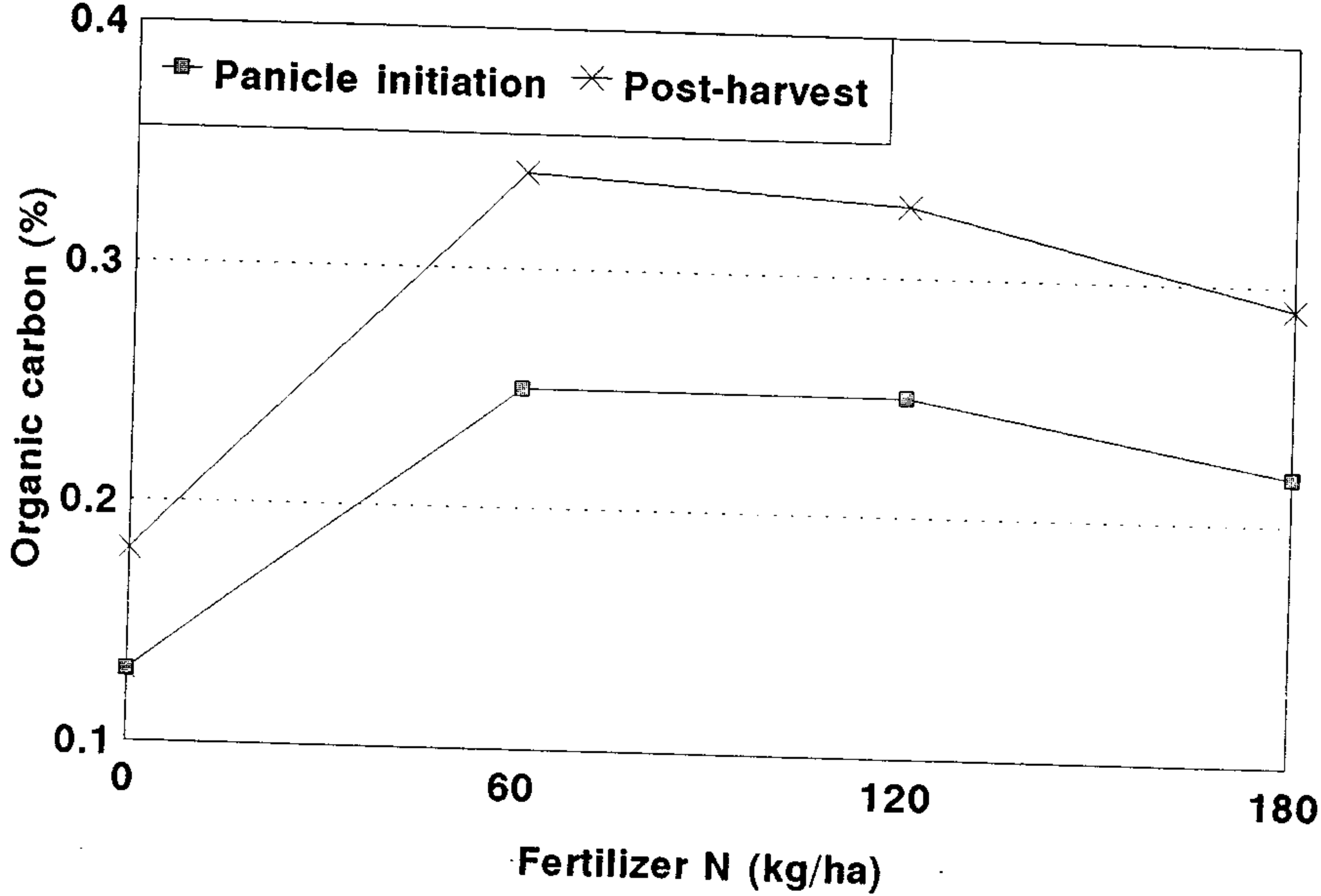


Fig.15(a). Relation between soil N and fertilizer N in rice at Jagtial during kharif 1996

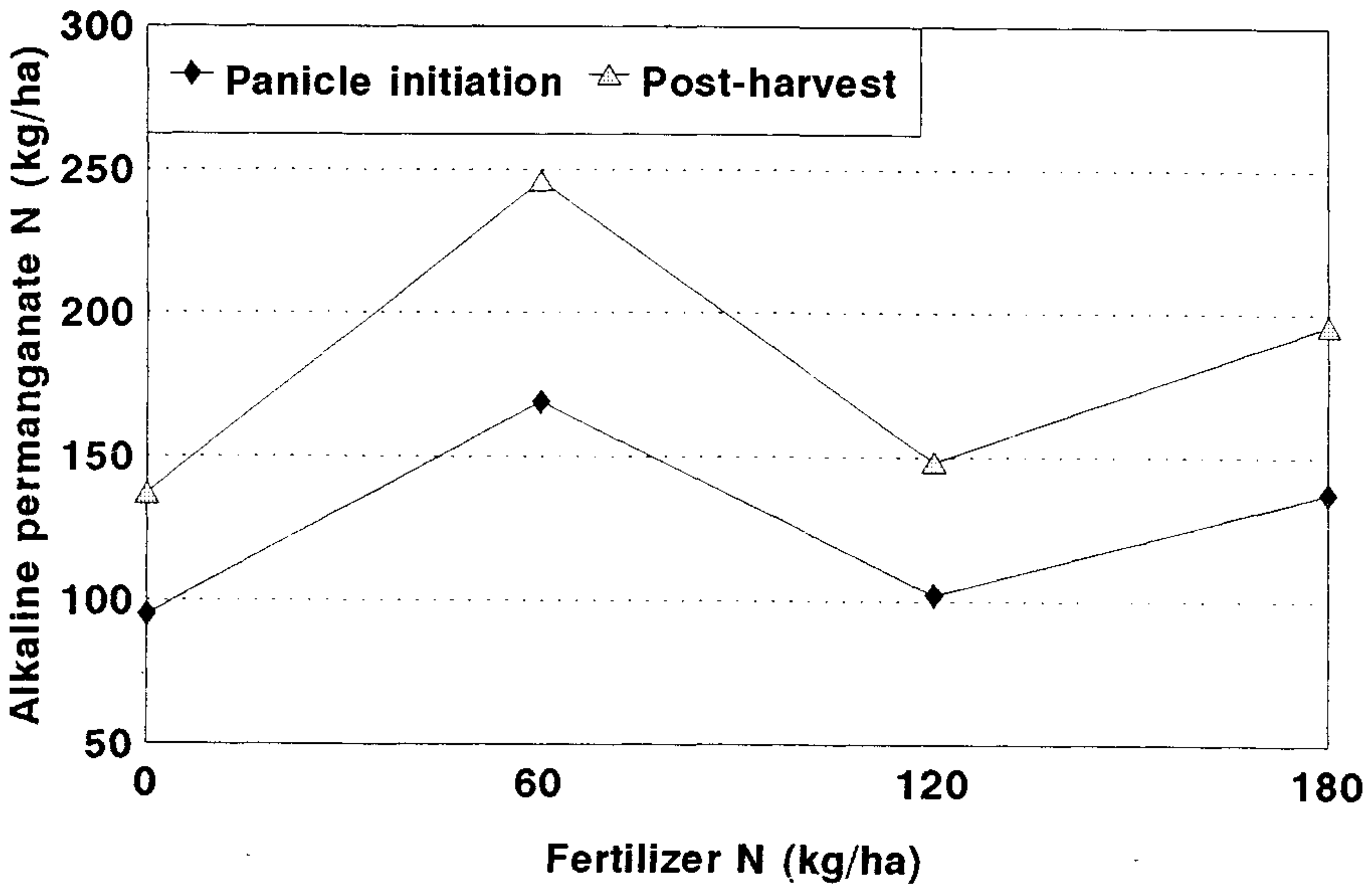
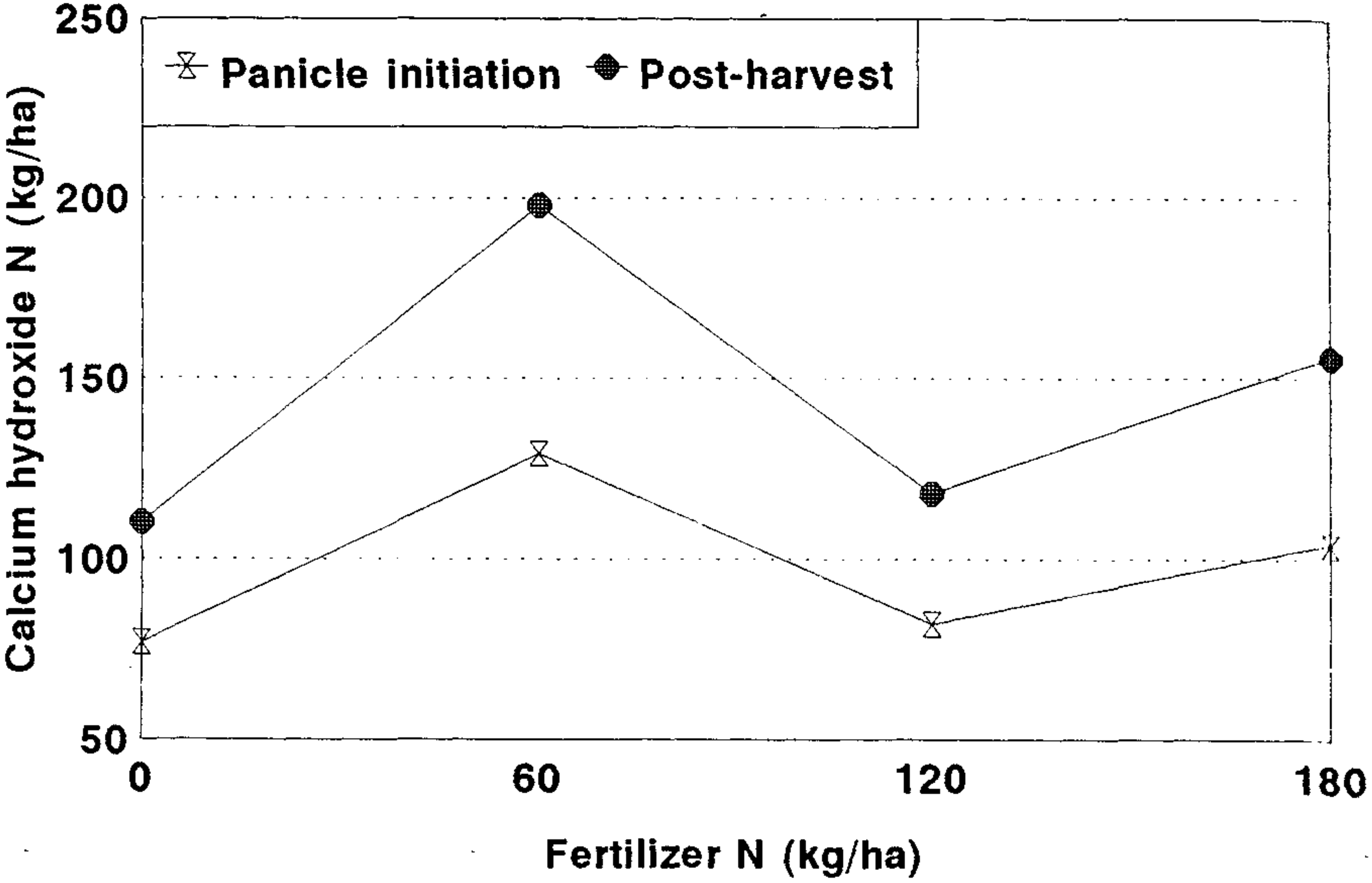


Fig.16(a). Relation between soil N and fertilizer N in rice at Jagtial during kharif 1996



The fertilizer requirement as estimated under the Conventional procedure was comparitively higher than the estimates obtained by adopting the Simultaneous procedure. If the soil available K is less than 500 kg/ha there is a need for K fertilization as estimated with either Conventional or Simultaneous procedures. The need of fertilizer K emerges when either soil K is lower than 500 kg/ha or when the targetted yields are higher than 35 q/ha.

5.3.6. PREDICTION OF POST-HARVEST SOIL TEST VALUES

5.3.6.1. JAGTIAL CENTRE :

Based on the analysis of variance (ANOVA) of soil test values collected at the panicle initiation and post-harvest stages from each plot it was observed that the effects of fertilizer treatments were significantly different from each other. The mean soil available N (kg/ha was found to be higher at the post-harvest stage (157.8) when compared to the panicle initiation stage (109.4). The coefficient of variation of soil N under all the three methods viz., organic carbon, $KMnO_4$ and $Ca(OH)_2$ methods was found to be around 31 % at panicle initiation stage and around 33 % at post-harvest stage, thus indicating a build-up of soil N at post-harvest stage of crop growth as given in Tables 19 and 21. The mean organic carbon (%) was found to be 0.29 with a C.V. (%) of 29

Fig.17(a). Relation between soil available P and fertilizer P in field experiment at Jagtial

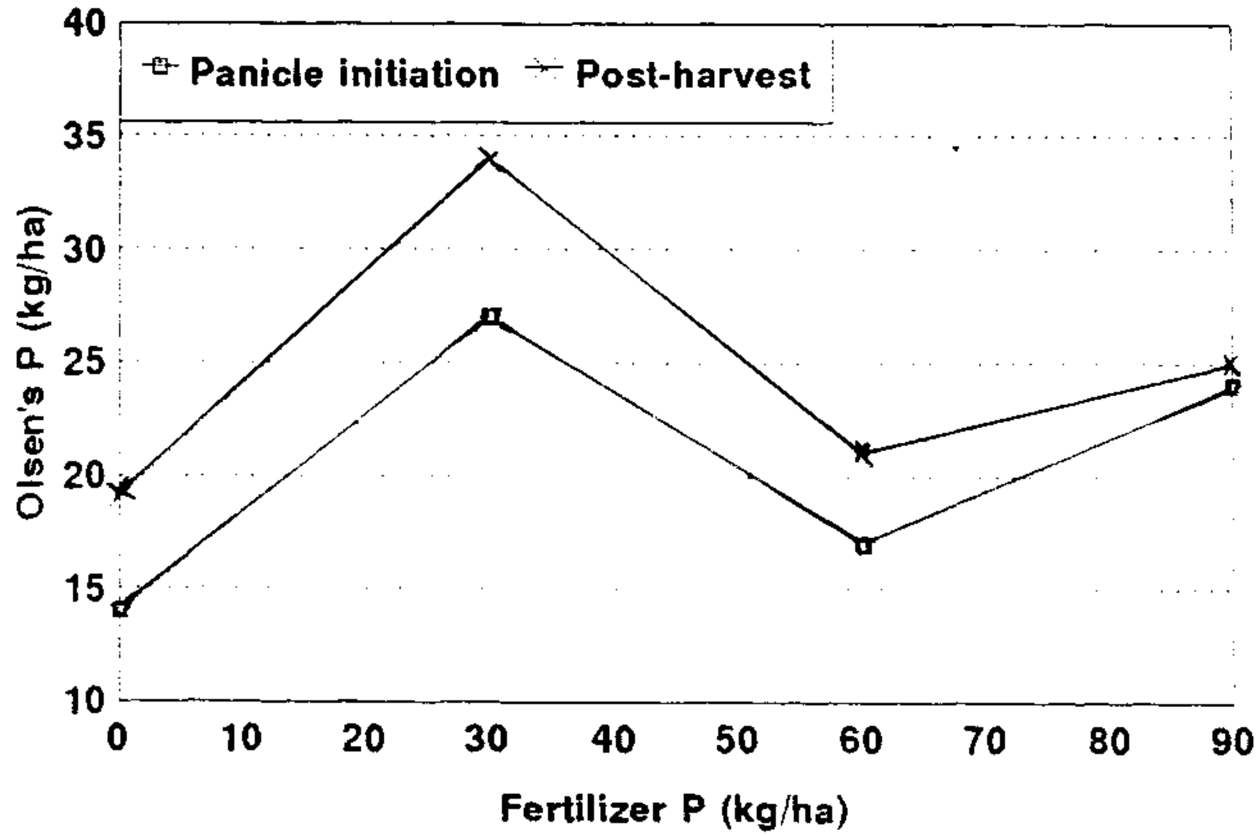
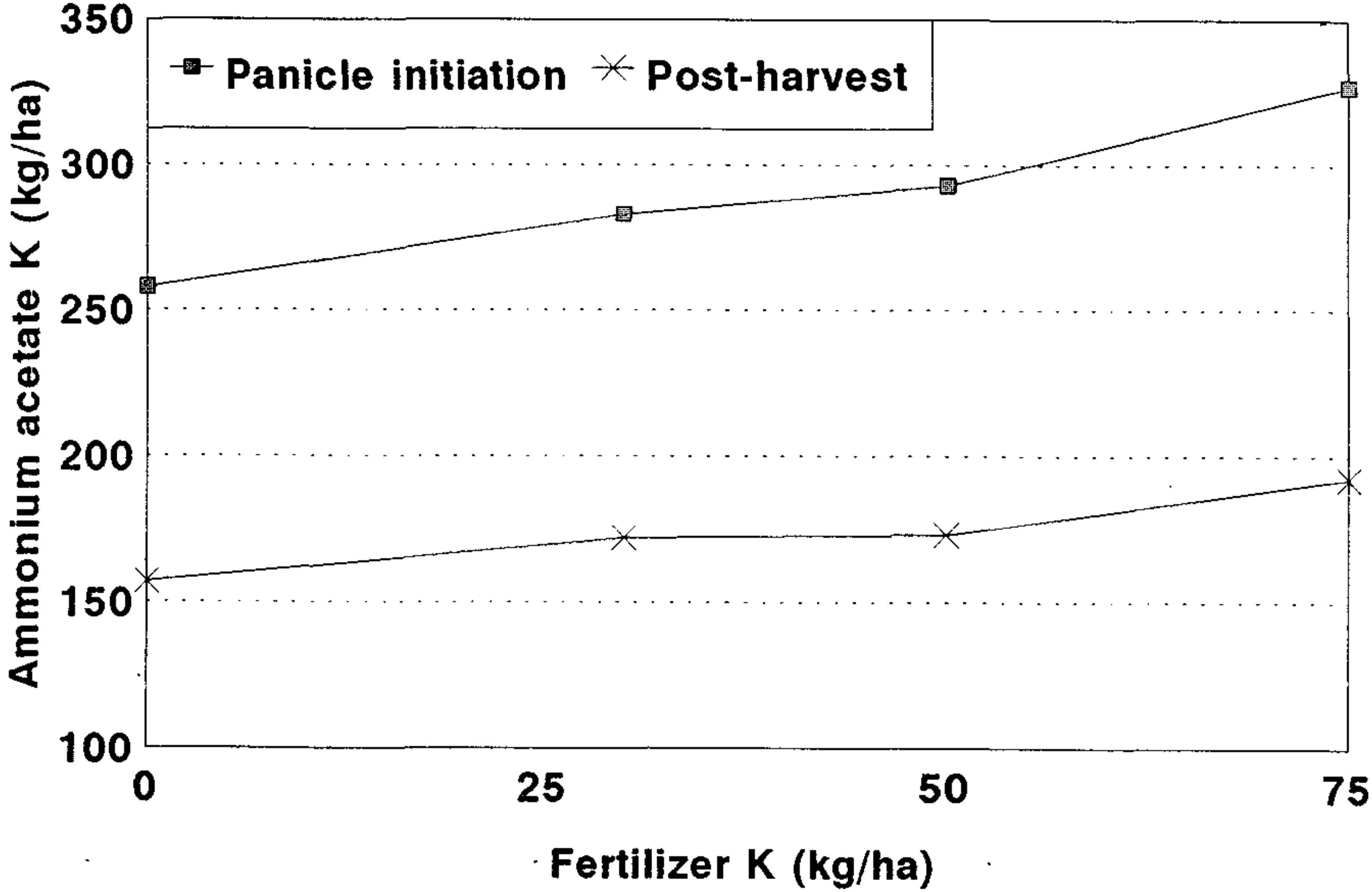


Fig.18(a). Relation between soil K and fertilizer K in rice at Jagtial during kharif 1996



at post-harvest stage as against 0.21 with a C.V. (%) of 28.1 at panicle initiation stage thus indicating a build-up of organic carbon. Similarly, the mean soil N (kg/ha based on $Ca(OH)_2$ at post-harvest stage was found to be 126.3 with a C.V. (%) of 32.9 as against 86.1 with a C.V. (%) of 28.7 at panicle initiation stage, thus showing a build-up of soil N. The relations between organic carbon at panicle initiation and post-harvest stages at different levels of fertilization are given in Fig.14(a). Similar relations for soil N by $KMnO_4$ and $Ca(OH)_2$ methods are given in Fig.15(a) and 16(a). The relations of soil test values of Olsen's P with fertilizer P, and ammonium acetate K with fertilizer K are given in Fig.17(a) and 18(a) respectively. The average soil test values from plots which received same level of fertilizer dose have been worked out and are given in Table 36 which indicated that the soil test values increased with the increase in fertilizer dose.

The coefficient of variation decreased in the case of soil P and K contents from the panicle initiation to the post-harvest stages, although there was a build-up in soil P while there was a depletion in soil K status.

5.3.6.2. WARANGAL CENTRE :

From the Tables 20 and 22, it is observed that there was a build-up of soil N based on all the three methods

Fig.14(b). Relation between soil N and fertilizer N in rice at Warangal during kharif 1996

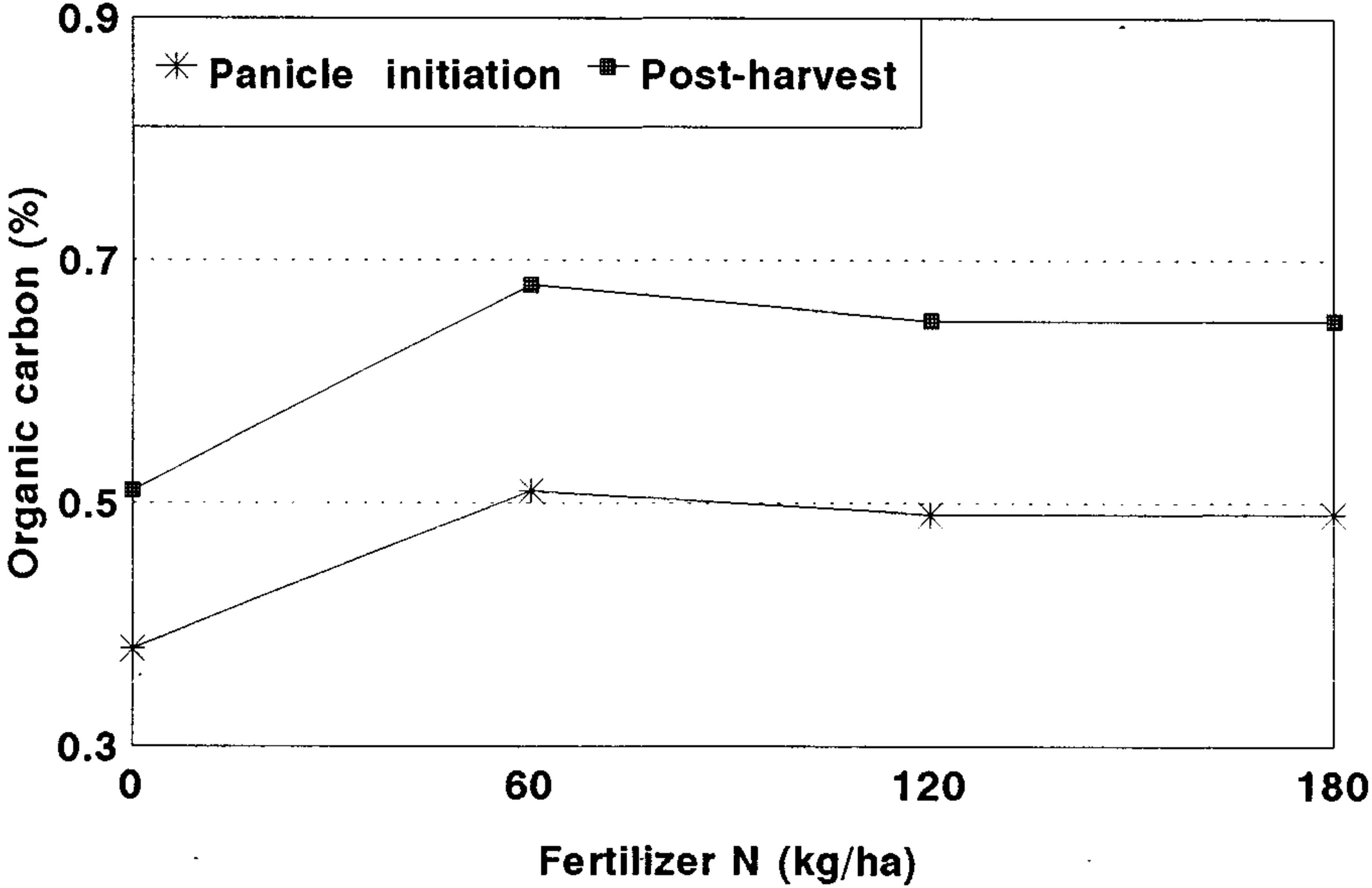


Fig.15(b). Relation between soil N and fertilizer N in rice at Warangal during kharif 1996

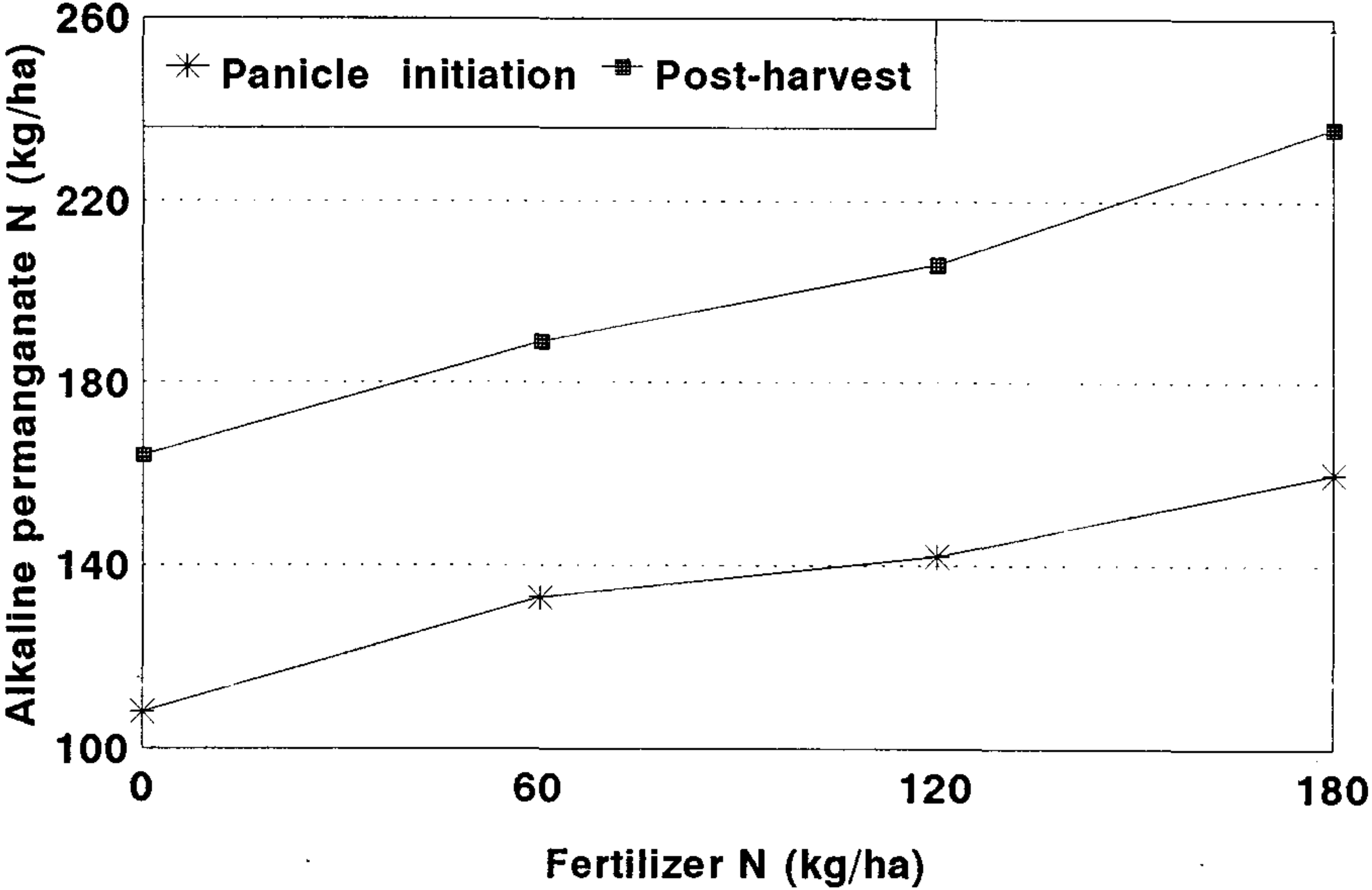
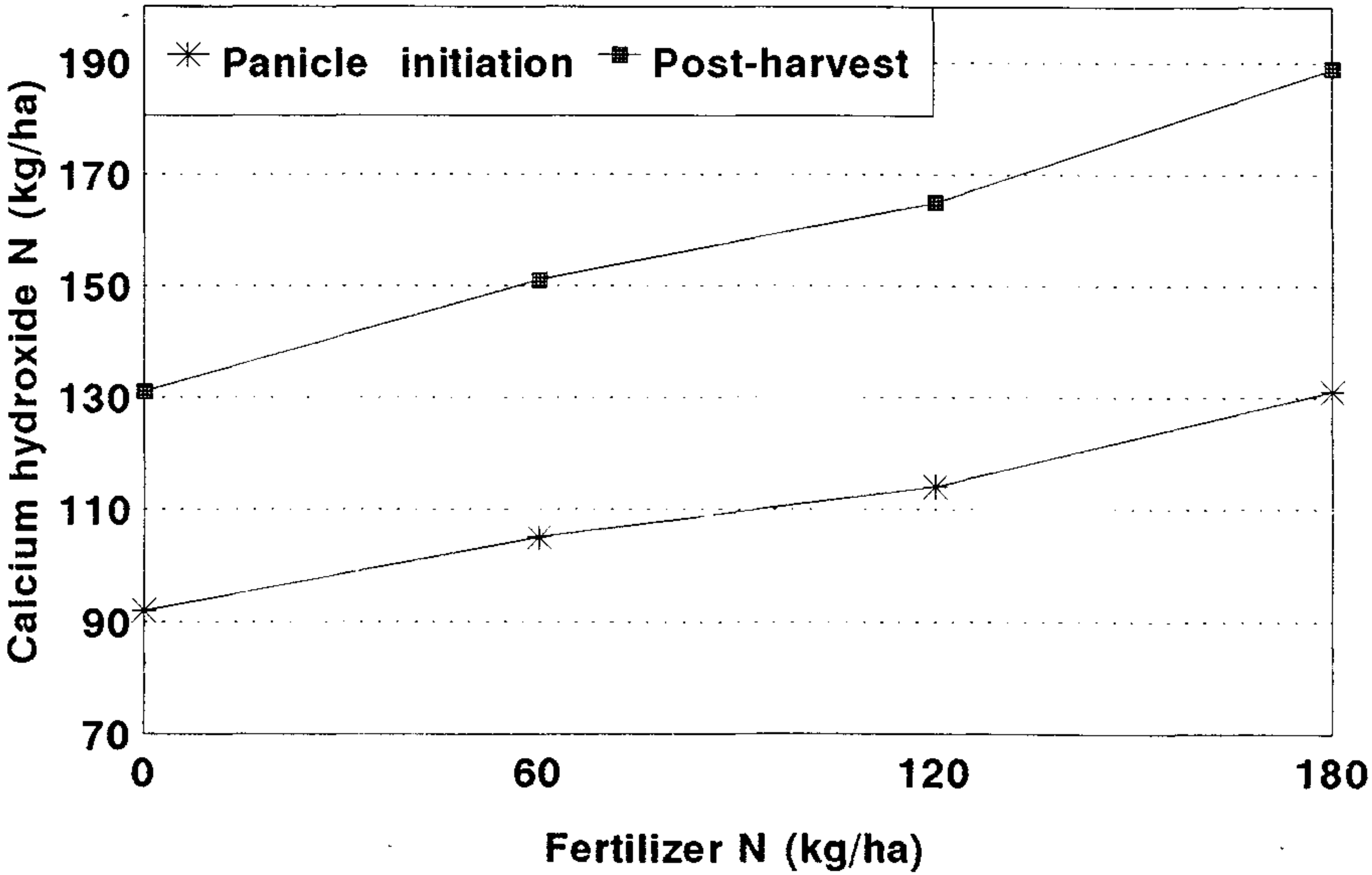


Fig.16(b). Relation between soil N and fertilizer N in rice at Warangal during kharif 1996



of soil N viz., organic carbon, $KMnO_4$ and $Ca(OH)_2$ methods. The mean Soil N (kg/ha) based on $KMnO_4$ method was found to be 201.7 (C.V. (%) of 12.9) as against 137.7 (C.V. (%) of 10.5). The mean values of organic carbon (%) were 0.64 (C.V. (%) of 24.3) at post-harvest stage as against 0.48 (C.V. (%) of 24.5) at panicle initiation stage. Similarly, the mean soil N (kg/ha) based on $Ca(OH)_2$ method were found to be 161.6 (C.V. (%) of 12.7) as against 112.4 (C.V. (%) of 10.7) at panicle initiation stage. Thus it is observed that there is a clear build-up of soil N by all the three methods from panicle initiation to post-harvest stage.

In respect of soil P, there was a build-up from the panicle initiation to the post-harvest stage with a mean soil P of 27.9 and 30.4 kg/ha. Similarly, there was a build-up of soil K from 516.7 at panicle initiation to 578.1 kg/ha at post-harvest stage.

The relations between organic carbon at panicle initiation and post-harvest stages at different levels of fertilization are given in Fig.14(b). Similar relations for soil N by $KMnO_4$ and $Ca(OH)_2$ methods are given in Fig.15(b) and 16(b). The relations of soil test values of Olsen's P with fertilizer P, and ammonium acetate K with fertilizer K are given in Fig.17(b) and 18(b) respectively. The means of soil test values from plots which received the same level of

Fig.17(b). Relation between soil available P and fertilizer P in field experiment at Warangal

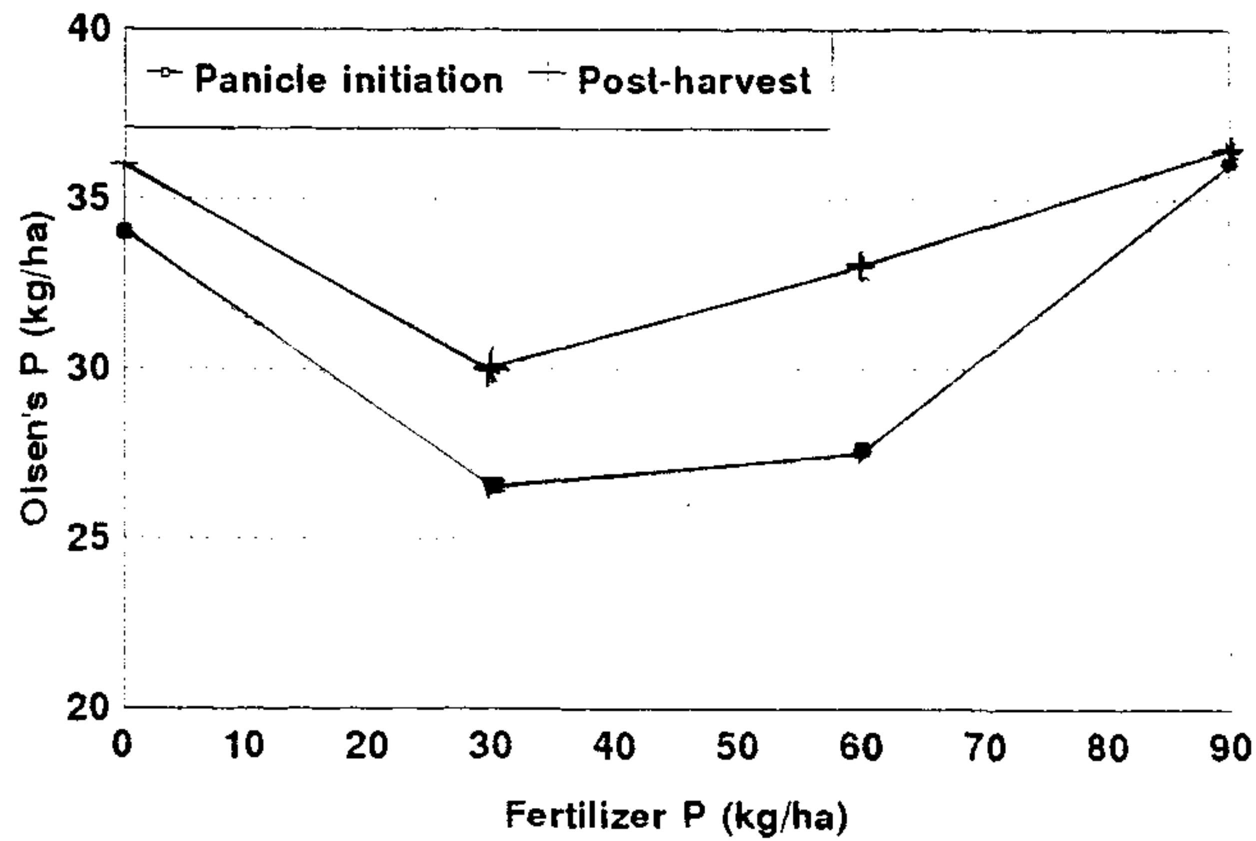
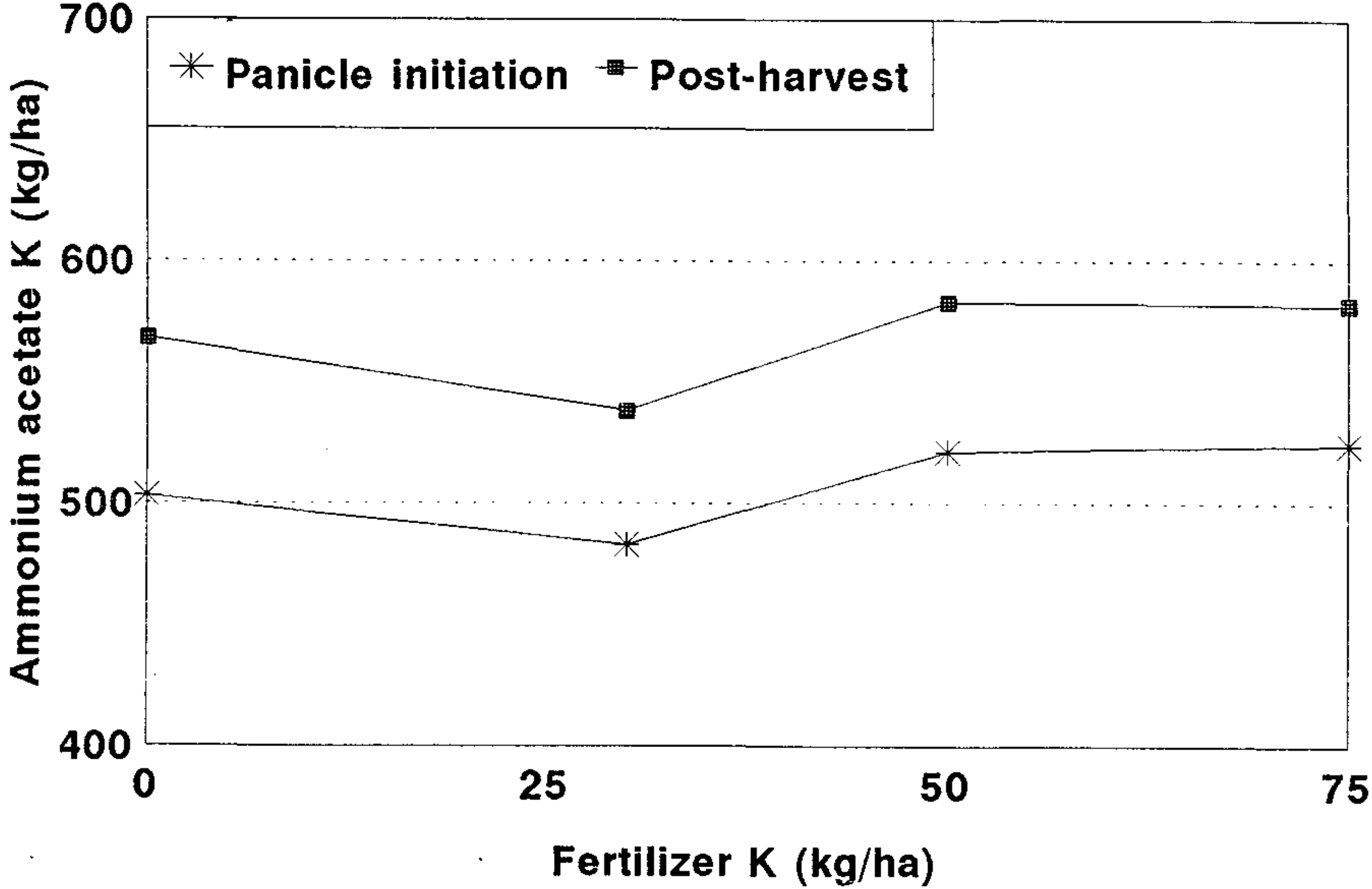


Fig.18(b). Relation between soil K and fertilizer K in rice at Warangal during kharif 1996



fertilizer dose have been worked out and are given in Table 37, which clearly indicate that the soil fertility status improved due to increase in the fertilizer application.

The survey data and results has also indicated that the farmer's were getting higher yields in Warangal district which is clearly reflected in the experimental data and results of this centre. It was also observed that the soil fertility was higher in the soils of Warangal district when compared to the soil fertility of the other three districts in the command area of Sreeramsagar project.

5.3.6.3. PREDICTION EQUATIONS OF POST-HARVEST SOIL TEST VALUES

As indicated by the data and results of soil fertility status at both Jagtial and Warangal locations, the soil fertility interms of available N, P and K has changed from the panicle initiation to the post-harvest stages. Significant correlations were found to exist between the soil test values of N, P and K nutrients as observed at these two stages at both locations. The correlations of soil test values at panicle initiation and post-harvest stages were found to be 0.81 (**) for organic carbon, 0.88 (**) for $KMnO_4$, 0.77 (**) for $Ca(OH)_2$, 0.87 (**) for Olsen's P, and 0.79 (**) for ammonium acetate K at Jagtial. These estimates

Table 23(a). Prediction equations of post-harvest soil test values at Jagtial and Warangal during kharif 1996

Location	Multiple regression equation	R2	r-value
Jagtial	OC (PH) = 0.001 + 1.342 OC (PI) ** - 0.0001 FN - 0.0001 GY	0.85 **	0.81 **
	KM (PH) = -1.750 + 1.515 KM (PI) ** + 0.0128 FN - 0.0032 GY	0.91 **	0.88 **
	CA (PH) = -13.46 + 1.640 CA (PI) ** - 0.0129 FN - 0.0001 GY	0.81 **	0.77 **
	OL (PH) = 5.632 + 1.202 OL (PI) ** - 0.0553 FN - 0.0001 GY	0.82 **	0.87 **
	AM (PH) = 229.4 - 0.183 AM (PI) ** + 0.5529 FN - 0.0109 GY	0.79 **	0.79 **
Warangal	OC (PH) = 0.011 + 1.337 OC (PI) ** + 0.0001 FN - 0.0001 GY	0.89 **	0.83 **
	KM (PH) = 17.98 + 1.480 KM (PI) ** - 0.0179 FN - 0.0055 GY	0.91 **	0.91 **
	CA (PH) = -14.80 + 1.609 CA (PI) ** - 0.0172 FN - 0.0007 GY	0.81 **	0.81 **
	OL (PH) = 22.20 + 1.349 OL (PI) ** - 0.0119 FN + 0.0032 GY	0.79 **	0.82 **
	AM (PH) = 40.18 + 1.036 AM (PI) ** - 0.0803 FN + 0.0017 GY	0.86 **	0.89 **

** : significant at 1 % level of significance

r-value : correlation between soil test values at panicle initiation and post-harvest stages

R2 : coefficient of predictability of post-harvest soil test values through soil test values at panicle initiation stage, fertilizer doses, grain yield for Warangal were 0.83 (**), 0.91 (**), 0.81 (**), 0.82 (**), and 0.89 (**) respectively for all the above pairs of variables. The estimates of correlation are given in Table 23(a). All the correlations were higher at Jagtial than at Warangal except for Olsen's P.

The regression equations of post-harvest soil test values through soil test values observed at panicle initiation stage, fertilizer doses applied and grain yield attained have been calibrated and are given in Table 23 (a). A high and significant predictability (R^2) was observed for soil N, P and K nutrients at both locations. The values of predictability were found to be 0.85 (**) for organic carbon, 0.91 (**) for soil N ($KMnO_4$), 0.81 (**) for soil N ($Ca(OH)_2$), 0.82 (**) for soil P and 0.79 (**) for soil K at Jagtial location. These values for Warangal were 0.89 (**), 0.91 (**), 0.81 (**), 0.79 (**) and 0.86 (**) respectively. Thus the equations have clearly indicated that it is possible to predict post-harvest soil test values of N, P and K nutrients through soil test values as observed at panicle initiation stage. The regression coefficients of soil N, P and K variables of panicle initiation stage of both Jagtial and Warangal were highly significant at 1 % level of significance for predicting post-harvest soil test values, and hence further deriving fertilizer recommendations for attaining different levels of yields. These results are also in confirmity with the data and results as observed in the survey of rice soils of Sreeramsagar project command area of all the four districts. The experimental results have also indicated that prediction post-harvest soil N based on alkaline permanganate method through the soil test values of the panicle initiation stage were higher when compared to the predictions based on the organic carbon and calcium hydroxide methods.

5.4. FERTILIZER RECOMMENDATIONS FOR SREERAMSAGAR PROJECT COMMAND AREA

The survey results of four districts of Sreeramsagar project and the results of experiments conducted at Jagtial and Warangal have been compared and it is observed that the experimental results can be extended to the farmers fields and hence have inherent practical utility. The results that can be extended to the surveyed soils are fertilizer prescription based on soil test values for maximum and economic yields, a desired rate of return and targetted yields based on predicted post-harvest soil test values through soil test values as observed at the panicle initiation stage.

5.4.1. PREDICTION OF POST-HARVEST SOIL TEST VALUES FOR FERTILIZER RECOMMENDATION

From the experimental study and results of Jagtial and Warangal, regression equations have been developed for predicting post-harvest soil N, P and K nutrients through available soil test values obtained either at initial or panicle initiation stages with a high and significant degree of predictability (R^2) as given in Table 23 (a). The coefficients of predictability were found to be ranging between 0.79 and 0.91 for N, P and K prediction at both locations. After predicting the soil test values, the optimum fertilizer doses can be derived using different fertilizer adjustment equations calibrated for attaining maximum, economic and targetted yields. The fertilizer adjustment equations developed for Jagtial and Warangal are given in Tables 27 and 30 which can be used for the soils of the area surveyed for deriving optimum fertilizer doses. Dhillon et al (1978) have shown that precise fertilizer recommendation can be made based on soil test values to get maximum yield, maximum profit and maximum marginal return on fertilizer investment using multiple regression equations which have a higher and significant R^2 value.

Table 29(d). Fertilizer N, P and K schedule based on soil test values for maximum yield, maximum profit and a desired rate of return of rice in Karimnagar soils under Sreeramsagar Project Command Area

(Using Equation 5 of fertilizer adjustment equations)

Soil test values			Optimum fertilizer doses (kg/ha) for attaining								
			Maximum yield			Maximum profit			DRR		
OC-N	OL-P	AM-K	N	P	K	N	P	K	N	P	K
0.10	5	90	242	68	9	222	59	8	203	50	7
0.15	10	95	204	65	5	184	56	5	165	48	4
0.20	15	100	166	63	2	146	54	1	127	45	1
0.25	20	105	128	60	0	108	51	0	89	43	0
0.30	25	110	90	58		70	49		51	40	
0.35	30	115	52	55		32	46		13	38	
0.40	35	120	14	53		0	44		0	35	
0.45	40	125	0	50			41			33	
0.50	45	130		48			39			30	
0.55	50	135		45			36			28	
0.60	55	140		43			34			25	
0.65	60	145		40			31			23	

Maximum yield (kg/ha)
Maximum profit (Rs/ha)
DRR : Desired rate of return (DRR = 1:2)

OC-N : Organic carbon (%)
OL-P : Olsen's P (kg/ha)
AM-K : Ammonium acetate K (kg/ha)

Fertlizer adjustment equations :

FN = 318 - 760 SN - 12.50 R
FP2O5 = 70 - 0.50 SP - 5.00 R
FK2O = 67 - 0.65 SP - 0.65 R

Table 29(e). Fertilizer N, P and K schedule based on soil test values for maximum yield, maximum profit and a desired rate of return of rice in Karimnagar soils under Sreeramsagar Project Command Area

(Using Equation 6 of fertilizer adjustment equations)

Soil test values			Optimum fertilizer doses (kg/ha) for attaining								
			Maximum yield			Maximum profit			DRR		
KM-N	OL-P	AM-K	N	P	K	N	P	K	N	P	K
75	5	90	92	71	11	88	66	11	84	61	10
100	10	95	79	67	10	75	62	10	71	57	9
125	15	100	67	63	9	63	58	9	59	53	8
150	20	105	54	59	8	50	54	8	46	49	8
175	25	110	42	55	7	38	49	7	34	44	7
200	30	115	29	50	6	25	45	6	21	40	6
225	35	120	17	46	5	13	41	5	9	36	5
250	40	125	4	42	4	0	37	4	0	32	4
275	45	130	0	38	3		33	3		28	3
300	50	135		34	2		29	2		24	2
325	55	140		30	1		25	1		20	1
350	60	145		26	0		21	0		16	0

Maximum yield (kg/ha)
Maximum profit (Rs/ha)
DRR : Desired rate of return (DRR = 1:2)

KM-N : Alkaline permanaganate N (kg/ha)
OL-P : Olsen's P (kg/ha)
AM-K : Ammonium acetate K (kg/ha)

Fertlizer adjustment equations :

$$FN = 129 - 0.50\ SN - 2.50\ R$$
$$FP2O5 = 75 - 0.82\ SP - 2.94\ R$$
$$FK2O = 28 - 0.19\ SP - 0.40\ R$$

5.4.2. FERTILIZER RECOMMENDATION FOR MAXIMUM YIELD, PROFIT AND DESIRED RATE OF RETURN

The fertilizer recommendations for maximum yield, maximum profit and a desired rate of return have been derived for the Sreeramsagar Project command area by using the fertilizer adjustment equations developed for Jagtial and Warangal locations and are given in Tables 29(d) and 29(e) for the soils of Karimnagar district, and Tables 31(d) and 31(e) for Warangal district. From Table 29(d), as a package for soils of Karimnagar district, it can be prescribed that a farmer has to apply fertilizer N, P and K doses of 52, 60 and 9 kg/ha at available soil test values of 0.35 (%) organic carbon, 20 kg/ha of soil P, and 90 kg/ha of soil K for attaining a maximum yield. At the same level of soil test values, for attaining maximum profit, a farmer has to apply 32, 51 and 8 of N, P and K fertilizer doses. Similarly, at the same level of soil fertility, the fertilizer N, P and K doses for a desired rate of return (say 1 : 2) are 13, 43 and 7 kg/ha respectively. The optimum fertilizer N, P and K at soil test values of 175, 25 and 110 N, P and K based on $KMnO_4$ N, Olsen's P and ammonium acetate K methods are 42,55 and 7 for attaining maximum yield, 38, 49 and 7 for maximum profit, and 34, 44 and 7 kg/ha for desired rate of return respectively. The fertilizer doses derived are lower and more

Table 31(d). Fertilizer N, P and K schedule based on soil test values for maximum yield, maximum profit and a desired rate of return of rice in Warangal soils under Sreeramsagar Project Command Area

(Using Equation 5 of fertilizer adjustment equations)

Soil test values			Optimum fertilizer doses (kg/ha) for attaining								
			Maximum yield			Maximum profit			DRR		
OC-N	OL-P	AM-K	N	P	K	N	P	K	N	P	K
0.3	4	100	111	65	21	92	61	21	73	57	21
0.5	8	130	102	61	20	84	57	19	65	53	19
0.7	12	160	94	57	18	75	53	18	57	49	18
0.9	16	190	86	53	17	67	49	16	48	45	16
1.1	20	220	78	49	15	59	45	15	40	41	0
1.3	24	250	70	45	14	51	41	13	32	37	
1.5	28	280	61	41	12	42	37	12	24	33	
1.7	32	310	53	37	11	34	33	10	15	29	
1.9	36	340	45	33	9	26	29	9	7	25	
2.1	40	370	37	29	8	18	25	7	0	21	

Maximum yield (kg/ha)
Maximum profit (Rs/ha)
DRR : Desired rate of return (DRR = 1:2)

OC-N : Organic carbon (%)
OL-P : Olsen's P (kg/ha)
AM-K : Ammonium acetate K (kg/ha)

Fertilizer adjustment equations :

$FN = 123 - 41.10\ SN - 12.00\ R$
$FP_2O_5 = 69 - 1.00\ SP - 2.38\ R$
$FK_2O = 26 - 0.05\ SK - 0.23\ R$

Table 31(e). Fertilizer N, P and K schedule based on soil test values for maximum yield, maximum profit and a desired rate of return of rice in Warangal soils under Sreeramsagar Project Command Area

(Using Equation 6 of fertilizer adjustment equations)

Soil test values			Optimum fertilizer doses (kg/ha) for attaining								
			Maximum yield			Maximum profit			DRR		
KM-N	OL-P	AM-K	N	P	K	N	P	K	N	P	K
100	4	100	66	34	34	55	31	34	44	29	33
120	8	130	46	29	32	35	27	32	24	24	32
140	12	160	26	25	30	0	22	30	0	20	30
160	16	190	0	20	29		18	28		15	28
180	20	220		16	27		13	27		11	26
200	24	250		11	25		9	25		0	24
220	28	280		0	23		0	23			23
240	32	310			21			21			21
260	36	340			20			19			19
280	40	370			0			0			0

Maximum yield (kg/ha)
Maximum profit (Rs/ha)
DRR : Desired rate of return (DRR = 1:2)

KM-N : Alkaline permanaganate N (kg/ha)
OL-P : Olsen's P (kg/ha)
AM-K : Ammonium acetate K (kg/ha)

Fertilizer adjustment equations :

$$FN = 166 - 1.00\ SN - 7.14\ R$$
$$FP2O5 = 38 - 1.11\ SP - 1.43\ R$$
$$FK2O = 40 - 0.06\ SK - 0.39\ R$$

economical when calibrated using the fertilizer adjustment equations developed with KMnO4, Olsen'P and ammonium acetate combinations. The above methodolgy and results are in confirmity with the work of Soil Test Crop Response project and also with the works of other research workers (Velayutham et al. 1984, Ramamoorthy et al. 1974, Rani Perumal et al. 1984, and Dev et al 1985).

The fertilizer doses for attaining maximum yield, maximum profit, and a desired rate of return (1 : 2) for the soils of Warangal district under Sreeramsagar project command using the fertilizer adjustment equations derived based on the studies at Warangal are given in Tables 31(d) and 31(e). The fertilizer N, P and K doses for attaining maximum yield at an available soil test values of 0.9 (%) organic carbon, 20 kg/ha of Olsen's P and 190 kg/ha of ammonium acetate K were found to be 86, 49 and 17 kg/ha respectively. Similarly, the fertilizer N, P and K doses at the same level of soil fertility were found to be 67, 45 and 16 for maximum profit, and 48, 41 and 16 kg/ha for desired rate of return as given in Table 31(d). The fertilizer N, P and K doses based on the equations with $KMnO_4$ combination were found to be 46, 16, 29 for maximum yield, 35, 13, 28 for maximum profit, and 24, 11, 28 kg/ha at 120, 20 and 190 kg/ha soil N, P and K test values. The fertilizer doses have clearly indicated that they

Table 34(a). Fertilizer N, P and K schedule for making fertilizer recommendation for yield targets of rice based on soil test values for Karimnagar soils under Sreeramsagar Project Command Area

WHOLE FIELD (Conventional)

			T=30 (q/ha)			T=35 (q/ha)		
Soil test values (kg/ha)			Fertilizer doses (kg/ha)					
KMnO4-N	OLSEN-P	AMAC-K	FN	FP	FK	FN	FP	FK
70	4	90	228	126	93	274	149	112
110	10	140	203	112	82	248	135	100
150	16	190	178	98	70	223	121	89
190	22	240	153	84	58	198	107	77
230	28	290	128	71	47	173	93	66
270	34	340	102	57	35	148	79	54
310	40	390	77	43	24	122	65	43
350	46	440	52	29	12	97	52	31
390	52	490	27	15	1	72	38	20
430	58	540	2	1	0	47	24	8

Fertilizer adjustment equations are :

FN = 9.08 T - 0.63 SN
FP2O5 = 4.51 T - 2.31 SP
FK2O = 3.79 T - 0.23 SK

YIELD MAXIMUM (Conventional)

70	4	90	146	96	78	175	113	94
110	10	140	127	84	67	157	101	83
150	16	190	109	72	55	139	89	71
190	22	240	90	60	43	120	78	60
230	28	290	72	48	32	102	66	48
270	34	340	54	36	20	83	54	37
310	40	390	35	25	9	65	42	26
350	46	440	17	13	0	47	30	14
390	52	490	0	1		28	18	2
430	58	540		0		10	6	0

Fertilizer adjustment equations are :

FN = 5.93 T - 0.46 SN
FP2O5 = 3.46 T - 1.98 SP
FK2O = 3.29 T - 0.23 SK

Table 35(a). Fertilizer N, P and K schedule for making fertilizer recommendation for yield targets of rice based on soil test values for Warangal soils under Sreeramsagar Project Command Area

WHOLE FIELD (Conventional procedure)

			T=35 (q/ha)			T=45 (q/ha)		
Soil test values (kg/ha)			Fertilizer doses (kg/ha)					
KMnO4-N	OLSEN-P	AMAC-K	FN	FP	FK	FN	FP	FK
100	5	100	233	122	258	336	158	343
130	10	140	195	118	242	298	154	327
160	15	180	156	113	226	260	150	311
190	20	220	118	109	210	221	145	295
220	25	260	80	104	194	183	141	279
250	30	300	41	100	178	144	136	263
280	35	340	3	96	162	106	132	247
310	40	380	0	91	146	68	127	231

Fertilizer adjustment equations are :

$$FN = 10.32\ T - 1.28\ SN$$
$$FP2O5 = 3.62\ T - 0.89\ SP$$
$$FK2O = 8.51\ T - 0.40\ SK$$

YIELD MAXIMUM (Conventional procedure)

100	5	100	178	127	208	262	165	279
130	10	140	142	122	193	227	160	264
160	15	180	107	117	178	191	155	248
190	20	220	72	112	163	156	150	233
220	25	260	36	107	148	121	145	218
250	30	300	1	101	132	85	139	203
280	35	340	0	96	117	50	134	188
310	40	380		91	102	14	129	172

Fertilizer adjustment equations are :

$$FN = 8.45\ T - 1.18\ SN$$
$$FP2O5 = 3.79\ T - 1.04\ SP$$
$$FK2O = 7.04\ T - 0.38\ SK$$

are lower and more economical based on the fertilizer adjustment equations derived using combination of KMnO4 N, Olsen's P and ammonium acetate K methods.

5.4.3. FERTILIZER RECOMMENDATION FOR TARGETTED YIELD OF RICE

The basic data viz., nutrient requirement (NR), contribution from soil (CS) and contrbution from fertilizer (CF) and fertilizer adjustment equations for attaining different yield targets for Jagtial and Warangal locations have been computed and are given in Tables 32 and 33 respectively. Using these fertilizer adjustment equations, optimum fertilizer doses for varying soil test values and for attaining yield targets of 30 and 35 q/ha in the soils of Karimnagar district, and 35 and 45 q/ha in the soils of Warangal district of Sreeramsagar project command area have been derived and are given in Tables 34(a) and 35(a) respectively. As a package, the fertilizer N, P and K doses for attaining a targetted yield of 35 q/ha at available soil test values (kg/ha) of 230 N, 28 P, and 290 K were found to be 102, 66 and 48 kg/ha respectively based on the fertilizer adjustment equations derived under yield-maximum method.

Similarly, the fertilizer N, P and K doses for attaining an yield target of 35 q/ha in the soils of Warangal district with available soil test values of 190 N, 20 P and

220 kg/ha of K were found to be 72, 112 and 163 kg/ha respectively. The methodology and these results are in confirmity with the results of Soil Test Crop Response project and also with those of the previous research workers.

5.4.4. QUICK SOIL TESTS FOR ASSESSING SOIL FERTILITY IN SOIL TESTING LABORATORIES OF ANDHRA PRADESH

Based on quick soil tests of colour comparison for organic carbon determination which is adopted in soil testing laboratories, it was observed that 88.7 % of soils under different textures were found to be low (133 out of 150 samples) in all the four districts studied. This is followed by 6 % in medium and 5.3 % in high soil fertility categories in all districts irrespective of textures. The evaluation of three methods of N revealed that 88.7 % samples were low in visual colour comparitive method of OC as against 4 % low under Walkley and Black's titrimetric method, and 95 % low under Subbiah and Asija method of soil available N in the four surveyed districts irrespective of textures. This indicated that alkaline permanganate method of soil N is a good evaluator and index of N availability in rice soils.

Based on the Results and Discussions, the following conclusions are drawn :

1. The Sreeramsagar Project Command Area surveyed revealed that red (alfisols and inceptisols) chalka and black (vertisols) clay soils are predominanat groups.

2. The red soil which comprise of 65 % of the area were sandy loam to loamy sand in texture. The black soil which comprise *of 35 % of the area were found to be clay loam to silty clay* loam in texture.

3. Available N estimates based on KMnO4 oxidation was found to be a good index of available Nitrogen in soils surveyed.

4. For P and K soil tests, Olsen's and ammonium acetate extraction methods were found to be suitable soil test methods respectively for both survey and experimental soils.

5. Categorization of soil nutrient availability into low, medium and high soil fertility groups based on survey data of farmers fields was done at initial, panicle initiation and post-harvest stage of the crop to assess the soil fertility and examine the basis of fertilizer recommendation. It was found that 221 fields were low, 8 were medium and 1 was high in Karimnagar district. The frequencies for the other districts were 14, 1, 0 under L, M and H for Nizamabad, 25, 0, 0 for Warangal and 28, 2, 0 for Adilabad respectively.

This indicated that most of the Rice fields (about 97 % surveyed) are low to medium for all the three nutrients.

6. Rice yield obtained by farmers in SRSP surveyed ranged from 12 to 52.8 q/ha in Karimnagar, 17.6 to 21 in Nizamabad, 16 to 42 in Warangal and from 14 to 28 q/ha in Adilabad districts respectively.

7. High and significant correlation between initial and post-harvest soil test values of the three nutrients in all the four districts were observed. The estimates of correlation were 0.83, 0.78, 0.72 for N, P and K at Karimnagar district. The values were 0.87, 0.84 and 0.61 at Nizamabad, 0.92, 0.82 and 0.73 at Warangal and 0.71, 0.90 and 0.93 at Adilabad for N, P and K nutrients respectively.

8. Prediction of alkaline permanganate extracted N through organic carbon content of soils were found to be significant in all the four districts of Sreeramsagar Project surveyed and soil N prediction equations over all the soil textures are :

Karimnagar : $KMnO4 = 152 + 12.78^{**}\ OC\ (\%)$

$(R^2 = 0.66^{**}, \quad \sigma = 47.4, \quad C.V.\ (\%) = 25.1)$

Nizamabad : $KMnO4 = 288 - 59.81^{**}\ OC\ (\%)$

$(R^2 = 0.60^{**}, \quad \sigma = 72.8, \quad C.V.\ (\%) = 34.4)$

Warangal : $KMnO4 = 174 + 12.25^{**}\ OC\ (\%)$

$(R^2 = 0.61^{**},\quad \sigma = 43.8,\quad C.V.\ (\%) = 23.8)$

Adilabad : $KMnO4 = 125 + 68.99^{**}\ OC\ (\%)$

$(R^2 = 0.71^{**},\quad \sigma = 32.7,\quad C.V.\ (\%) = 15.8)$

9. Quick soil tests for organic carbon by colour comparative method as adopted in soil testing laboratories were tested with 150 soils and compared with routine soil tests organic carbon (Walkley and Black 1934) and available N method of Subbaiah and Asija (1956) and ratings were given texture wise also and it is assessed from the results that quick soil tests were not reliable in more than 50 % of the cases analysed and therefore cannot form the basis for fertilizer recommendations.

The alkaline permanganate method is the reliable and accurate for assessment of soil available N in survey soils.

10. Two field experiments were conducted one at Jagtial (alfisols) and the other at Warangal (vertisols) locations during kharif 1996. At Jagtial, maximum grain yield was recorded in T12 treatment (180 - 90 - 75) followed by T8 (120 - 90 - 50) treatment with 2701 kg/ha. The yield of rice (IR-64 test crop) ranged from 2339 to 3691 with a mean of 2260 (S.D. of 661) kg/ha. The plant uptake of N ranged between

24.1 to 126.9, P between 3.7 and 13.3 and K between 16.6 and 65.1 with mean (S.D.) of 70.9 (26.2), 8 (2.5) and 44.5 (12.3) Kg/ha respectively.

11. At Warangal with Rice variety Erramallelu as test crop, T14 treatment (120 - 60 - 30) recorded highest grain yield (3915 kg/ha). T6 (120 - 60 - 50) recorded highest drymatter production (5340 kg/ha). The grain yield ranged from 2210 to 4719 with a mean (S.D.) of 3297 (525.5) kg/ha. The uptake of N was found to range between 26.9 and 145.8, P between 3.8 and 10, and K between 28.3 and 60.3 with a mean (S.D.) of 63 (25.6), 6.5 (1.5) and 39.3 (7.3) kg/ha respectively.

12. Nitrogen test was evaluated by three methods in experimental soils viz., Organic carbon, Alkaline permanganate method and Hot $Ca(OH)_2$ distillation method (Prasad 1966). These three methods have been correlated with different parameters like grain yield, drymatter, plant uptake of N, P and K, plant height, panicle length, applied fertilizer nutrients and inferences about the suitability of a soil test method have been drawn. Soil N based on alkaline permanganate method was found to have a high and significant correlation with grain yield at both Jagtial (0.549) and Warangal (0.492). Therefore it is a better method over the other two methods.

13. High yields of rice obtained at Warangal are possibly due to even rainfall distribution coupled with better native soil fertility status and heavier texture of the soil as compared to Jagtial soils which are comparitively light textured.

14. Positive response to application of N, P and K fertilizers were observed both at Jagtial and Warangal centres. At Jagtial N was found to give response upto 180 kg/ha. The response ratios (kg/kg) were found to be 7.8 at 60 kg/ha and 10 at 120 kg/ha for N. Fertilizer P was found to provide response upto 90 kg/ha, with a decrease in response ratio when compared at 30 and 60 kg/ha of application.

15. At Warangal, N has responded upto 60 kg/ha only. The response ratios were of the order 6.2 at 40 kg/ha, 3 at 60 kg/ha and 1.5 at 120 kg/ha. The response to P was found to be negative at all levels of application. However, K was found to provide response upto 30 kg/ha of application and negative thereafter.

16. The multiple regression equations were calibrated for predicting the yield through 12 variables comprising of 6 fertilizer terms, 3 soil terms and 3 soil and fertilizer interaction terms. Using the regression equations, fertilizer adjustment equations have been calibrated and ready reckoners of soil test based fertilizer doses have been worked out for

attaining maximum yield, maximum profit and a desired rate of return for both locations.

For Jagtial soils, the fertilizer doses were found to be meaningful and within the doses experimented in the soils. It was observed that optimum fertilizer N doses were higher with the equation using organic carbon (%) when compared to those of $KMnO_4$ and $Ca(OH)_2$ equations. The N, P and K fertilizer adjustment equations are given below for Jagtial soils for varying soil test values (with $KMnO_4$ combination).

$$FN = 129 - 0.50\ SN - 2.50\ R$$

$$FP_2O_5 = 75 - 0.82\ SP - 2.94\ R$$

$$FK_2O = 28 - 0.19\ SK - 0.40\ R$$

For Warangal soils also, the same trends were observed i.e., a higher dose based on organic carbon (%) equation when compared with $KMnO_4$ or $Ca(OH)_2$ combinations.

$$FN = 166 - 1.00\ SN - 7.14\ R$$

$$FP_2O_5 = 38 - 1.11\ SP - 1.43\ R$$

$$FK_2O = 40 - 0.06\ SK - 0.39\ R$$

17. Basic data and targetted yield equations have been derived under both conventional (whole field of 42 plots) and simultaneous procedures (14 plots which are means of 3 replications). The estimates were found to be marginally higher under the conventional procedure. However, the doses

calculated based on either of the two procedures were found to be meaningful for attaining a desired yield target of rice. The basic data indicates that nutrient requirement of N is around 3.0, while P_2O_5 and K_2O are around 0.75 and 2.0 respectively for Jagtial centre whereas at Warangal centre, NR of N is around 1.8, while P_2O_5 and K_2O are around 0.22 and 1.2 respectively. Thus it was evident that the nutrient requirement per quintal of grain production was more in Jagtial centre indicating more efficient utilization of absorbed nutrients for grain production.

18. I.R.64 variety of rice responded significantly upto 180 kg N/ha at Jagtial whereas Erramallelu has responded upto 60 kg N/ha at Warangal.

Soil testing and Soil Test based fertilizer recommendation are still elusive under the Indian farming situations. The large number of STL's and a wide network of research projects carried out under ICAR sponsored Soil Test Crop Response Correlation project have generated voluminous data which needs to be correlated and used for evolving appropriate fertilizer recommendations for crops and cropping systems. The correlation is carried out continuously and recommendations have been provided. However, under irrigation commands of large irrigation projects having extended acreages under different cropping systems, the need for evolving adoptable fertilizer recommendations has been felt more than ever both because of economic compulsion and for protecting the environment from excessive loads of residual fertilizer nutrients. To tackle these issues, studies have been conducted to evolve appropriate fertilizer schedules for different types of soils under the Sreeramsagar project area which has 3.97 laks ha under its command in Andhra Pradesh. The project is one of the largest of its kind in the state. The need for this study has arisen because it has been reported that fertilization to rice based cropping systems practiced by farmers are not based on any scientific facts even though blanket recommendations have been evolved. The studies have indicated that for achieving yield optimization, or a particular yield level (targetted yield) or a economic return to investments in fertilizers available N estimates employing the method evolved by Subbiah and Asija (1956) where $KMnO_4$ is used as the principal reagent is ideal. It is possible to evolve appropriate fertilization schedules based on the native soil fertility and adjust the fertilizer additions properly so as to avoid excessive use of fertilizers or thier use in lesser quantities than actually required. A rationale for fertilizer use has thus been evolved which can be recommended for rice in the Sreeramsagar project command area.

SUMMARY

CHAPTER VI

SUMMARY

Nitrogen fertilizers account for a major portion among the fertilizers being used in Indian agriculture and nitrogen deficiency in the soils is well spread. Efforts to develop chemical indexes continue to be stimulated by the need for a more reliable and rapid method of assessing the N availability. Evaluation of various chemical indexes for assessment of N availability in soils based on Soil Test Crop Response correlation studies formed the key for fertilizer 'N' recommendation to crops. Based on the needs, the present study was undertaken to :

i) evaluate N availability indices in rice and work out relationship between soil test values and yield responses to fertilizer nitrogen ;

ii) develop bases for evolving fertilizer recommendation for maximum yield, maximum profit and desired yield targets of kharif paddy applicable to the command area of the Sreeramsagar Project, spread over four districts of Andhra Pradesh viz., Karimnagar, Warangal, Nizamabad and Adilabad.

With these objectives in view, an extensive survey was conducted during the year 1993 and 1994 covering four districts of Sreeramsagar Project viz., Karimnagar, Warangal, Nizamabad and Adilabad in irrigated rice fields. For this purpose, 60 villages were selected for the study and 300 soil samples were collected at the rate of 5 samples per each village. The area surveyed covered 21 mandals spread over the four districts. The survey was conducted after formulating an appropriate questionnaire which enabled collection of uniform data in the desired form and for its easy collection, synthesis and analysis. The soil samples were collected from the selected fields thrice i.e., before transplantation of rice, at its panicle initiation and after harvest of the rice crop. The plant samples of rice (3rd leaf from the top) was collected at panicle initiation stage of growth. Post harvest data pertaining to yield of rice crop were obtained from all the locations.

The predominent soil types in Command Area were identified as alfisols and inceptisols referred as red chalka soils and vertisols referred to as black soils. Texturally the soils ranged from light textured sandy loams to medium textured clay loams.

The soils were classified into different fertility classes based on organic carbon content, available N, P and K status. District and texture wise categorization of soils into different fertility groups was also carried out. Plant samples collected at panicle initiation stage were analysed for plant nutrient concentrations and correlated with yield.

The results indicated that high and significant correlations were obtained between initial and post harvest N, P and K soil test values in all four districts surveyed. The estimate of correlation coefficients were 0.83^{**}, 0.78^{**}, 0.72^{**} for N, P and K nutrients at Karimnagar district. The corresponding values were 0.87^{**}, 0.84^{**}, 0.61^{**} at Nizamabad, 0.92^{**}, 0.82^{**}, 0.73^{**} at Warangal and 0.71^{**}, 0.90^{**}, 0.93^{**} at Adilabad districts respectively.

The correlations between fertiliser N, P and K and grain yield were found to be significant in Karimnagar district viz., 0.39^{**}, 0.21^{*} and 0.46^{**} respectively. The relation between fertiliser K and grain yield alone was found to be significant in Warangal district (0.39^{*}). With respect to Adilabad district relationship between grain yield and fertiliser N and P 0.49^{*} and 0.48^{*} respectively. All other correlations were found to be not significant possibly due to irrational and non-judicious application of fertilisers to rice crop which was not based on soil test values.

Rice yields obtained by farmers in the project command surveyed ranged from 12 to 53 q/ha in Karimnagar, 17.6 to 21.0 in Nizamabad, 16 to 42 in Warangal and from 14 to 28 q/ha in Adilabad districts respectively. That there was a wide variation in yields obtained in farmers fields was evident which may be due to management practices adopted including fertilisation, irrigation management and native fertility status of soil.

The post-harvest soil test values were found to be highly and significantly correlated with initial soil test values in farmer's fields. The prediction equations of post-harvest soil test values through inital soil test values which can be used by soil testing laboratories for making fertiliser recommendation for Karimnagar district are as follows :

$$SN\ (PH) = 29.65 + 0.704^{**}\ SN\ (I) + 0.134\ FN - 0.149\ GY$$

$$(R^2 = 0.69^{**}\ ,\ e = 7.8\ ,\ C.V.\ (\%) = 14.2)$$

$$SP\ (PH) = 10.60 + 0.884^{**}\ SP\ (I) - 0.884\ FN + 0.0.063\ Y$$

$$(R^2 = 0.62^{**}\ ,\ e = 7.8\ ,\ C.V.\ (\%) = 28.7)$$

$$SK\ (PH) = 100.76 + 0.712^{**}\ SK\ (I) - 0.348\ FN - 0.324\ GY$$

$$(R^2 = 0.52^{**}\ ,\ e = 65.7\ ,\ C.V.\ (\%) = 24.8)$$

A significant relationship betwen O.C. (%) as determined by Walkle and Black (1934) volumetric procedure and $KMnO_4$ as deterimined by Subbaiah and Asija (1956) methods was evident for soils of different textural classes in Karimnagar district. Prediction equations have been calibrated and are given below for predicting soil N through O.C. of soils of the district.

Clay loam :	$KM = 159 + 39.9^{**}\ OC$	$R^2 = 0.62^{**}$
Sandy clay loam :	$KM = 168 + 21.7^{**}\ OC$	$R^2 = 0.69^{**}$
Sandy loam :	$KM = 148 + 44.3^{**}\ OC$	$R^2 = 0.57^{**}$
Silt loam :	$KM = 78 + 145.8^{**}\ OC$	$R^2 = 0.59^{**}$

Quick soil tests as adopted in state soil testing laboratories were also performed utilisating soil samples obtained from 150 locations of different cultivators fields of the project command spread over all the four districts. Organic matter as determined by the quick soil test of colour comparison as an index of availability of N was employed. The studies revealed that in Karimnagar district out of 120 soil samples 83.7% of them were rated as 'low', 7% medium and 9.3% high under sandy clay loam texture (SC), 97.1% under clay loam (CL) and 88.4% under sandy loam (SL) were rated as low in this district. A small percentage of soils were rated as 'high' and 'medium' in availability of N in clay and sandy loam textural classes. In Nizamabad and Warangal districts, all the sampled fields were found to be 'low' category of OC status. In Adilabad district 85.7% were low and 14.3% were medium under sandy clay loam, 57.1% were low and 42.9% medium under sandy loam texture.

Evaluation of three N indices i.e. visual colour comparison method as adopted in STL's, organic carbon by titrimetric method and alkaline permanganate soil N method were done in 150 soil selected and ratings were given with nutrient indices. It is observed that 133 cases were low, 9 were medium and 8 were high under visual colour comparative method. The low, medium and high cases were 15, 20 and 115 under titrimetric method and 143 low, 7 medium under alkaline permanganate method of N in the surveyed districts thus indicating that alkaline permanganate method was found to be a better index of available N for the soils of command area surveyed. All the four districts were found to be having low nutrient indices based on routine soil test for available N.

Data generated in the survey was confirmed by laying out two field experiments in the same command area in two locations viz., Jagtial (Red sandy loam) and Warangal (Black clay loam) during kharif 1996 with 'IR-64' and 'Yerramallelu' as test crops respectively. For this field experiment 12 fertiliser application treatment as per the recommendations of International Soil Fertility Evaluation method were used in addition to a treatment involving the most common method of fertilistion practice adopted by the farmers of the area and another treatment representing the recommended fertilisation schedule for the area. Thus the experiment was laid out consisting of 14 treatments confirming to a factorial Randomised Block Design (RBD).

At Jagtial location maximum grain yield of 3691 kg/ha was recorded in T12 treatment (180-90-75). The yields ranged from 2339 to 3691 in different treatments with a mean of 2260 kg/ha. The available soil N as determined by KMnO4 method ranged from 94.1 to 435.9 with a mean of 158 kg/ha, O.C. from 0.06 to 0.73% with a mean of 0.29%, while soil N based on Ca(OH)2 method ranged between 75.3 and 348.7 with a mean of 126.3 kg/ha. The plant uptake of N ranged from 24.1 to 126.9 with a mean of 70.9, P from 3.7 to 13.3 with a mean of 8, and K from 16.6 to 65.1 with a mean of 44.5 kg/ha.

At the Warangal location, highest grain yield of 3915 kg/ha was recorded in T14 treatment (120-60-30) whereas the highest drymatter production of 5340 kg/ha was obtained in T6 treatment (120-60-50). The grain yields ranged from 2210 to 4719 with a mean of 3297 kg/ha. The uptake of N ranged from 26.9 to 145.8, P from 3.8 to 10 and K from 28.3 to 60.3 with a mean of 63, 6.5 and 39.3 kg/ha respectively. The soil N based on KMnO4 ranged from 141.6 to 351.2 with a mean of 201.7 kg/ha, O.C. from 0.12 to 1.05 with a mean of 0.64 percent while soil N based on Ca(OH)2 method ranged from 115.2 to 281 with a mean of 161.6 kg/ha.

Significant correlation existed between grain and straw yields with N, P and K uptake and fertilizers at both centres. Significant responses of rice to application of N, P and K fertilisation were observed at both Jagtial and Warangal locations. At Jagtial, N was found to give response upto 180 kg/ha, the response ratio (kg/kg) being 7.8 at 60 kg/ha and 10 at 120 kg/ha. Fertilizer P was found to give response upto 90 kg/ha. At Warangal, N responded upto 60 kg/ha only. The response ratio was of the order 6.2 at 40 kg/ha, 3 at 60 kg/ha and 1.5 at 120 kg/ha. The response to P was negative at all levels of P application. The response to K application upto 30 kg/ha was evident.

The experimental data indicated that predictions of post-harvest soil test values of N, P and K nutrients through soil test values at panicle initiation stage, applied fertilizer doses and grain yields can be made which were agreeing with the results obtained in the survey.

Soil N based on alkaline permanganate method was found to have a high and significant correlation with grain yield at Jagtial (0.549) and Warangal (0.492) which indicated its suitability over the other two methods viz., organic carbon and Ca (OH)2 method.

The multiple regression equations for predicting yield through fertilizer N, P and K nutrients and their interactions have been developed for both locations.

Fertilizer adjustment equations have been derived for attaining maximum yield, maximum profit and a desired rate of return. Based on the fertilizer adjustment equations, optimum fertilizer doses have been worked out for both the locations.

From the estimates of basic data and targetted yield equations derived for rice at Jagtial and Warangal centres using the conventional and simultaneous procedures it was evident that fertilizer levels required to be applied were lower under simultaneous than under conventional procedure for all the three nutrients. The estimates of soil and fertiliser efficiencies of N and K were higher under conventional procedure, while for P the estimates were found to be higher under simultaneous procedure at both centres. The basic data and targetted yield equations using the data of all the 42 plots (Whole field) for the two locations are as follows :

Jagtial (Conventional procedure) :

	NR	CS	CF	Targetted yield Equation
N	3.21	22.4	35.4	$FN = 9.08\ T - 0.63\ SN$
P_2O_5	0.81	17.5	17.9	$FP_2O_5 = 4.51\ T - 2.31\ SP$
K_2O	2.43	12.0	64.1	$FK_2O = 3.79\ T - 0.23\ SK$

Response ratio (kg/kg) = 5.8

Warangal (Conventional procedure) :

	NR	CS	CF	Targetted yield Equation
N	1.82	44.4	143.7	FN = 10.32 T - 1.28 SN
P_2O_5	0.72	4.8	5.6	FP_2O_5 = 3.62 T - 0.89 SP
K_2O	0.18	12.3	16.9	FK_2O = 8.51 T - 0.40 SK

Response ratio (kg/kg) = 4.5

Based on the ready reckoners of optimum soil test based fertilizer doses, it was observed that the targetted yields of 35 and 45 q/ha can be attained with meaningful fertilizer doses at Jagtial and Warangal locations respectively.

APPENDICES

Appendix - 1

Format of Questinnaire for survey work in Sree Ramsagar Project

S.No	Details requested	Response
1.	Sample number	
2.	Date of collection	
3.	Depth of collection	
4.	Name & address of cultivator	
5.	Survey No. & area of field cultivated	
6.	Field location with description on direction from a permanent point such as well etc.,	
7.	Previous crop history	
a)	Crop and variety	
b)	Manuring	
c)	Fertilizers	
d)	Yield	
e)	Diseases and pest incidence	
8.	Drainage condition	
9.	Variety of crop grown	
10.	Nursery date	
11.	Date and week of transplantation	
12.	Details of manuring of test crop	
13.	Details of plant protection measures	
14.	Crop condition and deficiency symptoms	
15.	Yield recorded	
16.	Whether soil testing is done anytime earlier, if so details and what result, if any	

Appendix - 1(b)

CANALWISE DISTRICT-WISE AYACUT/IRRIGATION POTENTIAL CREATED (Ha)

Stage-I

S.No.	District	Kakatiya Canal		Saraswati Canal		Laxmi Canal		Total	
		Total Ayacut	I.P. Created	Total Ayacut	I.P. Created	Total Ayacut	I.P. Created	Total Ayacut	I.P. Created
1.	Nizamabad	4463	4463	-	-	8,849	3425	13,312	7,888
2.	Adilabad	-	-	14,151	8,509	-	-	14,151	8,509
3.	Karimnagar	2,34,734	*2,19,548	-	-	-	-	2,24,734	*2,19,548
4.	Warangal	1,44,803	19,015	-	-	-	-	1,44,803	19,015
	Total	**3,74,000**	**2,43,026**	**14,151**	**8,509**	**8,849**	**3,425**	**3,97,000**	**2,54,960**

Stage-II

* Above LMD - 160252
Below LMD - 59296
Total - 219548

S.No.	District	Kakatiya Canal	Saraswati Canal	Kaddam Canal	Total
		Ayacut	Ayacut	Stabilisation of Ayacut	
1.	Warangal, Nalgonda, and Khamam	1,86,800	-	-	1,86,800
2.	Adilabad	-	31.970	27,519	* 59,489
	Total	1,86,800	31.970	27,519	*2,46,289

* Including 27,519 ha. of Stabilisation of Kaddam Canal

Appendix - 2

Soil characterisation based on initial soil test values in the Sreeramsagar Project command area

S.No	Sample	Farmer's name	Village	Soil Texture	pH	EC	OC (%)	Initial STV (kg/ha) KMNO4-N	Olsen-P	Amac-K	Applied fertilizers (kg/ha) N	P2O5	K2O
		I. KARIMNAGAR											
1	106	E.Rajam	Alipoor	Clay loam	8.28	0.29	1.82	288.51	19.00	375.00	100	60	40
2	81	J.Rajeshwara Rao	Beerpur	Clay loam	6.70	0.18	1.04	119.17	41.00	277.00	100	60	40
3	164	G.Srihari Rao	Chinnakoluvala	Clay loam	8.18	0.31	1.06	150.52	14.00	408.00	100	50	40
4	162	V.Sugunakar Rao	Chinnakoluvala	Clay loam	7.76	0.18	0.76	197.57	12.00	416.00	100	60	40
5	216	K.S.Rama Rao	Dandepally	Clay loam	6.75	0.11	0.79	141.12	25.00	218.00	100	60	50
6	218	M.Uppalaiah	Dandepally	Clay loam	6.94	0.17	0.74	194.43	6.00	154.00	100	60	40
7	31	G.Rajalingum	Gollapalli	Clay loam	7.38	0.45	0.92	131.71	32.00	216.00	80	40	0
8	203	G.Chinna Rajam	Gundaram	Clay loam	8.21	0.39	0.60	285.38	20.00	368.00	100	60	40
9	204	S.Pochaiah	Gundaram	Clay loam	8.36	0.27	1.18	225.79	28.00	350.00	100	60	40
10	201	G.Pedda Rajam	Gundaram	Clay loam	7.95	0.02	0.66	200.70	16.00	388.00	100	60	40
11	202	D.Muthaiah	Gundaram	Clay loam	7.97	0.43	1.02	301.06	19.00	464.00	100	60	40
12	137	N.Muthanna	Ibrahimpatnam	Clay loam	6.85	0.47	1.16	178.75	21.00	189.00	100	60	40
13	138	K.Chinnaiah	Ibrahimpatnam	Clay loam	8.16	0.46	1.02	141.12	20.00	198.00	100	60	40
14	178	V.Nambaiah	Kajapur	Clay loam	8.06	0.42	0.83	178.75	36.00	260.00	80	45	0
15	179	M.Hanumantha Reddy	Kajapur	Clay loam	8.85	0.39	0.65	219.52	25.00	280.00	80	45	0
16	195	E.Venkat Reddy	Katkampally	Clay loam	6.85	0.22	1.35	156.80	48.00	298.00	100	50	40
17	194	K.Venkat Reddy	Katkampally	Clay loam	7.88	0.34	1.51	169.34	38.00	270.00	100	60	50
18	191	K.Prathap Reddy	Katkampally	Clay loam	7.03	0.32	0.83	172.48	28.00	226.00	100	60	50
19	90	S.Narasaiah	Kolwai	Clay loam	8.23	0.13	0.80	131.71	24.00	170.00	100	60	50
20	119	M.A.Gaffar	Koratla	Clay loam	8.30	0.20	1.22	263.42	24.00	412.00	100	45	40
21	118	D.Gangaram	Koratla	Clay loam	8.08	0.27	1.05	128.58	21.00	396.00	100	60	40
22	181	V.Venkata Rao	Lokapet	Clay loam	8.78	0.23	0.67	175.62	25.00	292.00	100	60	40
23	184	D.Ravindra Rao	Lokapet	Clay loam	8.43	0.15	1.16	175.62	10.00	310.00	100	60	40
24	185	D.Rajeshwara Rao	Lokapet	Clay loam	8.80	0.40	1.37	743.20	9.00	298.00	100	60	40
25	36	S.Ganga Reddy	Metpally	Clay loam	8.52	0.20	0.74	141.12	29.00	648.00	100	60	40
26	38	K.L.Gangaram	Metpally	Clay loam	8.03	0.26	1.94	178.75	25.00	416.00	100	60	40
27	39	P.Janga Reddy	Metpally	Clay loam	6.27	0.25	1.14	222.66	26.00	298.00	100	60	40
28	37	P.Linga Reddy	Metpally	Clay loam	6.36	0.25	1.54	150.53	37.00	272.00	100	60	40
29	54	V.Vijayendra Rao	Muthyampet	Clay loam	6.43	0.18	1.04	206.98	10.00	165.00	100	60	40
30	206	B.K.Rami Reddy	Nagaram	Clay loam	8.68	0.22	0.49	185.02	26.00	309.00	100	60	40
31	210	B.Venkata Reddy	Nagaram	Clay loam	8.11	0.06	1.00	153.66	19.00	189.00	100	60	40
32	209	B.Laxmi Reddy	Nagaram	Clay loam	8.27	0.04	0.96	225.79	22.00	252.00	100	60	40
33	207	B.K.Raji Reddy	Nagaram	Clay loam	8.82	0.28	0.24	103.49	27.00	280.00	100	60	40
34	167	V.Pedda Rajaiah	Narayanpur	Clay loam	8.32	0.12	0.31	156.80	20.00	305.00	100	60	40
35	196	Y.Ramaiah	Parepally	Clay loam	8.03	0.30	0.56	137.98	51.00	298.00	100	60	40
36	200	V.Shankaraiah	Parepally	Clay loam	8.30	0.33	1.39	103.49	29.00	368.00	100	60	40
37	197	M.Komaraiah	Parepally	Clay loam	8.05	0.16	0.75	185.02	46.00	346.00	100	60	40
38	199	M.Kamaraiah	Parepally	Clay loam	6.50	0.27	1.35	228.93	30.00	119.00	100	50	40
39	18	G.Chandraiah	Pegadapally	Clay loam	7.93	0.45	1.28	194.43	11.00	220.00	100	60	40
40	19	G.Gopala Rao	Pegadapally	Clay loam	7.84	0.59	1.33	116.03	9.00	168.00	100	45	40

41	17	M.Narasimha Reddy	Pegadapally	Clay loam	7.80	0.36	1.52	341.82	26.00	227.00	100	60	40
42	214	Saibaba	Puttapaka	Clay loam	8.45	0.20	0.40	175.62	22.00	345.00	100	60	40
43	213	Pedda Kamaiah	Puttapaka	Clay loam	8.38	0.10	1.25	175.62	20.00	480.00	100	60	40
44	25	R.Bheemaiah	Rapalle	Clay loam	8.31	0.42	0.40	272.83	10.00	168.00	100	40	0
45	30	K.Prakash Rao	Rapalle	Clay loam	5.93	0.15	1.19	159.94	31.00	276.00	100	40	0
46	113	P.Linga Reddy	Sangam	Clay loam	8.42	0.28	0.73	232.06	19.00	168.00	100	45	40
47	187	C.Jakkaiah	Sayampet	Clay loam	6.94	0.40	0.59	279.10	24.00	188.00	100	60	40
48	190	B.Sathyanarayana Re	Sayampet	Clay loam	8.29	0.20	1.44	159.44	32.00	230.00	100	60	40
49	22	K.Venkanna	Thirumalapur	Clay loam	8.15	0.35	0.79	235.20	23.00	225.00	100	60	50
50	50	D.Shyam Rao	Vellulla	Clay loam	7.73	0.25	0.93	141.12	9.00	387.00	100	60	40
51	172	I.Papaiah	Wadkapur	Clay loam	8.52	0.19	1.10	206.98	25.00	289.00	80	45	0
52	219	P.Madhava Rao	Dandepally	Clayey	5.73	0.26	0.71	188.16	17.00	110.00	100	60	40
53	188	B.Venkataiah	Sayampet	Clayey	8.03	0.39	1.22	235.20	24.00	180.00	100	60	40
54	109	K.Jagannatham	Alipoor	Loamy sand	8.15	0.45	1.59	288.51	25.00	310.00	80	40	0
55	110	S.Mallaiah	Alipoor	Loamy sand	8.45	0.39	0.66	210.11	25.00	310.00	80	40	0
56	35	P.Bheemaiah	Gollapalli	Loamy sand	7.18	0.23	0.53	106.62	10.00	125.00	80	40	0
57	135	L.Gangaram	Komati Kondapur	Loamy sand	7.90	0.45	1.10	216.38	24.00	365.00	80	40	0
58	107	E.Pachalu	Alipoor	Sandy clay loam	7.08	0.09	1.14	159.94	22.00	222.00	100	45	50
59	11	C.Anjaiah	Aravally	Sandy clay loam	6.68	0.11	0.86	197.57	27.00	189.00	100	45	50
60	13	P.Anjaiah	Aravally	Sandy clay loam	7.73	0.36	0.89	144.26	20.00	166.00	100	45	50
61	12	V.Rajalingam	Aravally	Sandy clay loam	7.99	0.10	1.13	232.06	21.00	148.00	100	45	50
62	85	A.Laxman	Beerpur	Sandy clay loam	7.75	0.40	1.79	301.06	19.00	460.00	80	45	0
63	84	A.Rajamallu	Beerpur	Sandy clay loam	8.00	0.25	0.74	219.52	36.00	381.00	80	45	0
64	71	K.Bheemaiah	Chelgal	Sandy clay loam	7.96	0.29	0.86	191.30	25.00	186.00	100	60	50
65	72	K.C.Gangaram	Chelgal	Sandy clay loam	8.39	0.16	0.47	150.52	25.00	180.00	100	60	50
66	73	E.Rajanna	Chelgal	Sandy clay loam	7.74	0.21	1.05	134.85	18.00	235.00	100	60	50
67	74	E.Lingam	Chelgal	Sandy clay loam	7.05	0.34	0.98	122.30	25.00	196.00	100	60	50
68	165	G.Rajeshwar	Chinnakoluvala	Sandy clay loam	8.04	0.23	0.98	125.44	22.00	386.00	80	40	0
69	217	P.Linga Rao	Dandepally	Sandy clay loam	8.29	0.11	0.86	200.70	9.00	146.00	100	60	40
70	5	B.Rajam	Dharmapuri	Sandy clay loam	7.99	0.33	0.80	134.85	24.00	375.00	100	45	40
71	6	P.Narayana	Donnur	Sandy clay loam	7.86	0.28	0.84	219.52	25.00	250.00	100	45	40
72	7	Y. Narayana Rao	Donnur	Sandy clay loam	6.80	0.24	1.48	122.30	43.00	243.00	100	45	40
73	32	M.Bheemaiah	Gollapalli	Sandy clay loam	6.49	0.45	0.98	200.70	38.00	246.00	80	40	0
74	34	H.Rajanna	Gollapalli	Sandy clay loam	7.84	0.33	0.73	181.89	21.00	156.00	80	40	0
75	146	C.P.Narasaiah	Gudur	Sandy clay loam	8.09	0.43	0.62	233.20	21.00	268.00	80	40	0
76	147	B.B.Yellaiah	Gudur	Sandy clay loam	6.65	0.35	1.06	150.53	10.00	166.00	80	40	0
77	148	B.Narayana	Gudur	Sandy clay loam	8.06	0.49	0.62	410.82	42.00	218.00	80	40	0
78	149	P.Gangaram	Gudur	Sandy clay loam	8.01	0.49	1.29	203.84	19.00	206.00	80	40	0
79	224	K.S.S.Reddy	Huzurabad	Sandy clay loam	7.97	0.41	1.00	266.56	10.00	178.00	80	45	40
80	140	B.Gangaram	Ibrahimpatnam	Sandy clay loam	8.26	0.40	1.17	244.61	24.00	366.00	80	45	40
81	136	E.C.Bheemaiah	Ibrahimpatnam	Sandy clay loam	8.05	0.41	1.48	247.74	25.00	206.00	80	45	40
82	96	E.Raja Reddy	Itkyal	Sandy clay loam	6.75	0.36	1.00	232.06	10.00	156.00	80	45	40
83	93	V.Raja Reddy	Itkyal	Sandy clay loam	6.90	0.46	0.77	163.07	7.00	175.00	80	45	40
84	92	B.Gangaram	Itkyal	Sandy clay loam	6.30	0.31	1.08	144.26	21.00	205.00	80	45	40
85	91	C.Rajam	Itkyal	Sandy clay loam	6.14	0.32	1.04	228.93	21.00	170.00	80	45	40
86	94	B.Linga Reddy	Itkyal	Sandy clay loam	5.56	0.22	0.77	122.30	9.00	138.00	80	45	40
87	232	A.Saiyulu	Jammikunta	Sandy clay loam	7.87	0.20	1.35	191.30	42.00	250.00	100	45	40
88	231	M.Kanakaiah	Jammikunta	Sandy clay loam	8.00	0.46	0.56	175.03	21.00	188.00	80	40	0
89	177	A.Mallaiah	Kajapur	Sandy clay loam	6.76	0.32	0.79	257.15	35.00	260.00	80	45	0
90	176	M.Rama Reddy	Kajapur	Sandy clay loam	8.06	0.46	0.53	185.02	38.00	248.00	80	45	0

91	180	G.Veeraiah	Kajapur	Sandy clay loam	8.46	0.18	0.71	175.26	34.00	366.00	80	40	0
92	193	Anjam Raju	Katkampally	Sandy clay loam	7.51	0.47	0.93	191.30	36.00	172.00	100	60	50
93	192	P.Swamy	Katkampally	Sandy clay loam	5.62	0.20	0.87	228.93	26.00	282.00	100	60	50
94	87	T.Rajalingam	Kolwai	Sandy clay loam	7.04	0.20	1.02	169.34	11.00	278.00	100	60	50
95	88	R.Janardhan Rao	Kolwai	Sandy clay loam	6.53	0.28	1.48	244.61	11.00	296.00	100	60	50
96	86	D.T.Chandraiah	Kolwai	Sandy clay loam	8.05	0.31	1.20	203.84	14.00	318.00	100	60	50
97	89	M.Rajam	Kolwai	Sandy clay loam	8.06	0.28	0.90	200.70	10.00	280.00	100	60	50
98	134	B.Erranna	Komati Kondapur	Sandy clay loam	7.52	0.58	1.48	219.52	19.00	295.00	100	60	50
99	133	T.Bheemaiah	Komati Kondapur	Sandy clay loam	6.83	0.27	1.44	188.16	18.00	316.00	100	60	50
100	117	A.A.Saleem	Koratla	Sandy clay loam	6.43	0.42	1.03	178.75	25.00	240.00	100	45	40
101	116	Md.Eglabuddin	Koratla	Sandy clay loam	7.86	0.74	1.43	244.61	20.00	302.00	100	45	40
102	120	D.Laxmi Rajam	Koratla	Sandy clay loam	7.87	0.52	0.91	232.06	20.00	148.00	100	45	40
103	103	C.C.Rajanna	Kummarapally	Sandy clay loam	8.09	0.34	1.08	363.78	9.00	130.00	100	45	40
104	105	T.Ganga Reddy	Kummarapally	Sandy clay loam	8.11	0.31	0.41	222.66	15.00	140.00	100	45	40
105	102	C.Rajanna	Kummarapally	Sandy clay loam	6.53	0.19	0.80	109.76	10.00	128.00	100	45	40
106	101	C.Linganna	Kummarapally	Sandy clay loam	6.90	0.38	0.89	188.16	8.00	120.00	100	45	40
107	104	T.Bukkanna	Kummarapally	Sandy clay loam	6.92	0.41	0.80	178.75	12.00	139.00	100	45	40
108	183	V.Vasantha Rao	Lokapet	Sandy clay loam	8.38	0.30	0.93	185.02	12.00	368.00	100	45	40
109	128	B.Chinna Pochaiah	Metpally	Sandy clay loam	8.35	0.18	0.92	156.80	21.00	246.00	100	45	40
110	129	Md.Hafeez	Metpally	Sandy clay loam	8.15	0.31	0.97	228.93	21.00	246.00	100	45	40
111	130	K.C.Bheemaiah	Metpally	Sandy clay loam	8.36	0.14	1.08	141.12	24.00	316.00	100	45	40
112	126	S.Hussain	Metpally	Sandy clay loam	8.35	0.23	0.59	112.90	22.00	290.00	100	45	40
113	40	G.Mallesham	Metpally	Sandy clay loam	7.45	0.24	0.58	163.07	24.00	158.00	100	45	40
114	127	K.M.Sambaji	Metpally	Sandy clay loam	8.26	0.38	0.91	216.38	26.00	288.00	100	45	40
115	70	B.Mallaiah	Mogilipet	Sandy clay loam	6.49	0.16	1.08	137.98	8.00	168.00	100	45	40
116	67	Y.S.Ganganna	Mogilipet	Sandy clay loam	6.90	0.14	1.05	141.12	24.00	368.00	100	45	40
117	68	B.Rajanna	Mogilipet	Sandy clay loam	8.05	0.15	1.19	235.20	21.00	376.00	100	45	40
118	121	Ch.Bheema Rao	Mohanraopet	Sandy clay loam	6.51	0.25	1.19	128.58	32.00	192.00	80	40	40
119	123	C.Mukund Rao	Mohanraopet	Sandy clay loam	5.14	0.19	0.49	163.07	24.00	176.00	80	40	40
120	125	B.Rajam	Mohanraopet	Sandy clay loam	7.10	0.43	1.10	178.75	20.00	168.00	80	40	40
121	124	B.Lingam	Mohanraopet	Sandy clay loam	5.67	0.19	0.92	191.30	36.00	168.00	80	40	40
122	51	B.Venkanna	Muthyampet	Sandy clay loam	7.21	0.10	1.11	141.12	8.00	180.00	80	40	0
123	53	M.Anadhaiah	Muthyampet	Sandy clay loam	7.70	0.19	0.86	144.26	11.00	178.00	80	40	0
124	52	E.Raghava Reddy	Muthyampet	Sandy clay loam	7.95	0.46	0.96	210.11	13.00	165.00	80	40	0
125	64	Venkata Rao	Nadukude	Sandy clay loam	7.06	0.12	0.76	134.85	8.00	156.00	80	40	0
126	65	K.Raji Reddy	Nadukude	Sandy clay loam	8.23	0.19	0.80	200.70	7.00	148.00	80	40	0
127	61	Pansha Goud	Nadukude	Sandy clay loam	6.50	0.17	0.98	203.84	11.00	187.00	80	40	0
128	62	R.Linganna	Nadukude	Sandy clay loam	7.48	0.29	0.92	122.30	10.00	171.00	80	40	0
129	166	A.Lingaiah	Narayanpur	Sandy clay loam	8.48	0.17	0.38	235.20	14.00	295.00	100	45	40
130	170	A.Chinna Rajaiah	Narayanpur	Sandy clay loam	8.81	0.15	1.45	169.34	26.00	288.00	80	40	0
131	198	G.Rajalingam	Parepally	Sandy clay loam	8.14	0.66	0.88	156.80	49.00	450.00	100	50	40
132	159	K.Ramulu	Peddabankur	Sandy clay loam	7.43	0.45	0.44	122.30	21.00	266.00	80	45	0
133	160	Sriram Ramayya	Peddabankur	Sandy clay loam	7.65	0.28	0.53	169.24	20.00	248.00	100	45	0
134	158	S.Ramayya	Peddabankur	Sandy clay loam	8.04	0.41	0.85	250.88	25.00	242.00	100	45	40
135	156	C.Nambaiah	Peddabankur	Sandy clay loam	7.95	0.51	1.16	166.21	30.00	396.00	100	40	0
136	151	K.Subba Reddy	Peddapally	Sandy clay loam	8.50	0.35	1.08	250.88	24.00	280.00	100	40	0
137	153	C.P.Narasaiah	Peddapally	Sandy clay loam	7.18	0.31	0.86	216.38	38.00	246.00	100	40	0
138	154	M.V.Ramana Reddy	Peddapally	Sandy clay loam	8.04	0.34	1.03	206.98	31.00	368.00	100	40	0
139	152	Rami Reddy	Peddapally	Sandy clay loam	8.53	0.27	0.96	235.20	21.00	290.00	100	40	0
140	155	M.Mallesham	Peddapally	Sandy clay loam	8.05	0.42	1.26	141.12	30.00	246.00	100	40	0

141	16	K.Rajaiah	Pegadapally	Sandy clay loam	8.20	0.40	0.96	244.61	8.00	96.00	100	45	40
142	77	M.Venkati	Polasa	Sandy clay loam	8.34	0.24	0.71	235.20	10.00	326.00	80	60	0
143	78	N.Rajanna	Polasa	Sandy clay loam	7.81	0.20	0.52	131.70	10.00	326.00	80	60	0
144	76	D.Narasaiah	Polasa	Sandy clay loam	8.42	0.25	0.80	213.25	8.00	188.00	80	60	0
145	79	K.Bheemaiah	Polasa	Sandy clay loam	8.03	0.21	0.89	203.84	42.00	277.00	80	60	0
146	80	S.Mondaiah	Polasa	Sandy clay loam	8.38	0.21	0.79	225.79	21.00	282.00	80	60	0
147	229	P.Devender Reddy	Pothareddypet	Sandy clay loam	6.52	0.15	1.58	213.25	6.00	106.00	80	45	40
148	230	P.Ravindra Reddy	Pothareddypet	Sandy clay loam	7.64	0.33	1.01	216.38	20.00	192.00	100	45	40
149	226	G.Malla Reddy	Pothareddypet	Sandy clay loam	6.57	0.03	0.59	166.21	25.00	171.00	100	45	40
150	228	G.Niranjan Reddy	Pothareddypet	Sandy clay loam	6.48	0.38	1.39	244.61	8.00	116.00	80	45	40
151	211	I.Mandaiah	Puttapaka	Sandy clay loam	8.53	0.26	0.29	147.39	14.00	179.00	80	45	40
152	212	Ganga Raju	Puttapaka	Sandy clay loam	8.33	0.24	1.29	194.43	16.00	126.00	80	45	40
153	215	Md.Chandbee	Puttapaka	Sandy clay loam	8.22	0.42	0.36	232.06	25.00	450.00	80	45	40
154	99	P.Linga Reddy	Raikal	Sandy clay loam	7.13	0.26	0.86	150.53	19.00	102.00	80	45	40
155	97	N.Bhoomi Reddy	Raikal	Sandy clay loam	7.56	0.10	1.28	175.62	11.00	122.00	80	45	40
156	100	B.Gangaram	Raikal	Sandy clay loam	6.09	0.22	1.35	175.62	8.00	118.00	80	45	40
157	98	Abdul Nabiz	Raikal	Sandy clay loam	6.67	0.15	0.99	128.58	11.00	125.00	80	45	40
158	28	G.Purushotham	Rapalle	Sandy clay loam	7.79	0.24	1.44	150.58	54.00	282.00	100	45	0
159	29	M.Thirupathi Goud	Rapalle	Sandy clay loam	8.18	0.25	1.32	181.89	28.00	278.00	80	40	0
160	26	K.Suguna Rao	Rapalle	Sandy clay loam	7.93	0.29	0.79	194.43	40.00	217.00	100	45	0
161	27	G.Srinivasa Rao	Rapalle	Sandy clay loam	7.34	0.30	1.04	185.16	25.00	246.00	100	45	0
162	111	S.Ganga Reddy	Sangam	Sandy clay loam	8.01	0.50	0.83	260.29	21.00	268.00	100	45	40
163	114	Y.Kishan Rao	Sangam	Sandy clay loam	6.87	0.12	0.83	206.98	23.00	348.00	100	45	40
164	115	B.Balaiah	Sangam	Sandy clay loam	8.33	0.35	0.77	181.89	22.00	368.00	100	45	40
165	189	B.Rayamallu	Sayampet	Sandy clay loam	8.07	0.38	0.84	213.25	40.00	220.00	100	45	40
166	24	G.Rajaram	Thirumalapur	Sandy clay loam	6.94	0.34	0.99	172.48	16.00	176.00	100	45	40
167	23	K.P.Rajaiah	Thirumalapur	Sandy clay loam	7.74	0.29	0.67	128.58	21.00	218.00	100	45	40
168	142	K.Lingam	Thirumalapur	Sandy clay loam	7.95	0.28	1.05	128.58	28.00	176.00	100	45	40
169	141	G.gangaram	Thirumalapur	Sandy clay loam	6.90	0.10	0.68	163.07	25.00	198.00	100	45	40
170	145	K.Bheemaiah	Thirumalapur	Sandy clay loam	7.34	0.21	1.16	225.79	20.00	198.00	100	45	40
171	143	M.Ashalu	Thirumalapur	Sandy clay loam	7.30	0.19	0.89	260.29	20.00	305.00	100	45	40
172	144	D.Gangaram	Thirumalapur	Sandy clay loam	8.02	0.51	1.31	244.61	23.00	230.00	100	45	40
173	48	Nanda Kumar	Vellulla	Sandy clay loam	8.35	0.20	0.86	75.26	5.00	178.00	100	45	40
174	47	D.Venkata Ramana	Vellulla	Sandy clay loam	8.43	0.17	1.13	144.26	4.00	186.00	80	40	40
175	46	D.Ramachandran	Vellulla	Sandy clay loam	7.76	0.26	0.74	153.66	6.00	218.00	80	40	40
176	45	A.Muthyam Reddy	Vempet	Sandy clay loam	8.32	0.11	0.83	188.16	9.00	378.00	100	45	40
177	43	K.Raji Reddy	Vempet	Sandy clay loam	8.28	0.24	0.99	360.64	21.00	276.00	100	45	40
178	41	K.Shankar Reddy	Vempet	Sandy clay loam	7.76	0.24	0.99	131.71	25.00	350.00	80	40	0
179	42	A.Linga Reddy	Vempet	Sandy clay loam	8.43	0.17	0.96	106.62	25.00	318.00	100	45	40
180	171	K.Venkataiah	Wadkapur	Sandy clay loam	8.08	0.29	1.18	131.71	25.00	288.00	80	45	0
181	108	T.Ram Gangaram	Alipoor	Sandy loam	7.96	0.45	1.16	181.89	24.00	241.00	100	60	50
182	14	G. Madhava Reddy	Aravally	Sandy loam	6.50	0.27	0.28	197.57	10.00	109.00	100	60	50
183	15	M.Mallaiah	Aravally	Sandy loam	7.42	0.31	1.22	191.30	9.00	110.00	80	45	0
184	82	S.Narayana	Beerpur	Sandy loam	6.86	0.23	1.37	178.25	55.00	247.00	100	60	40
185	83	B.Narayana Rao	Beerpur	Sandy loam	6.83	0.19	1.28	206.98	41.00	372.00	100	60	40
186	75	P.Papaiah	Chelgal	Sandy loam	8.43	0.36	1.37	235.20	10.00	212.00	100	60	50
187	163	M.Chandraiah	Chinnakoluvala	Sandy loam	8.24	0.29	0.99	200.70	19.00	366.00	80	45	40
188	1	G.Shankar	Dharmapuri	Sandy loam	8.15	0.35	0.74	144.26	45.00	303.00	80	40	0
189	2	R.Rajaiah	Dharmapuri	Sandy loam	7.40	0.13	0.31	109.76	36.00	288.00	100	45	0
190	4	K.Narasaiah	Dharmapuri	Sandy loam	8.26	0.20	1.58	269.70	32.00	271.00	100	45	0

191	3	R.Rajalingaiah	Dharmapuri	Sandy loam	8.29	0.24	1.62	163.07	41.00	466.00	100	45	0
192	10	M.Gangaram	Donnur	Sandy loam	6.31	0.24	1.03	150.53	26.00	298.00	100	45	0
193	8	P.Mallaiah	Donnur	Sandy loam	8.22	0.28	1.48	169.34	24.00	266.00	100	45	0
194	9	M.Rameshwar	Donnur	Sandy loam	8.23	0.66	1.05	178.75	48.00	270.00	100	45	0
195	33	K.Sambi Reddy	Gollapalli	Sandy loam	7.98	0.69	1.07	156.80	30.00	246.00	80	40	0
196	150	V.Narsa Reddy	Gudur	Sandy loam	7.94	0.51	0.50	163.07	21.00	210.00	80	40	0
197	223	M.Ailayya	Huzurabad	Sandy loam	6.94	0.24	1.22	232.06	15.00	228.00	80	40	0
198	222	N.Raghotham Reddy	Huzurabad	Sandy loam	6.62	0.27	0.68	272.83	18.00	166.00	80	40	0
199	95	Badayam Reddy	Itkyal	Sandy loam	6.00	0.25	0.77	219.52	9.00	142.00	80	40	0
200	234	M.Kanakaiah	Jammikunta	Sandy loam	8.16	0.04	1.48	235.20	15.00	300.00	100	45	40
201	233	A.Yadi Reddy	Jammikunta	Sandy loam	8.83	0.46	1.29	197.57	42.00	266.00	100	45	40
202	132	K.Gangaram	Komati Kondapur	Sandy loam	6.65	0.33	0.61	215.71	19.00	388.00	100	45	40
203	131	P.Ankulam	Komati Kondapur	Sandy loam	6.60	0.31	0.92	188.16	15.00	400.00	100	45	40
204	66	Akula Sayeb	Mogilipet	Sandy loam	7.50	0.58	1.14	225.79	22.00	400.00	100	45	40
205	122	P.Venkata Narasaiah	Mohanraopet	Sandy loam	6.48	0.20	0.76	134.85	25.00	176.00	80	40	40
206	55	E.Raghava Reddy	Muthyampet	Sandy loam	6.20	0.16	0.65	197.57	9.00	140.00	80	40	40
207	63	A.Dharmaji	Nadukude	Sandy loam	8.70	0.55	0.96	191.30	9.00	168.00	80	40	40
208	169	V.Mallaiah	Narayanpur	Sandy loam	8.93	0.62	0.97	188.16	24.00	305.00	80	45	0
209	168	A.Chinna Lingaiah	Narayanpur	Sandy loam	8.92	0.33	0.09	144.26	23.00	422.00	80	45	0
210	157	K.Veeresham	Peddabankur	Sandy loam	6.76	0.16	0.86	266.56	28.00	266.00	100	40	0
211	20	G.Pramila	Pegadapally	Sandy loam	7.71	0.34	1.02	163.07	7.00	180.00	100	45	40
212	56	G.Devanna	Raghavapet	Sandy loam	8.24	0.34	1.63	260.29	8.00	164.00	80	40	0
213	60	C.Balaiah	Raghavapet	Sandy loam	8.08	0.12	0.86	166.21	11.00	171.00	80	40	0
214	57	P.Devanna	Raghavapet	Sandy loam	8.36	0.37	1.52	219.52	21.00	174.00	80	40	0
215	21	J.Ramaswamy	Thirumalapur	Sandy loam	8.49	0.47	1.02	206.98	5.00	168.00	100	60	50
216	44	K.Raji Reddy	Vempet	Sandy loam	8.47	0.20	0.89	169.34	11.00	346.00	100	45	40
217	221	C.Rajaiah	Huzurabad	Silt clay loam	5.20	0.07	1.97	178.75	8.00	110.00	80	40	0
218	208	B.Venkata Reddy	Nagaram	Silt clay loam	8.28	0.28	0.38	181.89	28.00	250.00	80	45	40
219	227	C.Papi Reddy	Pothareddypet	Silt clay loam	6.40	0.15	0.71	206.98	16.00	188.00	80	45	40
220	220	P.Rajaiah	Dandepally	Silt loam	7.00	0.08	0.47	134.86	14.00	525.00	100	60	40
221	205	P.Chandraiah	Gundaram	Silt loam	7.95	0.08	0.64	241.47	22.00	346.00	100	60	40
222	225	N.Linga Reddy	Huzurabad	Silt loam	5.62	0.05	0.56	169.34	9.00	166.00	100	45	40
223	139	P.C.Rajanna	Ibrahimpatnam	Silt loam	7.03	0.45	1.37	363.78	21.00	315.00	100	45	40
224	235	Ranga Laxmaiah	Jammikunta	Silt loam	8.68	0.30	1.39	210.11	32.00	305.00	80	40	0
225	182	D.Narendra	Lokapet	Silt loam	8.84	0.16	0.28	78.40	11.00	410.00	80	40	0
226	69	Y.S.B.Linganna	Mogilipet	Silt loam	5.87	0.15	1.03	134.85	9.00	182.00	80	40	0
227	112	N.Muthaiah	Sangam	Silt loam	6.57	0.15	0.53	134.86	20.00	246.00	100	45	40
228	186	B.Rami Reddy	Sayampet	Silt loam	6.57	0.25	1.19	263.42	36.00	170.00	100	60	40
229	173	I.Mallaiah	Wadkapur	Silt loam	8.24	0.36	0.68	238.34	21.00	305.00	80	45	0
230	161	K.Thirupathi Rao	Chinnakoluvala	Silty clay loam	7.81	0.19	0.62	156.80	15.00	528.00	100	60	40
		No.of Obsevations			230	230	230	230	230	230	230	230	230
		Mean			7.63	0.29	0.96	193.28	21.68	254.88	92.70	48.39	28.22
		S.D.			0.82	0.13	0.33	63.38	10.50	94.92	9.63	7.90	19.67
		C.V.(%)			10.74	46.36	34.61	32.79	48.42	37.24	10.39	16.33	69.70

		II. NIZAMABAD											
231	240	B.Ganga Ram	Doodgaon	Clay loam	7.67	0.36	1.09	241.47	19.00	360.00	100	60	45
232	245	N.C.Gangaram	Mandora	Sandy clay loam	6.49	0.30	0.89	185.02	25.00	416.00	100	60	45
233	243	T.Bhoomanna	Mandora	Sandy clay loam	6.93	0.06	1.66	197.57	21.00	302.00	100	45	50
234	242	D.Nadipanna	Mandora	Sandy clay loam	6.92	0.19	0.88	197.57	25.00	250.00	100	45	50
235	249	A.Gangaram	Yerragatla	Sandy clay loam	6.68	0.03	0.94	404.54	26.00	516.00	100	45	50
236	248	R.Chinnaiah	Yerragatla	Sandy clay loam	7.91	0.35	0.99	216.38	30.00	645.00	100	60	50
237	241	B.Gangayya	Mandora	Sandy loam	7.74	0.39	1.02	106.62	18.00	280.00	100	45	50
238	250	B.Raja Reddy	Yerragatla	Sandy loam	6.67	0.30	1.16	172.48	24.00	282.00	100	45	50
239	237	V.C.Bheemaiah	Doodgaon	Silt clay loam	7.41	0.07	0.87	244.61	46.00	368.00	100	45	50
240	239	G.Ashanna	Doodgaon	Silt clay loam	6.68	0.19	0.90	206.98	24.00	458.00	100	45	50
241	238	G.Narsimhulu	Doodgaon	Silt clay loam	6.87	0.30	0.87	238.34	20.00	189.00	100	45	50
242	244	A.Gangaram	Mandora	Silt clay loam	7.06	0.17	0.67	172.48	19.00	356.00	100	45	50
243	246	V.Ramachari	Yerragatla	Silt clay loam	6.45	0.25	0.73	238.34	21.00	360.00	100	45	50
244	236	B.P.Sanjanna	Doodgaon	Silt loam	7.20	0.40	0.92	131.71	21.00	216.00	100	60	50
245	247	Hanumantha Reddy	Yerragatla	Silt loam	6.73	0.23	1.25	203.84	28.00	416.00	100	60	50
		No.of Obsevations			15	15	15	15	15	15	15	15	15
		Mean			7.03	0.24	0.99	210.53	24.47	361.07	100.00	50.00	49.33
		S.D.			0.45	0.12	0.23	64.44	6.67	115.37	0.00	7.07	1.70
		C.V.(%)			6.37	48.30	23.24	30.61	27.27	31.95	0.00	14.14	3.45
		III. WARANGAL											
246	265	C.Rajaiah	Dubial	Clay loam	8.20	0.17	0.47	185.02	25.00	296.00	100	60	40
247	264	J.Sujana	Dubial	Clay loam	8.36	0.10	0.34	206.98	10.00	310.00	100	60	40
248	275	N.Prabhakar Reddy	Gummadavally	Clay loam	8.96	0.13	1.18	178.75	35.00	295.00	120	60	40
249	257	B.Mohan	Parlapally	Clay loam	8.46	0.31	0.62	116.03	20.00	316.00	100	45	40
250	258	B.Rayamallu	Parlapally	Clay loam	8.53	0.25	1.63	175.62	25.00	382.00	100	45	40
251	260	J.Mallaih	Parlapally	Clay loam	8.42	0.09	0.35	175.62	12.00	190.00	100	45	40
252	270	K.Krishna Reddy	Vallampally	Clay loam	8.66	0.37	0.80	147.39	32.00	180.00	100	60	40
253	267	G.Shiva Reddy	Vallampally	Clay loam	8.44	0.19	0.90	272.83	36.00	310.00	100	60	40
254	255	T.Veeresham	Pembarthy	Loamy sand	6.02	0.26	0.49	169.34	22.00	110.00	80	40	40
255	269	C.Tirupathi Rao	Vallampally	Loamy sand	8.74	0.37	1.58	228.93	38.00	198.00	80	40	40
256	268	V.dayananda Rao	Vallampally	Loamy sand	8.43	0.31	0.38	169.34	32.00	312.00	80	40	40
257	263	S.Mallaih	Dubial	Sandy clay loam	7.82	0.45	0.55	178.75	9.00	260.00	100	45	40
258	261	B.Kamaraiah	Dubial	Sandy clay loam	8.14	0.17	1.26	134.85	8.00	182.00	100	60	40
259	262	B.Sampath Rao	Dubial	Sandy clay loam	8.04	0.06	0.41	150.53	7.00	196.00	100	60	40
260	273	N.R.Papi Reddy	Gummadavally	Sandy clay loam	8.81	0.35	0.67	247.74	26.00	235.00	120	60	40
261	274	N.Pratap Reddy	Gummadavally	Sandy clay loam	8.05	0.43	0.71	163.07	29.00	260.00	120	60	40
262	256	K.Raja Saheb	Palapally	Sandy clay loam	8.59	0.23	1.12	219.52	23.00	302.00	100	45	40
263	259	R.Narasaiah	Parlapally	Sandy clay loam	8.21	0.27	0.49	144.26	21.00	306.00	100	45	40
264	251	P.P.Reddy	Pembarthy	Sandy clay loam	7.35	0.31	0.71	279.10	22.00	216.00	80	40	40
265	252	J.Venkataiah	Pembarthy	Sandy clay loam	8.98	0.22	0.37	147.39	8.00	102.00	80	40	40
266	253	B.Shekhar	Pembarthy	Sandy clay loam	8.04	0.16	0.47	197.57	20.00	176.00	80	40	40
267	272	N.Thirupathi Reddy	Gummadavally	Sandy loam	8.18	0.31	2.02	159.94	22.00	270.00	100	45	40
268	266	K.Vasudeva Reddy	Vallampally	Sandy loam	8.03	0.36	0.93	144.26	30.00	305.00	100	45	40
269	271	N.Suratham Reddy	Gummadavally	Silt clay loam	8.73	0.46	1.14	241.47	28.00	280.00	100	45	40
270	254	P.Samaiah	Pembarthy	Silt clay loam	8.35	0.18	0.31	153.66	20.00	182.00	80	40	40
		No.of Obsevations			25	25	25	25	25	25	25	25	25
		Mean			8.26	0.26	0.80	183.52	22.40	246.84	96.80	49.00	40.00
		S.D.			0.58	0.11	0.45	42.35	9.04	68.94	12.24	8.49	0.00
		C.V.(%)			7.06	42.62	56.70	23.08	40.37	27.93	12.64	17.32	0.00

		IV. ADILABAD											
271	290	C.Hanuman Goud	Kadthal	Clay loam	6.15	0.29	0.81	235.20	52.00	168.00	100	60	40
272	288	B.Gangaram	Kadthal	Clay loam	6.80	0.08	0.94	172.48	28.00	189.00	100	60	40
273	287	G.Sivanna	Kadthal	Clay loam	6.04	0.34	1.41	247.74	20.00	170.00	100	60	40
274	289	S.N.Goud	Kadthal	Clay loam	8.05	0.54	1.34	235.20	41.00	172.00	100	60	40
275	295	C.ganga Reddy	Lakshmanchanda	Clay loam	6.78	0.20	0.84	144.26	21.00	170.00	100	60	40
276	293	S.Gopala Reddy	Lakshmanchanda	Clay loam	5.79	0.09	0.80	141.12	22.00	116.00	100	60	40
277	292	S.Narasaiah	Lakshmanchanda	Clay loam	7.84	0.35	0.65	137.98	18.00	109.00	100	60	40
278	291	Ailu Venkanna	Lakshmanchanda	Clay loam	7.39	0.20	1.20	235.20	16.00	125.00	100	60	40
279	294	K.Pedda Gangaram	Lakshmanchanda	Clay loam	6.84	0.27	0.96	144.26	25.00	180.00	100	60	40
280	277	N.Gangaram	Pakapatla	Clay loam	6.61	0.35	0.89	131.71	21.00	298.00	100	60	40
281	301	B.Sathaiah	Ponkal	Clay loam	6.76	0.05	1.54	191.30	30.00	132.00	100	60	40
282	302	G.Rajanna	Ponkal	Clay loam	6.11	0.17	0.86	238.34	56.00	112.00	100	60	40
283	304	M.Sayanna	Ponkal	Clay loam	7.05	0.22	0.97	188.16	46.00	109.00	100	45	40
284	305	Ch.Hanumantha Rao	Ponkal	Clay loam	7.82	0.10	1.41	228.93	48.00	102.00	100	45	40
285	284	L.Venkanna	Soan	Clay loam	6.38	0.07	1.25	232.06	56.00	166.00	100	45	40
286	283	B.Anantha Rao	Soan	Clay loam	6.87	0.05	1.58	191.30	35.00	179.00	100	45	40
287	285	A.C.Malleshan	Soan	Clay loam	7.88	0.18	1.11	180.16	42.00	170.00	100	45	40
288	299	Bheem Reddy	Vadiyal	Clay loam	7.80	0.29	1.10	222.66	48.00	422.00	100	60	40
289	297	Rajaram	Vadiyal	Clay loam	6.51	0.16	0.94	228.93	36.00	502.00	100	60	40
290	296	L.Narayana Reddy	Vadiyal	Clay loam	8.16	0.23	0.82	194.43	30.00	416.00	100	60	40
291	298	Rajanna	Vadiyal	Clay loam	7.53	0.06	1.07	341.82	32.00	481.00	100	60	40
292	278	N.Rajabhan	Pakapatla	Loamy sand	5.61	0.68	1.52	310.46	18.00	310.00	100	60	40
293	279	G.Muttaih	Pakapatla	Loamy sand	6.96	0.36	1.08	238.34	10.00	406.00	100	60	40
294	286	K.Y.Gangaram	Kadthal	Sandy clay loam	6.53	0.18	1.31	209.70	18.00	166.00	100	60	40
295	280	I.Muthanna	Pakapatla	Sandy clay loam	6.52	0.36	0.47	225.79	8.00	359.00	100	60	40
296	281	G.Malleshan	Soan	Sandy clay loam	6.10	0.22	1.92	266.56	41.00	270.00	100	60	40
297	300	K.Babu	Vadiyal	Sandy clay loam	6.45	0.14	1.27	103.49	56.00	470.00	100	60	40
298	303	G.Ashanna	Ponkal	Sandy loam	6.86	0.44	1.22	203.84	61.00	156.00	100	45	40
299	282	G.Chinnaiah	Soan	Silt clay loam	6.50	0.18	1.17	206.98	36.00	280.00	100	60	40
300	276	I.Muthanna	Pakapatla	Silt loam	6.17	0.25	1.52	191.30	20.00	215.00	100	45	40
		No.of Obsevations			30	30	30	30	30	30	30	30	30
		Mean			6.83	0.24	1.13	207.32	33.03	237.33	100.00	56.50	40.00
		S.D.			0.69	0.14	0.31	50.72	14.78	123.70	0.00	6.34	0.00
		C.V.(%)			10.05	61.18	27.47	24.46	44.75	52.12	0.00	11.23	0.00

Appendix-3

Soil characterisation based on soil test values in the Sreeramsagar Project command area at panicle initiation and post-harvest stages of rice growth

S.No	Sample	Farmer's name	Village	Soil Texture	Panicle initiation stage OC (%)	KMNO4-N	Plant N (%)	GY (q/ha)	Post harvest STV (kg/ha) KMNO4-N	Olsen-P	Amac-K
		I. KARIMNAGAR									
1	106	E.Rajam	Alipoor	Clay loam	1.18	176.00	2.27				
2	81	J.Rajeshwara Rao	Beerpur	Clay loam	0.95	134.85	1.94	29	109	45	288
3	164	G.Srihari Rao	Chinnakoluvala	Clay loam	0.95	144.26	4.60	16	139	17	316
4	162	V.Sugunakar Rao	Chinnakoluvala	Clay loam	0.94	180.11	1.69	40	181	15	382
5	216	K.S.Rama Rao	Dandepally	Clay loam	0.74	109.76	2.34	26	168	26	22
6	218	M.Uppalaiah	Dandepally	Clay loam	0.81	150.53	1.66	26	171	10	162
7	31	G.Rajalingum	Gollapalli	Clay loam	0.52	131.71	1.70	18	148	46	316
8	203	G.Chinna Rajam	Gundaram	Clay loam	0.72	254.02	1.01				
9	204	S.Pochaiah	Gundaram	Clay loam	0.86	216.16	1.12				
10	201	G.Pedda Rajam	Gundaram	Clay loam	0.55	84.67	1.22				
11	202	D.Muthaiah	Gundaram	Clay loam	0.62	89.21	1.19				
12	137	N.Muthanna	Ibrahimpatnam	Clay loam	1.47	131.71	0.73				
13	138	K.Chinnaiah	Ibrahimpatnam	Clay loam	1.52	128.16	0.76				
14	178	V.Nambaiah	Kajapur	Clay loam	0.45	90.94	2.64	16	186	42	219
15	179	M.Hanumantha Reddy	Kajapur	Clay loam	0.54	81.91	2.11	17	206	26	292
16	195	E.Venkat Reddy	Katkampally	Clay loam	0.82	148.11	1.37	19	138	42	278
17	194	K.Venkat Reddy	Katkampally	Clay loam	0.76	167.12	1.29	18	136	22	312
18	191	K.Prathap Reddy	Katkampally	Clay loam	0.90	109.26	2.12	22	128	24	273
19	90	S.Narasaiah	Kolwai	Clay loam	1.20	119.17	3.20				
20	119	M.A.Gaffar	Koratla	Clay loam	0.78	120.06	1.20	24	216	32	416
21	118	D.Gangaram	Koratla	Clay loam	0.95	137.98	1.31	20	92	52	492
22	181	V.Venkata Rao	Lokapet	Clay loam	0.98	141.21	1.20				
23	184	D.Ravindra Rao	Lokapet	Clay loam	1.02	116.00	1.21				
24	185	D.Rajeshwara Rao	Lokapet	Clay loam	1.16	121.11	1.46				
25	36	S.Ganga Reddy	Metpally	Clay loam	0.83	129.32	1.73				
26	38	K.L.Gangaram	Metpally	Clay loam	0.42	125.44	1.47				
27	39	P.Janga Reddy	Metpally	Clay loam	0.81	150.53	1.70				
28	37	P.Linga Reddy	Metpally	Clay loam	0.86	84.67	2.25				
29	54	V.Vijayendra Rao	Muthyampet	Clay loam	1.37	232.06	2.45				
30	206	B.K.Rami Reddy	Nagaram	Clay loam	0.52	72.13	1.64				
31	210	B.Venkata Reddy	Nagaram	Clay loam	0.58	147.39	1.40				
32	209	B.Laxmi Reddy	Nagaram	Clay loam	0.61	149.19	1.29				
33	207	B.K.Raji Reddy	Nagaram	Clay loam	0.55	87.81	1.79				
34	167	V.Pedda Rajaiah	Narayanpur	Clay loam	1.74	153.66	2.26	18	186	26	362
35	196	Y.Ramaiah	Parepally	Clay loam	0.96	134.85	1.82	18	116	40	304
36	200	V.Shankaraiah	Parepally	Clay loam	0.66	90.94	1.10	22	89	20	312
37	197	M.Komaraiah	Parepally	Clay loam	0.90	162.15	1.82	19	202	19	126
38	199	M.Kamaraiah	Parepally	Clay loam	0.48	141.11	1.51	18	125	28	360
39	18	G.Chandraiah	Pegadapally	Clay loam	1.32	122.30	1.40	46	176	16	226
40	19	G.Gopala Rao	Pegadapally	Clay loam	1.24	114.16	1.16	47.2	152	22	181

41	17	M.Narasimha Reddy	Pegadapally	Clay loam	1.06	178.00	0.81	49.6	316	40	261
42	214	Saibaba	Puttapaka	Clay loam	0.46	151.66	1.24				
43	213	Pedda Kamaiah	Puttapaka	Clay loam	0.81	139.08	1.48				
44	25	R.Bheemaiah	Rapalle	Clay loam	0.94	139.25	1.51				
45	30	K.Prakash Rao	Rapalle	Clay loam	1.07	137.98	2.78	20	165	36	298
46	113	P.Linga Reddy	Sangam	Clay loam	1.07	122.30	2.19	22	182	24	149
47	187	C.Jakkaiah	Sayampet	Clay loam	1.36	120.92	1.20	14	189	32	192
48	190	B.Sathyanarayana Re	Sayampet	Clay loam	0.99	116.03	2.46	45	142	42	264
49	22	K.Venkanna	Thirumalapur	Clay loam	1.32	87.81	2.03	49.6	189	30	240
50	50	D.Shyam Rao	Vellulla	Clay loam	0.90	81.42	1.16	48	126	12	396
51	172	I.Papaiah	Wadkapur	Clay loam	0.87	134.85	1.89	18	142	32	245
52	219	P.Madhava Rao	Dandepally	Clayey	0.77	106.13	1.96	26	167	19	126
53	188	B.Venkataiah	Sayampet	Clayey	1.48	116.28	1.48	21	208	28	202
54	109	K.Jagannatham	Alipoor	Loamy sand	1.95	564.48	2.15				
55	110	S.Mallaiah	Alipoor	Loamy sand	1.28	134.85	2.10				
56	35	P.Bheemaiah	Gollapalli	Loamy sand	0.96	89.20	1.61	20	116	14	162
57	135	L.Gangaram	Komati Kondapur	Loamy sand	0.92	92.11	1.08				
58	107	E.Pachalu	Alipoor	Sandy clay loam	1.14	141.12	1.89				
59	11	C.Anjaiah	Aravally	Sandy clay loam	1.24	109.76	2.27	51.2	169	47	204
60	13	P.Anjaiah	Aravally	Sandy clay loam	0.60	109.76	1.16	52.2	138	24	174
61	12	V.Rajalingam	Aravally	Sandy clay loam	0.69	131.71	1.45	50	218	30	182
62	85	A.Laxman	Beerpur	Sandy clay loam	1.05	260.29	2.13	20	268	22	314
63	84	A.Rajamallu	Beerpur	Sandy clay loam	0.70	198.80	1.78	20	201	38	396
64	71	K.Bheemaiah	Chelgal	Sandy clay loam	1.43	134.85	2.06	36	176	29	128
65	72	K.C.Gangaram	Chelgal	Sandy clay loam	1.07	84.67	1.54	40	132	32	210
66	73	E.Rajanna	Chelgal	Sandy clay loam	1.01	175.62	1.46	40	120	15	280
67	74	E.Lingam	Chelgal	Sandy clay loam	0.81	460.99	1.57	38	108	20	228
68	165	G.Rajeshwar	Chinnakoluvala	Sandy clay loam	0.58	84.67	2.45	15	125	23	409
69	217	P.Linga Rao	Dandepally	Sandy clay loam	0.90	75.26	1.01	26	162	12	158
70	5	B.Rajam	Dharmapuri	Sandy clay loam	0.82	129.42	1.89	22	142	26	412
71	6	P.Narayana	Donnur	Sandy clay loam	0.75	144.26	2.85				
72	7	Y. Narayana Rao	Donnur	Sandy clay loam	0.86	151.02	1.91				
73	32	M.Bheemaiah	Gollapalli	Sandy clay loam	0.84	163.07	2.45	18	206	32	236
74	34	H.Rajanna	Gollapalli	Sandy clay loam	1.16	129.19	1.96	20	178	16	149
75	146	C.P.Narasaiah	Gudur	Sandy clay loam	1.66	153.66	1.90				
76	147	B.B.Yellaiah	Gudur	Sandy clay loam	1.01	181.16	1.76				
77	148	B.Narayana	Gudur	Sandy clay loam	0.89	295.98	2.10				
78	149	P.Gangaram	Gudur	Sandy clay loam	0.68	198.11	3.14				
79	224	K.S.S.Reddy	Huzurabad	Sandy clay loam	0.87	238.34	1.46	23	219	15	192
80	140	B.Gangaram	Ibrahimpatnam	Sandy clay loam	1.37	126.02	1.35				
81	136	E.C.Bheemaiah	Ibrahimpatnam	Sandy clay loam	0.61	166.21	2.89				
82	96	E.Raja Reddy	Itkyal	Sandy clay loam	1.12	121.16	2.12				
83	93	V.Raja Reddy	Itkyal	Sandy clay loam	1.23	106.02	2.17				
84	92	B.Gangaram	Itkyal	Sandy clay loam	1.29	194.43	2.50				
85	91	C.Rajam	Itkyal	Sandy clay loam	1.06	122.90	2.11				
86	94	B.Linga Reddy	Itkyal	Sandy clay loam	1.16	99.19	3.35				
87	232	A.Saiyulu	Jammikunta	Sandy clay loam	0.72	263.42	2.96	20	181	80	292
88	231	M.Kanakaiah	Jammikunta	Sandy clay loam	0.87	181.89	2.12	20	168	26	198
89	177	A.Mallaiah	Kajapur	Sandy clay loam	1.21	186.15	2.03	18	168	40	206
90	176	M.Rama Reddy	Kajapur	Sandy clay loam	1.32	191.30	1.82	17	159	38	194

91	180	G.Veeraiah	Kajapur	Sandy clay loam	0.62	101.00	1.89	16	182	39	402
92	193	Anjam Raju	Katkampally	Sandy clay loam	0.89	188.00	1.77	20	169	37	176
93	192	P.Swamy	Katkampally	Sandy clay loam	1.07	200.70	2.19	19	204	31	289
94	87	T.Rajalingam	Kolwai	Sandy clay loam	1.23	144.26	1.46				
95	88	R.Janardhan Rao	Kolwai	Sandy clay loam	1.11	103.49	1.87				
96	86	D.T.Chandraiah	Kolwai	Sandy clay loam	1.05	84.67	1.94				
97	89	M.Rajam	Kolwai	Sandy clay loam	1.24	100.36	1.39				
98	134	B.Erranna	Komati Kondapur	Sandy clay loam	1.11	121.02	1.16				
99	133	T.Bheemaiah	Komati Kondapur	Sandy clay loam	1.02	137.98	1.31				
100	117	A.A.Saleem	Koratla	Sandy clay loam	0.76	148.10	1.48	18	142	38	246
101	116	Md.Eglabuddin	Koratla	Sandy clay loam	0.73	153.66	1.54	18	186	28	406
102	120	D.Laxmi Rajam	Koratla	Sandy clay loam	0.84	184.11	1.94	21	209	24	152
103	103	C.C.Rajanna	Kummarapally	Sandy clay loam	1.05	232.06	1.70				
104	105	T.Ganga Reddy	Kummarapally	Sandy clay loam	1.29	181.00	1.82				
105	102	C.Rajanna	Kummarapally	Sandy clay loam	1.20	103.49	1.89				
106	101	C.Linganna	Kummarapally	Sandy clay loam	1.23	175.62	2.75				
107	104	T.Bukkanna	Kummarapally	Sandy clay loam	1.16	198.00	1.98				
108	183	V.Vasantha Rao	Lokapet	Sandy clay loam	0.89	98.12	0.96				
109	128	B.Chinna Pochaiah	Metpally	Sandy clay loam	0.56	92.08	1.40	32	192	19	318
110	129	Md.Hafeez	Metpally	Sandy clay loam	0.64	89.19	2.76	52	212	24	262
111	130	K.C.Bheemaiah	Metpally	Sandy clay loam	0.79	92.16	1.89	30	178	25	296
112	126	S.Hussain	Metpally	Sandy clay loam	0.63	72.13	1.38	42	108	24	310
113	40	G.Mallesham	Metpally	Sandy clay loam	0.77	138.16	1.64				
114	127	K.M.Sambaji	Metpally	Sandy clay loam	0.49	84.16	1.01	45	129	29	346
115	70	B.Mallaiah	Mogilipet	Sandy clay loam	1.44	194.43	2.08				
116	67	Y.S.Ganganna	Mogilipet	Sandy clay loam	0.96	108.62	1.21				
117	68	B.Rajanna	Mogilipet	Sandy clay loam	1.53	357.50	1.17				
118	121	Ch.Bheema Rao	Mohanraopet	Sandy clay loam	1.05	288.51	1.88	18	172	46	208
119	123	C.Mukund Rao	Mohanraopet	Sandy clay loam	1.14	219.00	1.46	21	121	26	192
120	125	B.Rajam	Mohanraopet	Sandy clay loam	0.90	128.58	1.57	19	138	46	175
121	124	B.Lingam	Mohanraopet	Sandy clay loam	1.07	97.22	1.43	21	140	50	180
122	51	B.Venkanna	Muthyampet	Sandy clay loam	1.11	109.76	1.42	26	102	10	192
123	53	M.Anadhaiah	Muthyampet	Sandy clay loam	1.21	107.00	0.58	29	129	13	180
124	52	E.Raghava Reddy	Muthyampet	Sandy clay loam	1.08	121.10	1.29	24	184	16	173
125	64	Venkata Rao	Nadukude	Sandy clay loam	0.77	120.22	1.32				
126	65	K.Raji Reddy	Nadukude	Sandy clay loam	0.96	119.02	1.46				
127	61	Pansha Goud	Nadukude	Sandy clay loam	1.08	153.66	2.03				
128	62	R.Linganna	Nadukude	Sandy clay loam	1.02	106.62	1.64				
129	166	A.Lingaiah	Narayanpur	Sandy clay loam	0.33	101.23	2.41	24	212	18	306
130	170	A.Chinna Rajaiah	Narayanpur	Sandy clay loam	1.40	159.94	2.59	15	152	31	298
131	198	G.Rajalingam	Parepally	Sandy clay loam	0.55	156.11	1.66	18	138	52	432
132	159	K.Ramulu	Peddabankur	Sandy clay loam	0.96	191.30	1.85	16	120	22	288
133	160	Sriram Ramayya	Peddabankur	Sandy clay loam	0.99	94.08	2.12	12	172	26	296
134	158	S.Ramayya	Peddabankur	Sandy clay loam	0.81	147.39	1.35	12	231	19	268
135	156	C.Nambaiah	Peddabankur	Sandy clay loam	1.04	109.76	1.80	20	148	29	415
136	151	K.Subba Reddy	Peddapally	Sandy clay loam	1.14	137.98	1.79				
137	153	C.P.Narasaiah	Peddapally	Sandy clay loam	1.13	313.60	1.84				
138	154	M.V.Ramana Reddy	Peddapally	Sandy clay loam	0.87	116.03	2.01				
139	152	Rami Reddy	Peddapally	Sandy clay loam	0.93	736.96	1.98				
140	155	M.Mallesham	Peddapally	Sandy clay loam	1.20	87.81	1.52				

141	16	K.Rajaiah	Pegadapally	Sandy clay loam	1.44	109.76	2.01	50.4	218	13	106
142	77	M.Venkati	Polasa	Sandy clay loam	1.04	109.76	2.10	18	176	12	342
143	78	N.Rajanna	Polasa	Sandy clay loam	0.93	116.03	1.40	20	126	12	290
144	76	D.Narasaiah	Polasa	Sandy clay loam	0.69	206.98	1.45	25	182	14	200
145	79	K.Bheemaiah	Polasa	Sandy clay loam	0.68	388.86	1.52	19	168	48	302
146	80	S.Mondaiah	Polasa	Sandy clay loam	0.72	261.10	1.33	20	180	19	294
147	229	P.Devender Reddy	Pothareddypet	Sandy clay loam	1.48	209.08	1.48	21	192	12	112
148	230	P.Ravindra Reddy	Pothareddypet	Sandy clay loam	0.40	232.06	1.78	23	196	25	204
149	226	G.Malla Reddy	Pothareddypet	Sandy clay loam	0.62	161.11	1.91	20	152	26	192
150	228	G.Niranjan Reddy	Pothareddypet	Sandy clay loam	1.29	231.16	1.62	26	190	10	118
151	211	I.Mandaiah	Puttapaka	Sandy clay loam	1.02	97.22	2.62				
152	212	Ganga Raju	Puttapaka	Sandy clay loam	0.27	141.12	1.79				
153	215	Md.Chandbee	Puttapaka	Sandy clay loam	0.42	263.42	0.58				
154	99	P.Linga Reddy	Raikal	Sandy clay loam	1.32	285.38	2.30				
155	97	N.Bhoomi Reddy	Raikal	Sandy clay loam	1.21	108.00	2.02				
156	100	B.Gangaram	Raikal	Sandy clay loam	1.08	249.18	1.47				
157	98	Abdul Nabiz	Raikal	Sandy clay loam	1.04	84.67	2.70				
158	28	G.Purushotham	Rapalle	Sandy clay loam	0.63	109.76	2.64	26	169	28	265
159	29	M.Thirupathi Goud	Rapalle	Sandy clay loam	1.77	94.08	2.19	18	182	28	278
160	26	K.Suguna Rao	Rapalle	Sandy clay loam	1.10	163.07	1.40				
161	27	G.Srinivasa Rao	Rapalle	Sandy clay loam	1.49	203.84	1.56	26	169	28	265
162	111	S.Ganga Reddy	Sangam	Sandy clay loam	1.02	166.21	2.52	20	211	26	287
163	114	Y.Kishan Rao	Sangam	Sandy clay loam	1.02	128.58	1.78	23	196	32	356
164	115	B.Balaiah	Sangam	Sandy clay loam	0.77	125.44	1.87	19	159	29	402
165	189	B.Rayamallu	Sayampet	Sandy clay loam	0.92	101.22	1.69	45	205	45	268
166	24	G.Rajaram	Thirumalapur	Sandy clay loam	0.78	128.46	1.90				
167	23	K.P.Rajaiah	Thirumalapur	Sandy clay loam	0.65	141.12	2.03	52	124	26	246
168	142	K.Lingam	Thirumalapur	Sandy clay loam	0.98	102.11	1.26				
169	141	G.gangaram	Thirumalapur	Sandy clay loam	1.37	97.22	1.70				
170	145	K.Bheemaiah	Thirumalapur	Sandy clay loam	1.20	196.21	2.16				
171	143	M.Ashalu	Thirumalapur	Sandy clay loam	1.12	146.02	1.45				
172	144	D.Gangaram	Thirumalapur	Sandy clay loam	1.21	151.00	3.02				
173	48	Nanda Kumar	Vellulla	Sandy clay loam	1.14	94.08	0.89	34	62	8	180
174	47	D.Venkata Ramana	Vellulla	Sandy clay loam	0.92	141.12	1.68	28	128	12	198
175	46	D.Ramachandran	Vellulla	Sandy clay loam	0.99	120.15	2.50	29	108	9	268
176	45	A.Muthyam Reddy	Vempet	Sandy clay loam	0.94	154.19	1.34	40	171	11	302
177	43	K.Raji Reddy	Vempet	Sandy clay loam	1.05	119.17	0.91	28	286	36	294
178	41	K.Shankar Reddy	Vempet	Sandy clay loam	1.07	100.35	1.89	21	116	29	378
179	42	A.Linga Reddy	Vempet	Sandy clay loam	1.24	109.76	1.50	30	88	28	346
180	171	K.Venkataiah	Wadkapur	Sandy clay loam	1.30	94.08	1.56	20	198	24	306
181	108	T.Ram Gangaram	Alipoor	Sandy loam	1.44	238.34	1.76				
182	14	G. Madhava Reddy	Aravally	Sandy loam	0.86	247.74	1.75	48	182	14	126
183	15	M.Mallaiah	Aravally	Sandy loam	1.25	147.39	1.82	52	178	13	121
184	82	S.Narayana	Beerpur	Sandy loam	0.78	191.19	1.98	26	188	55	246
185	83	B.Narayana Rao	Beerpur	Sandy loam	0.69	186.22	1.30	25	162	60	252
186	75	P.Papaiah	Chelgal	Sandy loam	1.12	360.78	1.72	35	198	14	270
187	163	M.Chandraiah	Chinnakoluvala	Sandy loam	0.68	112.90	2.80	28	170	21	374
188	1	G.Shankar	Dharmapuri	Sandy loam	0.86	75.26	1.70	18	142	44	329
189	2	R.Rajaiah	Dharmapuri	Sandy loam	0.46	87.81	1.17	15	116	42	296
190	4	K.Narasaiah	Dharmapuri	Sandy loam	0.96	90.94	1.45	18	261	31	288

191	3	R.Rajalingaiah	Dharmapuri	Sandy loam	0.92	85.62	1.10	20	174	39	509
192	10	M.Gangaram	Donnur	Sandy loam	1.23	141.12	1.40				
193	8	P.Mallaiah	Donnur	Sandy loam	1.14	153.66	1.21				
194	9	M.Rameshwar	Donnur	Sandy loam	1.17	141.12	1.36				
195	33	K.Sambi Reddy	Gollapalli	Sandy loam	0.55	97.22	1.57	20	189	25	208
196	150	V.Narsa Reddy	Gudur	Sandy loam	0.77	177.26	2.02				
197	223	M.Ailayya	Huzurabad	Sandy loam	0.58	62.72	1.58				
198	222	N.Raghotham Reddy	Huzurabad	Sandy loam	0.65	213.25	2.38	20	216	18	190
199	95	Badayam Reddy	Itkyal	Sandy loam	1.08	112.11	2.41				
200	234	M.Kanakaiah	Jammikunta	Sandy loam	1.17	297.92	2.68	20	219	18	312
201	233	A.Yadi Reddy	Jammikunta	Sandy loam	0.89	269.70	3.20	20	178	46	268
202	132	K.Gangaram	Komati Kondapur	Sandy loam	0.56	99.02	1.02				
203	131	P.Ankulam	Komati Kondapur	Sandy loam	0.68	89.11	1.10				
204	66	Akula Sayeb	Mogilipet	Sandy loam	1.01	122.30	1.09				
205	122	P.Venkata Narasaiah	Mohanraopet	Sandy loam	1.21	206.16	1.09	20	116	52	193
206	55	E.Raghava Reddy	Muthyampet	Sandy loam	1.05	163.07	1.88				
207	63	A.Dharmaji	Nadukude	Sandy loam	0.68	110.96	1.29				
208	169	V.Mallaiah	Narayanpur	Sandy loam	1.13	178.75	1.99	15	144	27	312
209	168	A.Chinna Lingaiah	Narayanpur	Sandy loam	1.12	108.11	2.31	14	124	29	439
210	157	K.Veeresham	Peddabankur	Sandy loam	0.87	68.99	3.04	18	270	26	281
211	20	G.Pramila	Pegadapally	Sandy loam	1.22	106.62	1.21	48	147	11	198
212	56	G.Devanna	Raghavapet	Sandy loam	1.47	188.16	2.24	26	168	21	168
213	60	C.Balaiah	Raghavapet	Sandy loam	0.89	140.02	1.56				
214	57	P.Devanna	Raghavapet	Sandy loam	0.98	162.04	1.89				
215	21	J.Ramaswamy	Thirumalapur	Sandy loam	0.89	188.16	1.36	52.8	178	12	162
216	44	K.Raji Reddy	Vempet	Sandy loam	1.19	112.04	0.87	42	92	29	341
217	221	C.Rajaiah	Huzurabad	Silt clay loam	1.48	142.06	2.50	16	168	16	546
218	208	B.Venkata Reddy	Nagaram	Silt clay loam	0.55	153.66	1.87				
219	227	C.Papi Reddy	Pothareddypet	Silt clay loam	0.70	200.05	1.76	20	189	20	202
220	220	P.Rajaiah	Dandepally	Silt loam	0.50	121.19	1.62	24	170	20	118
221	205	P.Chandraiah	Gundaram	Silt loam	0.87	134.85	1.21				
222	225	N.Linga Reddy	Huzurabad	Silt loam	0.42	78.40	2.03	24	160	12	172
223	139	P.C.Rajanna	Ibrahimpatnam	Silt loam	1.68	116.09	0.81				
224	235	Ranga Laxmaiah	Jammikunta	Silt loam	0.91	254.02	2.15	16	190	34	326
225	182	D.Narendra	Lokapet	Silt loam	0.96	78.40	2.11				
226	69	Y.S.B.Linganna	Mogilipet	Silt loam	1.29	265.16	1.02				
227	112	N.Muthaiah	Sangam	Silt loam	1.14	181.89	2.03	20	126	21	256
228	186	B.Rami Reddy	Sayampet	Silt loam	1.20	108.26	0.96	18	243	48	198
229	173	I.Mallaiah	Wadkapur	Silt loam	1.08	269.70	1.73	16	231	18	329
230	161	K.Thirupathi Rao	Chinnakoluvala	Silty clay loam	0.92	175.62	2.03	24	138	19	542
		No.of Obsevations			230	230	230	132	132	132	132
		Mean			0.97	153.33	1.77	25.96	167.37	27.36	264.64
		S.D.			0.29	77.15	0.55	11.04	41.68	12.53	93.86
		C.V.(%)			30.05	50.31	31.41	42.53	24.91	45.79	35.47

II. NIZAMABAD											
231	240	B.Ganga Ram	Doodgaon	Clay loam	1.02	202.16	1.56	20	258	21	294
232	245	N.C.Gangaram	Mandora	Sandy clay loam	0.68	126.21	1.55				
233	243	T.Bhoomanna	Mandora	Sandy clay loam	0.78	112.90	1.78	21	168	30	285
234	242	D.Nadipanna	Mandora	Sandy clay loam	1.14	128.58	1.99	20	204	46	261
235	249	A.Gangaram	Yerragatla	Sandy clay loam	1.17	250.88	2.24	15	410	29	349
236	248	B.Chinnaiah	Yerragatla	Sandy clay loam	1.12	181.02	1.26	16	221	38	542
237	241	B.Gangayya	Mandora	Sandy loam	1.01	119.17	2.29	18	124	19	206
238	250	B.Raja Reddy	Yerragatla	Sandy loam	1.04	97.22	2.65				
239	237	V.C.Bheemaiah	Doodgaon	Silt clay loam	0.80	216.15	1.46	14	135	22	186
240	239	G.Ashanna	Doodgaon	Silt clay loam	0.90	198.00	1.87	20	209	27	321
241	238	G.Narsimhulu	Doodgaon	Silt clay loam	0.87	220.16	1.48	15	216	26	162
242	244	A.Gangaram	Mandora	Silt clay loam	0.72	116.09	1.62				
243	246	V.Ramachari	Yerragatla	Silt clay loam	0.48	178.16	1.40	16	196	36	616
244	236	B.P.Sanjanna	Doodgaon	Silt loam	0.81	128.01	1.71				
245	247	Hanumantha Reddy	Yerragatla	Silt loam	1.44	150.53	1.43	18	210	40	340
		No.of Obsevations			15	15	15	11	11	11	11
		Mean			0.93	161.68	1.75	17.55	213.73	30.36	323.82
		S.D.			0.23	46.17	0.36	2.35	72.19	8.24	134.60
		C.V.(%)			24.65	28.56	20.71	13.39	33.78	27.13	41.57
III. WARANGAL											
246	265	C.Rajaiah	Dubial	Clay loam	0.29	176.26	2.12	35.5	187	26	298
247	264	J.Sujana	Dubial	Clay loam	0.59	198.19	2.01	36	216	14	268
248	275	N.Prabhakar Reddy	Gummadavally	Clay loam	1.09	176.65	1.65	20	182	36	219
249	257	B.Mohan	Parlapally	Clay loam	0.60	118.11	2.11	36.4	148	46	300
250	258	B.Rayamallu	Parlapally	Clay loam	1.49	160.19	2.26	28.8	180	28	298
251	260	J.Mallaih	Parlapally	Clay loam	0.45	181.06	2.08	24.4	192	19	262
252	270	K.Krishna Reddy	Vallampally	Clay loam	0.96	168.02	1.16	20	162	29	146
253	267	G.Shiva Reddy	Vallampally	Clay loam	1.13	181.89	2.06	20	290	40	192
254	255	T.Veeresham	Pembarthy	Loamy sand	1.68	137.98	4.50	16	142	30	102
255	269	C.Tirupathi Rao	Vallampally	Loamy sand	1.48	241.06	1.29	21	241	41	173
256	268	V.dayananda Rao	Vallampally	Loamy sand	0.98	388.86	1.68	18	175	32	219
257	263	S.Mallaih	Dubial	Sandy clay loam	0.62	186.21	1.51	27.2	184	13	172
258	261	B.Kamaraiah	Dubial	Sandy clay loam	1.12	126.12	1.76	40	146	14	138
259	262	B.Sampath Rao	Dubial	Sandy clay loam	0.38	152.98	1.78	30	161	10	174
260	273	N.B.Papi Reddy	Gummadavally	Sandy clay loam	0.76	222.06	1.26	21	258	30	214
261	274	N.Pratap Reddy	Gummadavally	Sandy clay loam	0.70	160.96	1.39	20	171	32	189
262	256	K.Raja Saheb	Palapally	Sandy clay loam	1.09	125.55	2.61	39.4	242	32	271
263	259	R.Narasaiah	Parlapally	Sandy clay loam	0.52	140.00	1.89	42.2	128	32	402
264	251	P.P.Reddy	Pembarthy	Sandy clay loam	1.29	90.94	2.15	21	305	29	178
265	252	J.Venkataiah	Pembarthy	Sandy clay loam	0.46	152.16	2.06	21	138	21	162
266	253	B.Shekhar	Pembarthy	Sandy clay loam	0.51	148.02	2.41	16	213	28	186
267	272	N.Thirupathi Reddy	Gummadavally	Sandy loam	1.89	162.20	1.08	23	165	25	202
268	266	K.Vasudeva Reddy	Vallampally	Sandy loam	1.65	172.48	2.01	25	156	39	286
269	271	N.Suratham Reddy	Gummadavally	Silt clay loam	1.09	229.96	1.12	20	180	34	280
270	254	P.Samaiah	Pembarthy	Silt clay loam	0.80	134.85	2.57	18	170	23	160
		No.of Obsevations			25	25	25	25	25	25	25
		Mean			0.94	173.31	1.94	25.60	189.28	28.12	219.64
		S.D.			0.44	55.76	0.68	7.95	45.43	9.03	66.65
		C.V.(%)			46.50	32.17	34.93	31.04	24.00	32.13	30.35

IV. ADILABAD

271	290	C.Hanuman Goud	Kadthal	Clay loam	0.76	189.76	2.40				
272	288	B.Gangaram	Kadthal	Clay loam	1.26	144.26	1.52	20	182	30	168
273	287	G.Sivanna	Kadthal	Clay loam	1.39	246.89	1.68	18	250	28	106
274	289	S.N.Goud	Kadthal	Clay loam	1.19	168.01	2.72				
275	295	C.ganga Reddy	Lakshmanchanda	Clay loam	0.86	150.11	3.10				
276	293	S.Gopala Reddy	Lakshmanchanda	Clay loam	0.96	151.10	1.29	23	156	26	90
277	292	S.Narasaiah	Lakshmanchanda	Clay loam	0.63	335.55	1.37	26	142	21	195
278	291	Ailu Venkanna	Lakshmanchanda	Clay loam	0.84	153.66	1.99	27	240	18	104
279	294	K.Pedda Gangaram	Lakshmanchanda	Clay loam	0.50	263.42	4.48				
280	277	N.Gangaram	Pakapatla	Clay loam	0.92	129.06	2.16	15	138	31	216
281	301	B.Sathaiah	Ponkal	Clay loam	1.46	186.62	1.64	20	201	56	102
282	302	G.Rajanna	Ponkal	Clay loam	0.90	178.01	1.58	20	252	60	96
283	304	M.Sayanna	Ponkal	Clay loam	0.72	103.49	1.64	14	176	56	88
284	305	Ch.Hanumantha Rao	Ponkal	Clay loam	1.38	211.06	1.29				
285	284	L.Venkanna	Soan	Clay loam	1.09	201.02	2.68				
286	283	B.Anantha Rao	Soan	Clay loam	0.85	269.70	3.15				
287	285	A.C.Mallesham	Soan	Clay loam	1.08	181.06	2.42				
288	299	Bheem Reddy	Vadiyal	Clay loam	1.35	131.71	2.05	28	231	50	316
289	297	Rajaram	Vadiyal	Clay loam	1.02	202.11	1.68	19	234	56	486
290	296	L.Narayana Reddy	Vadiyal	Clay loam	0.90	196.00	2.96	20	200	32	346
291	298	Rajanna	Vadiyal	Clay loam	1.25	269.70	3.36				
292	278	N.Rajabhan	Pakapatla	Loamy sand	1.29	270.08	1.98				
293	279	G.Muttaih	Pakapatla	Loamy sand	0.96	208.88	1.88	20	240	12	272
294	286	K.Y.Gangaram	Kadthal	Sandy clay loam	0.07	87.81	1.47	20	270	21	122
295	280	I.Muthanna	Pakapatla	Sandy clay loam	0.52	231.02	2.06				
296	281	G.Mallesham	Soan	Sandy clay loam	1.86	335.55	2.24	16	168	54	216
297	300	K.Babu	Vadiyal	Sandy clay loam	1.19	146.16	1.89				
298	303	G.Ashanna	Ponkal	Sandy loam	0.93	275.97	1.50	18	241	58	120
299	282	G.Chinnaiah	Soan	Silt clay loam	1.47	150.53	1.94	18	211	40	191
300	276	I.Muthanna	Pakapatla	Silt loam	1.50	193.15	2.09	15	186	22	202
		No.of Obsevations			30	30	30	18	18	18	18
		Mean			1.04	198.72	2.14	19.83	206.56	37.28	190.89
		S.D.			0.36	61.58	0.71	3.89	39.24	15.91	104.75
		C.V.(%)			34.43	30.99	33.18	19.62	19.00	42.67	54.87

Appendix - 4

Soil textural classification, characteristics and initial soil test values of selected sampling sites under Sreeramsagar project command in Karimnagar district

S.No	Sample	Farmer's name	Village	Soil Texture	pH	EC	OC (%)	Initial STV (kg/ha) KMNO4-N	Olsen-P	Amac-K	Applied fertilizers (kg/ha) N	P2O5	K2O
1	106	E.Rajam	Alipoor	Clay loam	8.28	0.29	1.82	288.51	19.00	375.00	100	60	40
2	81	J.Rajeshwara Rao	Beerpur	Clay loam	6.70	0.18	1.04	119.17	41.00	277.00	100	60	40
3	164	G.Srihari Rao	Chinnakoluvala	Clay loam	8.18	0.31	1.06	150.52	14.00	408.00	100	50	40
4	162	V.Sugunakar Rao	Chinnakoluvala	Clay loam	7.76	0.18	0.76	197.57	12.00	416.00	100	60	40
5	216	K.S.Rama Rao	Dandepally	Clay loam	6.75	0.11	0.79	141.12	25.00	218.00	100	60	50
6	218	M.Uppalaiah	Dandepally	Clay loam	6.94	0.17	0.74	194.43	6.00	154.00	100	60	40
7	31	G.Rajalingum	Gollapalli	Clay loam	7.38	0.45	0.92	131.71	32.00	216.00	80	40	0
8	203	G.Chinna Rajam	Gundaram	Clay loam	8.21	0.39	0.60	285.38	20.00	368.00	100	60	40
9	204	S.Pochaiah	Gundaram	Clay loam	8.36	0.27	1.18	225.79	28.00	350.00	100	60	40
10	201	G.Pedda Rajam	Gundaram	Clay loam	7.95	0.02	0.66	200.70	16.00	388.00	100	60	40
11	202	D.Muthaiah	Gundaram	Clay loam	7.97	0.43	1.02	301.06	19.00	464.00	100	60	40
12	137	N.Muthanna	Ibrahimpatnam	Clay loam	6.85	0.47	1.16	178.75	21.00	189.00	100	60	40
13	138	K.Chinnaiah	Ibrahimpatnam	Clay loam	8.16	0.46	1.02	141.12	20.00	198.00	100	60	40
14	178	V.Nambaiah	Kajapur	Clay loam	8.06	0.42	0.83	178.75	36.00	260.00	80	45	0
15	179	M.Hanumantha Reddy	Kajapur	Clay loam	8.85	0.39	0.65	219.52	25.00	280.00	80	45	0
16	195	E.Venkat Reddy	Katkampally	Clay loam	6.85	0.22	1.35	156.80	48.00	298.00	100	50	40
17	194	K.Venkat Reddy	Katkampally	Clay loam	7.88	0.34	1.51	169.34	38.00	270.00	100	60	50
18	191	K.Prathap Reddy	Katkampally	Clay loam	7.03	0.32	0.83	172.48	28.00	226.00	100	60	50
19	90	S.Narasaiah	Kolwai	Clay loam	8.23	0.13	0.80	131.71	24.00	170.00	100	60	50
20	119	M.A.Gaffar	Koratla	Clay loam	8.30	0.20	1.22	263.42	24.00	412.00	100	45	40
21	118	D.Gangaram	Koratla	Clay loam	8.08	0.27	1.05	128.58	21.00	396.00	100	60	40
22	181	V.Venkata Rao	Lokapet	Clay loam	8.78	0.23	0.67	175.62	25.00	292.00	100	60	40
23	184	D.Ravindra Rao	Lokapet	Clay loam	8.43	0.15	1.16	175.62	10.00	310.00	100	60	40
24	185	D.Rajeshwara Rao	Lokapet	Clay loam	8.80	0.40	1.37	743.20	9.00	298.00	100	60	40
25	36	S.Ganga Reddy	Metpally	Clay loam	8.52	0.20	0.74	141.12	29.00	648.00	100	60	40
26	38	K.L.Gangaram	Metpally	Clay loam	8.03	0.26	1.94	178.75	25.00	416.00	100	60	40
27	39	P.Janga Reddy	Metpally	Clay loam	6.27	0.25	1.14	222.66	26.00	298.00	100	60	40
28	37	P.Linga Reddy	Metpally	Clay loam	6.36	0.25	1.54	150.53	37.00	272.00	100	60	40
29	54	V.Vijayendra Rao	Muthyampet	Clay loam	6.43	0.18	1.04	206.98	10.00	165.00	100	60	40
30	206	B.K.Rami Reddy	Nagaram	Clay loam	8.68	0.22	0.49	185.02	26.00	309.00	100	60	40
31	210	B.Venkata Reddy	Nagaram	Clay loam	8.11	0.06	1.00	153.66	19.00	189.00	100	60	40
32	209	B.Laxmi Reddy	Nagaram	Clay loam	8.27	0.04	0.96	225.79	22.00	252.00	100	60	40
33	207	B.K.Raji Reddy	Nagaram	Clay loam	8.82	0.28	0.24	103.49	27.00	280.00	100	60	40
34	167	V.Pedda Rajaiah	Narayanpur	Clay loam	8.32	0.12	0.31	156.80	20.00	305.00	100	60	40
35	196	Y.Ramaiah	Parepally	Clay loam	8.03	0.30	0.56	137.98	51.00	298.00	100	60	40
36	200	V.Shankaraiah	Parepally	Clay loam	8.30	0.33	1.39	103.49	29.00	368.00	100	60	40
37	197	M.Komaraiah	Parepally	Clay loam	8.05	0.16	0.75	185.02	46.00	346.00	100	60	40
38	199	M.Kamaraiah	Parepally	Clay loam	6.50	0.27	1.35	228.93	30.00	119.00	100	50	40
39	18	G.Chandraiah	Pegadapally	Clay loam	7.93	0.45	1.28	194.43	11.00	220.00	100	60	40
40	19	G.Gopala Rao	Pegadapally	Clay loam	7.84	0.59	1.33	116.03	9.00	168.00	100	45	40
41	17	M.Narasimha Reddy	Pegadapally	Clay loam	7.80	0.36	1.52	341.82	26.00	227.00	100	60	40

42	214	Saibaba	Puttapaka	Clay loam	8.45	0.20	0.40	175.62	22.00	345.00	100	60	40
43	213	Pedda Kamaiah	Puttapaka	Clay loam	8.38	0.10	1.25	175.62	20.00	480.00	100	60	40
44	25	R.Bheemaiah	Rapalle	Clay loam	8.31	0.42	0.40	272.83	10.00	168.00	100	40	0
45	30	K.Prakash Rao	Rapalle	Clay loam	5.93	0.15	1.19	159.94	31.00	276.00	100	40	0
46	113	P.Linga Reddy	Sangam	Clay loam	8.42	0.28	0.73	232.06	19.00	168.00	100	45	40
47	187	C.Jakkaiah	Sayampet	Clay loam	6.94	0.40	0.59	279.10	24.00	188.00	100	60	40
48	190	B.Sathyanarayana Re	Sayampet	Clay loam	8.29	0.20	1.44	159.44	32.00	230.00	100	60	40
49	22	K.Venkanna	Thirumalapur	Clay loam	8.15	0.35	0.79	235.20	23.00	225.00	100	60	50
50	50	D.Shyam Rao	Vellulla	Clay loam	7.73	0.25	0.93	141.12	9.00	387.00	100	60	40
51	172	I.Papaiah	Wadkapur	Clay loam	8.52	0.19	1.10	206.98	25.00	289.00	80	45	0
		No.of farmers			51	51	51	51	51	51	51	51	51
		Mean			7.85	0.27	0.99	198.85	23.90	291.55	98.43	56.47	36.27
		S.D.			0.75	0.12	0.37	93.49	10.06	100.23	5.38	6.59	13.57
		C.V.(%)			9.52	45.87	37.31	47.02	42.09	34.38	5.46	11.67	37.41
52	219	P.Madhava Rao	Dandepally	Clayey	5.73	0.26	0.71	188.16	17.00	110.00	100	60	40
53	188	B.Venkataiah	Sayampet	Clayey	8.03	0.39	1.22	235.20	24.00	180.00	100	60	40
		No.of farmers			2	2	2	2	2	2	2	2	2
		Mean			6.88	0.33	0.97	211.68	20.50	145.00	100.00	60.00	40.00
		S.D.			1.15	0.07	0.26	23.52	3.50	35.00	0.00	0.00	0.00
		C.V.(%)			16.72	20.00	26.42	11.11	17.07	24.14	0.00	0.00	0.00
54	109	K.Jagannatham	Alipoor	Loamy sand	8.15	0.45	1.59	288.51	25.00	310.00	80	40	0
55	110	S.Mallaiah	Alipoor	Loamy sand	8.45	0.39	0.66	210.11	25.00	310.00	80	40	0
56	35	P.Bheemaiah	Gollapalli	Loamy sand	7.18	0.23	0.53	106.62	10.00	125.00	80	40	0
57	135	L.Gangaram	Komati Kondapur	Loamy sand	7.90	0.45	1.10	216.38	24.00	365.00	80	40	0
		No.of farmers			4	4	4	4	4	4	4	4	4
		Mean			7.92	0.38	0.97	205.41	21.00	277.50	80.00	40.00	0.00
		S.D.			0.47	0.09	0.42	64.82	6.36	90.86	0.00	0.00	0.00
		C.V.(%)			0.06	0.24	0.43	0.32	0.30	0.33	0.00	0.00	ERR
58	107	E.Pachalu	Alipoor	Sandy clay loam	7.08	0.09	1.14	159.94	22.00	222.00	100	45	50
59	11	C.Anjaiah	Aravally	Sandy clay loam	6.68	0.11	0.86	197.57	27.00	189.00	100	45	50
60	13	P.Anjaiah	Aravally	Sandy clay loam	7.73	0.36	0.89	144.26	20.00	166.00	100	45	50
61	12	V.Rajalingam	Aravally	Sandy clay loam	7.99	0.10	1.13	232.06	21.00	148.00	100	45	50
62	85	A.Laxman	Beerpur	Sandy clay loam	7.75	0.40	1.79	301.06	19.00	460.00	80	45	0
63	84	A.Rajamallu	Beerpur	Sandy clay loam	8.00	0.25	0.74	219.52	36.00	381.00	80	45	0
64	71	K.Bheemaiah	Chelgal	Sandy clay loam	7.96	0.29	0.86	191.30	25.00	186.00	100	60	50
65	72	K.C.Gangaram	Chelgal	Sandy clay loam	8.39	0.16	0.47	150.52	25.00	180.00	100	60	50
66	73	E.Rajanna	Chelgal	Sandy clay loam	7.74	0.21	1.05	134.85	18.00	235.00	100	60	50
67	74	E.Lingam	Chelgal	Sandy clay loam	7.05	0.34	0.98	122.30	25.00	196.00	100	60	50
68	165	G.Rajeshwar	Chinnakoluvala	Sandy clay loam	8.04	0.23	0.98	125.44	22.00	386.00	80	40	0
69	217	P.Linga Rao	Dandepally	Sandy clay loam	8.29	0.11	0.86	200.70	9.00	146.00	100	60	40
70	5	B.Rajam	Dharmapuri	Sandy clay loam	7.99	0.33	0.80	134.85	24.00	375.00	100	45	40
71	6	P.Narayana	Donnur	Sandy clay loam	7.86	0.28	0.84	219.52	25.00	250.00	100	45	40
72	7	Y. Narayana Rao	Donnur	Sandy clay loam	6.80	0.24	1.48	122.30	43.00	243.00	100	45	40
73	32	M.Bheemaiah	Gollapalli	Sandy clay loam	6.49	0.45	0.98	200.70	38.00	246.00	80	40	0

74	34	H.Rajanna	Gollapalli	Sandy clay loam	7.84	0.33	0.73	181.89	21.00	156.00	80	40	0
75	146	C.P.Narasaiah	Gudur	Sandy clay loam	8.09	0.43	0.62	233.20	21.00	268.00	80	40	0
76	147	B.B.Yellaiah	Gudur	Sandy clay loam	6.65	0.35	1.06	150.53	10.00	166.00	80	40	0
77	148	B.Narayana	Gudur	Sandy clay loam	8.06	0.49	0.62	410.82	42.00	218.00	80	40	0
78	149	P.Gangaram	Gudur	Sandy clay loam	8.01	0.49	1.29	203.84	19.00	206.00	80	40	0
79	224	K.S.S.Reddy	Huzurabad	Sandy clay loam	7.97	0.41	1.00	266.56	10.00	178.00	80	45	40
80	140	B.Gangaram	Ibrahimpatnam	Sandy clay loam	8.26	0.40	1.17	244.61	24.00	366.00	80	45	40
81	136	E.C.Bheemaiah	Ibrahimpatnam	Sandy clay loam	8.05	0.41	1.48	247.74	25.00	206.00	80	45	40
82	96	E.Raja Reddy	Itkyal	Sandy clay loam	6.75	0.36	1.00	232.06	10.00	156.00	80	45	40
83	93	V.Raja Reddy	Itkyal	Sandy clay loam	6.90	0.46	0.77	163.07	7.00	175.00	80	45	40
84	92	B.Gangaram	Itkyal	Sandy clay loam	6.30	0.31	1.08	144.26	21.00	205.00	80	45	40
85	91	C.Rajam	Itkyal	Sandy clay loam	6.14	0.32	1.04	228.93	21.00	170.00	80	45	40
86	94	B.Linga Reddy	Itkyal	Sandy clay loam	5.56	0.22	0.77	122.30	9.00	138.00	80	45	40
87	232	A.Saiyulu	Jammikunta	Sandy clay loam	7.87	0.20	1.35	191.30	42.00	250.00	100	45	40
88	231	M.Kanakaiah	Jammikunta	Sandy clay loam	8.00	0.46	0.56	175.03	21.00	188.00	80	40	0
89	177	A.Mallaiah	Kajapur	Sandy clay loam	6.76	0.32	0.79	257.15	35.00	260.00	80	45	0
90	176	M.Rama Reddy	Kajapur	Sandy clay loam	8.06	0.46	0.53	185.02	38.00	248.00	80	45	0
91	180	G.Veeraiah	Kajapur	Sandy clay loam	8.46	0.18	0.71	175.26	34.00	366.00	80	40	0
92	193	Anjam Raju	Katkampally	Sandy clay loam	7.51	0.47	0.93	191.30	36.00	172.00	100	60	50
93	192	P.Swamy	Katkampally	Sandy clay loam	5.62	0.20	0.87	228.93	26.00	282.00	100	60	50
94	87	T.Rajalingam	Kolwai	Sandy clay loam	7.04	0.20	1.02	169.34	11.00	278.00	100	60	50
95	88	R.Janardhan Rao	Kolwai	Sandy clay loam	6.53	0.28	1.48	244.61	11.00	296.00	100	60	50
96	86	D.T.Chandraiah	Kolwai	Sandy clay loam	8.05	0.31	1.20	203.84	14.00	318.00	100	60	50
97	89	M.Rajam	Kolwai	Sandy clay loam	8.06	0.28	0.90	200.70	10.00	280.00	100	60	50
98	134	B.Erranna	Komati Kondapur	Sandy clay loam	7.52	0.58	1.48	219.52	19.00	295.00	100	60	50
99	133	T.Bheemaiah	Komati Kondapur	Sandy clay loam	6.83	0.27	1.44	188.16	18.00	316.00	100	60	50
100	117	A.A.Saleem	Koratla	Sandy clay loam	6.43	0.42	1.03	178.75	25.00	240.00	100	45	40
101	116	Md.Eglabuddin	Koratla	Sandy clay loam	7.86	0.74	1.43	244.61	20.00	302.00	100	45	40
102	120	D.Laxmi Rajam	Koratla	Sandy clay loam	7.87	0.52	0.91	232.06	20.00	148.00	100	45	40
103	103	C.C.Rajanna	Kummarapally	Sandy clay loam	8.09	0.34	1.08	363.78	9.00	130.00	100	45	40
104	105	T.Ganga Reddy	Kummarapally	Sandy clay loam	8.11	0.31	0.41	222.66	15.00	140.00	100	45	40
105	102	C.Rajanna	Kummarapally	Sandy clay loam	6.53	0.19	0.80	109.76	10.00	128.00	100	45	40
106	101	C.Linganna	Kummarapally	Sandy clay loam	6.90	0.38	0.89	188.16	8.00	120.00	100	45	40
107	104	T.Bukkanna	Kummarapally	Sandy clay loam	6.92	0.41	0.80	178.75	12.00	139.00	100	45	40
108	183	V.Vasantha Rao	Lokapet	Sandy clay loam	8.38	0.30	0.93	185.02	12.00	368.00	100	45	40
109	128	B.Chinna Pochaiah	Metpally	Sandy clay loam	8.35	0.18	0.92	156.80	21.00	246.00	100	45	40
110	129	Md.Hafeez	Metpally	Sandy clay loam	8.15	0.31	0.97	228.93	21.00	246.00	100	45	40
111	130	K.C.Bheemaiah	Metpally	Sandy clay loam	8.36	0.14	1.08	141.12	24.00	316.00	100	45	40
112	126	S.Hussain	Metpally	Sandy clay loam	8.35	0.23	0.59	112.90	22.00	290.00	100	45	40
113	40	G.Mallesham	Metpally	Sandy clay loam	7.45	0.24	0.58	163.07	24.00	158.00	100	45	40
114	127	K.M.Sambaji	Metpally	Sandy clay loam	8.26	0.38	0.91	216.38	26.00	288.00	100	45	40
115	70	B.Mallaiah	Mogilipet	Sandy clay loam	6.49	0.16	1.08	137.98	8.00	168.00	100	45	40
116	67	Y.S.Ganganna	Mogilipet	Sandy clay loam	6.90	0.14	1.05	141.12	24.00	368.00	100	45	40
117	68	B.Rajanna	Mogilipet	Sandy clay loam	8.05	0.15	1.19	235.20	21.00	376.00	100	45	40
118	121	Ch.Bheema Rao	Mohanraopet	Sandy clay loam	6.51	0.25	1.19	128.58	32.00	192.00	80	40	40
119	123	C.Mukund Rao	Mohanraopet	Sandy clay loam	5.14	0.19	0.49	163.07	24.00	176.00	80	40	40
120	125	B.Rajam	Mohanraopet	Sandy clay loam	7.10	0.43	1.10	178.75	20.00	168.00	80	40	40
121	124	B.Lingam	Mohanraopet	Sandy clay loam	5.67	0.19	0.92	191.30	36.00	168.00	80	40	40
122	51	B.Venkanna	Muthyampet	Sandy clay loam	7.21	0.10	1.11	141.12	8.00	180.00	80	40	0
123	53	M.Anadhaiah	Muthyampet	Sandy clay loam	7.70	0.19	0.86	144.26	11.00	178.00	80	40	0

124	52	E.Raghava Reddy	Muthyampet	Sandy clay loam	7.95	0.46	0.96	210.11	13.00	165.00	80	40	0
125	64	Venkata Rao	Nadukude	Sandy clay loam	7.06	0.12	0.76	134.85	8.00	156.00	80	40	0
126	65	K.Raji Reddy	Nadukude	Sandy clay loam	8.23	0.19	0.80	200.70	7.00	148.00	80	40	0
127	61	Pansha Goud	Nadukude	Sandy clay loam	6.50	0.17	0.98	203.84	11.00	187.00	80	40	0
128	62	R.Linganna	Nadukude	Sandy clay loam	7.48	0.29	0.92	122.30	10.00	171.00	80	40	0
129	166	A.Lingaiah	Narayanpur	Sandy clay loam	8.48	0.17	0.38	235.20	14.00	295.00	100	45	40
130	170	A.Chinna Rajaiah	Narayanpur	Sandy clay loam	8.81	0.15	1.45	169.34	26.00	288.00	80	40	0
131	198	G.Rajalingam	Parepally	Sandy clay loam	8.14	0.66	0.88	156.80	49.00	450.00	100	50	40
132	159	K.Ramulu	Peddabankur	Sandy clay loam	7.43	0.45	0.44	122.30	21.00	266.00	80	45	0
133	160	Sriram Ramayya	Peddabankur	Sandy clay loam	7.65	0.28	0.53	169.24	20.00	248.00	100	45	0
134	158	S.Ramayya	Peddabankur	Sandy clay loam	8.04	0.41	0.85	250.88	25.00	242.00	100	45	40
135	156	C.Nambaiah	Peddabankur	Sandy clay loam	7.95	0.51	1.16	166.21	30.00	396.00	100	40	0
136	151	K.Subba Reddy	Peddapally	Sandy clay loam	8.50	0.35	1.08	250.88	24.00	280.00	100	40	0
137	153	C.P.Narasaiah	Peddapally	Sandy clay loam	7.18	0.31	0.86	216.38	38.00	246.00	100	40	0
138	154	M.V.Ramana Reddy	Peddapally	Sandy clay loam	8.04	0.34	1.03	206.98	31.00	368.00	100	40	0
139	152	Rami Reddy	Peddapally	Sandy clay loam	8.53	0.27	0.96	235.20	21.00	290.00	100	40	0
140	155	M.Mallesham	Peddapally	Sandy clay loam	8.05	0.42	1.26	141.12	30.00	246.00	100	40	0
141	16	K.Rajaiah	Pegadapally	Sandy clay loam	8.20	0.40	0.96	244.61	8.00	96.00	100	45	40
142	77	M.Venkati	Polasa	Sandy clay loam	8.34	0.24	0.71	235.20	10.00	326.00	80	60	0
143	78	N.Rajanna	Polasa	Sandy clay loam	7.81	0.20	0.52	131.70	10.00	326.00	80	60	0
144	76	D.Narasaiah	Polasa	Sandy clay loam	8.42	0.25	0.80	213.25	8.00	188.00	80	60	0
145	79	K.Bheemaiah	Polasa	Sandy clay loam	8.03	0.21	0.89	203.84	42.00	277.00	80	60	0
146	80	S.Mondaiah	Polasa	Sandy clay loam	8.38	0.21	0.79	225.79	21.00	282.00	80	60	0
147	229	P.Devender Reddy	Pothareddypet	Sandy clay loam	6.52	0.15	1.58	213.25	6.00	106.00	80	45	40
148	230	P.Ravindra Reddy	Pothareddypet	Sandy clay loam	7.64	0.33	1.01	216.38	20.00	192.00	100	45	40
149	226	G.Malla Reddy	Pothareddypet	Sandy clay loam	6.57	0.03	0.59	166.21	25.00	171.00	100	45	40
150	228	G.Niranjan Reddy	Pothareddypet	Sandy clay loam	6.48	0.38	1.39	244.61	8.00	116.00	80	45	40
151	211	I.Mandaiah	Puttapaka	Sandy clay loam	8.53	0.26	0.29	147.39	14.00	179.00	80	45	40
152	212	Ganga Raju	Puttapaka	Sandy clay loam	8.33	0.24	1.29	194.43	16.00	126.00	80	45	40
153	215	Md.Chandbee	Puttapaka	Sandy clay loam	8.22	0.42	0.36	232.06	25.00	450.00	80	45	40
154	99	P.Linga Reddy	Raikal	Sandy clay loam	7.13	0.26	0.86	150.53	19.00	102.00	80	45	40
155	97	N.Bhoomi Reddy	Raikal	Sandy clay loam	7.56	0.10	1.28	175.62	11.00	122.00	80	45	40
156	100	B.Gangaram	Raikal	Sandy clay loam	6.09	0.22	1.35	175.62	8.00	118.00	80	45	40
157	98	Abdul Nabiz	Raikal	Sandy clay loam	6.67	0.15	0.99	128.58	11.00	125.00	80	45	40
158	28	G.Purushotham	Rapalle	Sandy clay loam	7.79	0.24	1.44	150.58	54.00	282.00	100	45	0
159	29	M.Thirupathi Goud	Rapalle	Sandy clay loam	8.18	0.25	1.32	181.89	28.00	278.00	80	40	0
160	26	K.Suguna Rao	Rapalle	Sandy clay loam	7.93	0.29	0.79	194.43	40.00	217.00	100	45	0
161	27	G.Srinivasa Rao	Rapalle	Sandy clay loam	7.34	0.30	1.04	185.16	25.00	246.00	100	45	0
162	111	S.Ganga Reddy	Sangam	Sandy clay loam	8.01	0.50	0.83	260.29	21.00	268.00	100	45	40
163	114	Y.Kishan Rao	Sangam	Sandy clay loam	6.87	0.12	0.83	206.98	23.00	348.00	100	45	40
164	115	B.Balaiah	Sangam	Sandy clay loam	8.33	0.35	0.77	181.89	22.00	368.00	100	45	40
165	189	B.Rayamallu	Sayampet	Sandy clay loam	8.07	0.38	0.84	213.25	40.00	220.00	100	45	40
166	24	G.Rajaram	Thirumalapur	Sandy clay loam	6.94	0.34	0.99	172.48	16.00	176.00	100	45	40
167	23	K.P.Rajaiah	Thirumalapur	Sandy clay loam	7.74	0.29	0.67	128.58	21.00	218.00	100	45	40
168	142	K.Lingam	Thirumalapur	Sandy clay loam	7.95	0.28	1.05	128.58	28.00	176.00	100	45	40
169	141	G.gangaram	Thirumalapur	Sandy clay loam	6.90	0.10	0.68	163.07	25.00	198.00	100	45	40
170	145	K.Bheemaiah	Thirumalapur	Sandy clay loam	7.34	0.21	1.16	225.79	20.00	198.00	100	45	40
171	143	M.Ashalu	Thirumalapur	Sandy clay loam	7.30	0.19	0.89	260.29	20.00	305.00	100	45	40
172	144	D.Gangaram	Thirumalapur	Sandy clay loam	8.02	0.51	1.31	244.61	23.00	230.00	100	45	40
173	48	Nanda Kumar	Vellulla	Sandy clay loam	8.35	0.20	0.86	75.26	5.00	178.00	100	45	40

174	47	D.Venkata Ramana	Vellulla	Sandy clay loam	8.43	0.17	1.13	144.26	4.00	186.00	80	40	40
175	46	D.Ramachandran	Vellulla	Sandy clay loam	7.76	0.26	0.74	153.66	6.00	218.00	80	40	40
176	45	A.Muthyam Reddy	Vempet	Sandy clay loam	8.32	0.11	0.83	188.16	9.00	378.00	100	45	40
177	43	K.Raji Reddy	Vempet	Sandy clay loam	8.28	0.24	0.99	360.64	21.00	276.00	100	45	40
178	41	K.Shankar Reddy	Vempet	Sandy clay loam	7.76	0.24	0.99	131.71	25.00	350.00	80	40	0
179	42	A.Linga Reddy	Vempet	Sandy clay loam	8.43	0.17	0.96	106.62	25.00	318.00	100	45	40
180	171	K.Venkataiah	Wadkapur	Sandy clay loam	8.08	0.29	1.18	131.71	25.00	288.00	80	45	0
		No.of farmers			123	123	123	123	123	123	123	123	123
		Mean			7.58	0.29	0.95	190.10	20.92	236.28	91.38	45.98	28.29
		S.D.			0.76	0.13	0.28	52.38	10.11	82.90	9.90	6.20	19.91
		C.V.(%)			0.10	0.44	0.29	0.28	0.48	0.35	0.11	0.13	0.70
181	108	T.Ram Gangaram	Alipoor	Sandy loam	7.96	0.45	1.16	181.89	24.00	241.00	100	60	50
182	14	G. Madhava Reddy	Aravally	Sandy loam	6.50	0.27	0.28	197.57	10.00	109.00	100	60	50
183	15	M.Mallaiah	Aravally	Sandy loam	7.42	0.31	1.22	191.30	9.00	110.00	80	45	0
184	82	S.Narayana	Beerpur	Sandy loam	6.86	0.23	1.37	178.25	55.00	247.00	100	60	40
185	83	B.Narayana Rao	Beerpur	Sandy loam	6.83	0.19	1.28	206.98	41.00	372.00	100	60	40
186	75	P.Papaiah	Chelgal	Sandy loam	8.43	0.36	1.37	235.20	10.00	212.00	100	60	50
187	163	M.Chandraiah	Chinnakoluvala	Sandy loam	8.24	0.29	0.99	200.70	19.00	366.00	80	45	40
188	1	G.Shankar	Dharmapuri	Sandy loam	8.15	0.35	0.74	144.26	45.00	303.00	80	40	0
189	2	R.Rajaiah	Dharmapuri	Sandy loam	7.40	0.13	0.31	109.76	36.00	288.00	100	45	0
190	4	K.Narasaiah	Dharmapuri	Sandy loam	8.26	0.20	1.58	269.70	32.00	271.00	100	45	0
191	3	R.Rajalingaiah	Dharmapuri	Sandy loam	8.29	0.24	1.62	163.07	41.00	466.00	100	45	0
192	10	M.Gangaram	Donnur	Sandy loam	6.31	0.24	1.03	150.53	26.00	298.00	100	45	0
193	8	P.Mallaiah	Donnur	Sandy loam	8.22	0.28	1.48	169.34	24.00	266.00	100	45	0
194	9	M.Rameshwar	Donnur	Sandy loam	8.23	0.66	1.05	178.75	48.00	270.00	100	45	0
195	33	K.Sambi Reddy	Gollapalli	Sandy loam	7.98	0.69	1.07	156.80	30.00	246.00	80	40	0
196	150	V.Narsa Reddy	Gudur	Sandy loam	7.94	0.51	0.50	163.07	21.00	210.00	80	40	0
197	223	M.Ailayya	Huzurabad	Sandy loam	6.94	0.24	1.22	232.06	15.00	228.00	80	40	0
198	222	N.Raghotham Reddy	Huzurabad	Sandy loam	6.62	0.27	0.68	272.83	18.00	166.00	80	40	0
199	95	Badayam Reddy	Itkyal	Sandy loam	6.00	0.25	0.77	219.52	9.00	142.00	80	40	0
200	234	M.Kanakaiah	Jammikunta	Sandy loam	8.16	0.04	1.48	235.20	15.00	300.00	100	45	40
201	233	A.Yadi Reddy	Jammikunta	Sandy loam	8.83	0.45	1.29	197.57	42.00	266.00	100	45	40
202	132	K.Gangaram	Komati Kondapur	Sandy loam	6.65	0.33	0.61	215.71	19.00	388.00	100	45	40
203	131	P.Ankulam	Komati Kondapur	Sandy loam	6.60	0.31	0.92	188.16	15.00	400.00	100	45	40
204	66	Akula Sayeb	Mogilipet	Sandy loam	7.50	0.58	1.14	225.79	22.00	400.00	100	45	40
205	122	P.Venkata Narasaiah	Mohanraopet	Sandy loam	6.48	0.20	0.76	134.85	25.00	176.00	80	40	40
206	55	E.Raghava Reddy	Muthyampet	Sandy loam	6.20	0.16	0.65	197.57	9.00	140.00	80	40	40
207	63	A.Dharmaji	Nadukude	Sandy loam	8.70	0.55	0.96	191.30	9.00	168.00	80	40	40
208	169	V.Mallaiah	Narayanpur	Sandy loam	8.93	0.62	0.97	188.16	24.00	305.00	80	45	0
209	168	A.Chinna Lingaiah	Narayanpur	Sandy loam	8.92	0.33	0.09	144.26	23.00	422.00	80	45	0
210	157	K.Veeresham	Peddabankur	Sandy loam	6.76	0.16	0.86	266.56	28.00	266.00	100	40	0
211	20	G.Pramila	Pegadapally	Sandy loam	7.71	0.34	1.02	163.07	7.00	180.00	100	45	40
212	56	G.Devanna	Raghavapet	Sandy loam	8.24	0.34	1.63	260.29	8.00	164.00	80	40	0
213	60	C.Balaiah	Raghavapet	Sandy loam	8.08	0.12	0.86	166.21	11.00	171.00	80	40	0
214	57	P.Devanna	Raghavapet	Sandy loam	8.36	0.37	1.52	219.52	21.00	174.00	80	40	0
215	21	J.Ramaswamy	Thirumalapur	Sandy loam	8.49	0.47	1.02	206.98	5.00	168.00	100	60	50
216	44	K.Raji Reddy	Vempet	Sandy loam	8.47	0.20	0.89	169.34	11.00	346.00	100	45	40
		No.of farmers			36	36	36	36	36	36	36	36	36
		Mean			7.66	0.33	1.01	194.23	22.42	256.81	91.11	45.69	20.00
		S.D.			0.86	0.15	0.38	38.74	12.85	92.35	9.94	6.79	21.34
		C.V.(%)			11.22	47.56	37.31	19.95	57.32	35.96	10.91	14.85	106.72

217	221	C.Rajaiah	Huzurabad	Silt clay loam	5.20	0.07	1.97	178.75	8.00	110.00	80	40	0
218	208	B.Venkata Reddy	Nagaram	Silt clay loam	8.28	0.28	0.38	181.89	28.00	250.00	80	45	40
219	227	C.Papi Reddy	Pothareddypet	Silt clay loam	6.40	0.15	0.71	206.98	16.00	188.00	80	45	40
220	161	K.Thirupathi Rao	Chinnakoluvala	Silt clay loam	7.81	0.19	0.62	156.80	15.00	528.00	100	60	40
		No.of farmers			5	5	5	5	5	5	5	5	5
		Mean			6.92	0.17	0.92	181.11	16.75	269.00	85.00	47.50	30.00
		S.D.			1.21	0.08	0.62	17.79	7.19	157.55	8.66	7.50	17.32
		C.V.(%)			17.50	43.84	67.18	9.82	42.92	58.57	10.19	15.79	57.74
221	220	P.Rajaiah	Dandepally	Silt loam	7.00	0.08	0.47	134.85	14.00	525.00	100	60	40
222	205	P.Chandraiah	Gundaram	Silt loam	7.95	0.08	0.64	241.47	22.00	346.00	100	60	40
223	225	N.Linga Reddy	Huzurabad	Silt loam	5.62	0.05	0.56	169.34	9.00	166.00	100	45	40
224	139	P.C.Rajanna	Ibrahimpatnam	Silt loam	7.03	0.45	1.37	363.78	21.00	315.00	100	45	40
225	235	Ranga Laxmaiah	Jammikunta	Silt loam	8.68	0.30	1.39	210.11	32.00	305.00	80	40	0
226	182	D.Narendra	Lokapet	Silt loam	8.84	0.16	0.28	78.40	11.00	410.00	80	40	0
227	69	Y.S.B.Linganna	Mogilipet	Silt loam	5.87	0.15	1.03	134.85	9.00	182.00	80	40	0
228	112	N.Muthaiah	Sangam	Silt loam	6.57	0.15	0.53	134..85	20.00	246.00	100	45	40
229	186	B.Rami Reddy	Sayampet	Silt loam	6.57	0.25	1.19	263.42	36.00	170.00	100	60	40
230	173	I.Mallaiah	Wadkapur	Silt loam	8.24	0.36	0.68	238.34	21.00	305.00	80	45	0
		No.of Obsevations			10	10	10	10	10	10	10	10	10
		Mean			7.24	0.20	0.81	196.94	19.50	297.00	92.00	48.00	24.00
		S.D.			1.08	0.13	0.38	79.06	8.73	108.04	9.80	8.12	19.60
		C.V.(%)			14.91	62.00	46.39	40.14	44.78	36.38	10.65	16.93	81.65

Appendix - 5

Soil characterisation of soil test values in the Sreeramsagar project command area at panicle initiation and post-harvest stages under each texture in Karimnagar district

S.No.	Sample	Farmer's name	Village	Soil Texture	OC (%)	Panicle initiation stage KMNO4-N	Panicle initiation stage Plant N (%)	GY (q/ha)	Post harvest STV (kg/ha) KMNO4-N	Post harvest STV (kg/ha) Olsen-P	Post harvest STV (kg/ha) Amac-K
1	106	E.Rajam	Alipoor	Clay loam	1.18	176.00	2.27				
2	81	J.Rajeshwara Rao	Beerpur	Clay loam	0.95	134.85	1.94	29	109	45	288
3	164	G.Srihari Rao	Chinnakoluvala	Clay loam	0.95	144.26	4.60	16	139	17	316
4	162	V.Sugunakar Rao	Chinnakoluvala	Clay loam	0.94	180.11	1.69	40	181	15	382
5	216	K.S.Rama Rao	Dandepally	Clay loam	0.74	109.76	2.34	26	168	26	22
6	218	M.Uppalaiah	Dandepally	Clay loam	0.81	150.53	1.66	26	171	10	162
7	31	G.Rajalingum	Gollapalli	Clay loam	0.52	131.71	1.70	18	148	46	316
8	203	G.Chinna Rajam	Gundaram	Clay loam	0.72	254.02	1.01				
9	204	S.Pochaiah	Gundaram	Clay loam	0.86	216.16	1.12				
10	201	G.Pedda Rajam	Gundaram	Clay loam	0.55	84.67	1.22				
11	202	D.Muthaiah	Gundaram	Clay loam	0.62	89.21	1.19				
12	137	N.Muthanna	Ibrahimpatnam	Clay loam	1.47	131.71	0.73				
13	138	K.Chinnaiah	Ibrahimpatnam	Clay loam	1.52	128.16	0.76				
14	178	V.Nambaiah	Kajapur	Clay loam	0.45	90.94	[illegible].64	16	186	42	219
15	179	M.Hanumantha Reddy	Kajapur	Clay loam	0.54	81.91	[illegible]	17	206	26	292
16	195	E.Venkat Reddy	Katkampally	Clay loam	0.82	148.11	1.[illegible]	19	138	42	278
17	194	K.Venkat Reddy	Katkampally	Clay loam	0.76	167.12	1.29	18	136	22	312
18	191	K.Prathap Reddy	Katkampally	Clay loam	0.90	109.26	2.12	22	128	24	273
19	90	S.Narasaiah	Kolwai	Clay loam	1.20	119.17	3.20				
20	119	M.A.Gaffar	Koratla	Clay loam	0.78	120.06	1.20	24	216	32	416
21	118	D.Gangaram	Koratla	Clay loam	0.95	137.98	1.31	20	92	52	492
22	181	V.Venkata Rao	Lokapet	Clay loam	0.98	141.21	1.20				
23	184	D.Ravindra Rao	Lokapet	Clay loam	1.02	116.00	1.21				
24	185	D.Rajeshwara Rao	Lokapet	Clay loam	1.16	121.11	1.46				
25	36	S.Ganga Reddy	Metpally	Clay loam	0.83	129.32	1.73				
26	38	K.L.Gangaram	Metpally	Clay loam	0.42	125.44	1.47				
27	39	P.Janga Reddy	Metpally	Clay loam	0.81	150.53	1.70				
28	37	P.Linga Reddy	Metpally	Clay loam	0.86	84.67	2.25				
29	54	V.Vijayendra Rao	Muthyampet	Clay loam	1.37	232.06	2.45				
30	206	B.K.Rami Reddy	Nagaram	Clay loam	0.52	72.13	1.64				
31	210	B.Venkata Reddy	Nagaram	Clay loam	0.58	147.39	1.40				
32	209	B.Laxmi Reddy	Nagaram	Clay loam	0.61	149.19	1.29				
33	207	B.K.Raji Reddy	Nagaram	Clay loam	0.55	87.81	1.79				
34	167	V.Pedda Rajaiah	Narayanpur	Clay loam	1.74	153.66	2.26	18	186	26	362
35	196	Y.Ramaiah	Parepally	Clay loam	0.96	134.85	1.82	18	116	40	304
36	200	V.Shankaraiah	Parepally	Clay loam	0.66	90.94	1.10	22	89	20	312
37	197	M.Komaraiah	Parepally	Clay loam	0.90	162.15	1.82	19	202	19	126
38	199	M.Kamaraiah	Parepally	Clay loam	0.48	141.11	1.51	18	125	28	360
39	18	G.Chandraiah	Pegadapally	Clay loam	1.32	122.30	1.40	46	176	16	226
40	19	G.Gopala Rao	Pegadapally	Clay loam	1.24	114.16	1.16	47.2	152	22	181
41	17	M.Narasimha Reddy	Pegadapally	Clay loam	1.06	176.00	0.81	49.6	316	40	261

42	214	Saibaba	Puttapaka	Clay loam	0.46	151.66	1.24				
43	213	Pedda Kamaiah	Puttapaka	Clay loam	0.81	139.08	1.48				
44	25	R.Bheemaiah	Rapalle	Clay loam	0.94	139.25	1.51				
45	30	K.Prakash Rao	Rapalle	Clay loam	1.07	137.98	2.78	20	165	36	298
46	113	P.Linga Reddy	Sangam	Clay loam	1.07	122.30	2.19	22	182	24	149
47	187	C.Jakkaiah	Sayampet	Clay loam	1.36	120.92	1.20	14	189	32	192
48	190	B.Sathyanarayana Re	Sayampet	Clay loam	0.99	116.03	2.46	45	142	42	264
49	22	K.Venkanna	Thirumalapur	Clay loam	1.32	87.81	2.03	49.6	189	30	240
50	50	D.Shyam Rao	Vellulla	Clay loam	0.90	81.42	1.16	48	126	12	396
51	172	I.Papaiah	Wadkapur	Clay loam	0.87	134.85	1.89	18	142	32	245
		No.of farmers			51	51	51	28	28	28	28
		Mean			0.90	133.16	1.70	26.62	161.25	29.21	274.43
		S.D.			0.30	36.56	0.67	12.00	44.60	11.04	95.31
		C.V. (%)			33.23	27.45	39.51	45.09	27.66	37.80	34.73
52	219	P.Madhava Rao	Dandepally	Clayey	0.77	106.13	1.96	26	167	19	126
53	188	B.Venkataiah	Sayampet	Clayey	1.48	116.28	1.48	21	208	28	202
		No.of farmers			2	2	2	2	2	2	2
		Mean			1.13	111.21	1.72	23.50	187.50	23.50	164.00
		S.D.			0.36	5.08	0.24	2.50	20.50	4.50	38.00
		C.V. (%)			31.56	4.56	13.95	10.64	10.93	19.15	23.17
54	109	K.Jagannatham	Alipoor	Loamy sand	1.95	564.48	2.15				
55	110	S.Mallaiah	Alipoor	Loamy sand	1.28	134.85	2.10				
56	35	P.Bheemaiah	Gollapalli	Loamy sand	0.96	89.20	1.61	20	116	14	162
57	135	L.Gangaram	Komati Kondapur	Loamy sand	0.92	92.11	1.08				
		No.of farmers			4	4	4	1	1	1	1
		Mean			1.28	220.16	1.74	20.00	116.00	14.00	162.00
		S.D.			0.41	199.61	0.43	0.00	0.00	0.00	0.00
		C.V. (%)			0.32	0.91	0.25	0.00	0.00	0.00	0.00
58	107	E.Pachalu	Alipoor	Sandy clay loam	1.14	141.12	1.89				
59	11	C.Anjaiah	Aravally	Sandy clay loam	1.24	109.76	2.27	51.2	169	47	204
60	13	P.Anjaiah	Aravally	Sandy clay loam	0.60	109.76	1.16	52.2	138	24	174
61	12	V.Rajalingam	Aravally	Sandy clay loam	0.69	131.71	1.45	50	218	30	182
62	85	A.Laxman	Beerpur	Sandy clay loam	1.05	260.29	2.13	20	268	22	314
63	84	A.Rajamallu	Beerpur	Sandy clay loam	0.70	198.80	1.78	20	201	38	396
64	71	K.Bheemaiah	Chelgal	Sandy clay loam	1.43	134.85	2.06	36	176	29	128
65	72	K.C.Gangaram	Chelgal	Sandy clay loam	1.07	84.67	1.54	40	132	32	210
66	73	E.Rajanna	Chelgal	Sandy clay loam	1.01	175.62	1.46	40	120	15	280
67	74	E.Lingam	Chelgal	Sandy clay loam	0.81	460.99	1.57	38	108	20	228
68	165	G.Rajeshwar	Chinnakoluvala	Sandy clay loam	0.58	84.67	2.45	15	125	23	409
69	217	P.Linga Rao	Dandepally	Sandy clay loam	0.90	75.26	1.01	26	162	12	158
70	5	B.Rajam	Dharmapuri	Sandy clay loam	0.82	129.42	1.89	22	142	26	412
71	6	P.Narayana	Donnur	Sandy clay loam	0.75	144.26	2.85				
72	7	Y. Narayana Rao	Donnur	Sandy clay loam	0.86	151.02	1.91				
73	32	M.Bheemaiah	Gollapalli	Sandy clay loam	0.84	163.07	2.45	18	206	32	236

74	34	H.Rajanna	Gollapalli	Sandy clay loam	1.16	129.19	1.96	20	178	16	149
75	146	C.P.Narasaiah	Gudur	Sandy clay loam	1.66	153.66	1.90				
76	147	B.B.Yellaiah	Gudur	Sandy clay loam	1.01	181.16	1.76				
77	148	B.Narayana	Gudur	Sandy clay loam	0.89	295.98	2.10				
78	149	P.Gangaram	Gudur	Sandy clay loam	0.68	198.11	2.14				
79	224	K.S.S.Reddy	Huzurabad	Sandy clay loam	0.87	238.34	1.46	23	219	15	192
80	140	B.Gangaram	Ibrahimpatnam	Sandy clay loam	1.37	126.02	1.35				
81	136	E.C.Bheemaiah	Ibrahimpatnam	Sandy clay loam	0.61	166.21	2.89				
82	96	E.Raja Reddy	Itkyal	Sandy clay loam	1.12	121.16	2.12				
83	93	V.Raja Reddy	Itkyal	Sandy clay loam	1.23	106.02	2.17				
84	92	B.Gangaram	Itkyal	Sandy clay loam	1.29	194.43	2.50				
85	91	C.Rajam	Itkyal	Sandy clay loam	1.06	122.90	2.11				
86	94	B.Linga Reddy	Itkyal	Sandy clay loam	1.16	99.19	3.36				
87	232	A.Saiyulu	Jammikunta	Sandy clay loam	0.72	263.42	2.96	20	181	80	292
88	231	M.Kanakaiah	Jammikunta	Sandy clay loam	0.87	181.89	2.12	20	168	26	198
89	177	A.Mallaiah	Kajapur	Sandy clay loam	1.21	186.15	2.03	18	168	40	206
90	176	M.Rama Reddy	Kajapur	Sandy clay loam	1.32	191.30	1.82	17	159	38	194
91	180	G.Veeraiah	Kajapur	Sandy clay loam	0.62	101.00	1.89	16	182	39	402
92	193	Anjam Raju	Katkampally	Sandy clay loam	0.89	188.00	1.77	20	169	37	176
93	192	P.Swamy	Katkampally	Sandy clay loam	1.07	200.70	2.19	19	204	31	289
94	87	T.Rajalingam	Kolwai	Sandy clay loam	1.23	144.26	1.46				
95	88	R.Janardhan Rao	Kolwai	Sandy clay loam	1.11	103.49	1.87				
96	86	D.T.Chandraiah	Kolwai	Sandy clay loam	1.05	84.67	1.94				
97	89	M.Rajam	Kolwai	Sandy clay loam	1.24	100.35	1.39				
98	134	B.Erranna	Komati Kondapur	Sandy clay loam	1.11	121.02	1.16				
99	133	T.Bheemaiah	Komati Kondapur	Sandy clay loam	1.02	137.98	1.31				
100	117	A.A.Saleem	Koratla	Sandy clay loam	0.76	148.10	1.48	18	142	38	246
101	116	Md.Eglabuddin	Koratla	Sandy clay loam	0.73	153.66	1.54	18	186	28	406
102	120	D.Laxmi Rajam	Koratla	Sandy clay loam	0.84	184.11	1.94	21	209	24	152
103	103	C.C.Rajanna	Kummarapally	Sandy clay loam	1.05	232.06	1.70				
104	105	T.Ganga Reddy	Kummarapally	Sandy clay loam	1.29	181.00	1.82				
105	102	C.Rajanna	Kummarapally	Sandy clay loam	1.20	103.49	1.89				
106	101	C.Linganna	Kummarapally	Sandy clay loam	1.23	175.62	2.75				
107	104	T.Bukkanna	Kummarapally	Sandy clay loam	1.16	198.00	1.98				
108	183	V.Vasantha Rao	Lokapet	Sandy clay loam	0.89	98.12	0.96				
109	128	B.Chinna Pochaiah	Metpally	Sandy clay loam	0.56	92.08	1.40	32	192	19	318
110	129	Md.Hafeez	Metpally	Sandy clay loam	0.64	89.19	2.76	52	212	24	262
111	130	K.C.Bheemaiah	Metpally	Sandy clay loam	0.79	92.16	1.89	30	178	25	296
112	126	S.Hussain	Metpally	Sandy clay loam	0.63	72.13	1.38	42	108	24	310
113	40	G.Mallesham	Metpally	Sandy clay loam	0.77	138.16	1.64				
114	127	K.M.Sambaji	Metpally	Sandy clay loam	0.49	84.16	1.01	45	129	29	346
115	70	B.Mallaiah	Mogilipet	Sandy clay loam	1.44	194.43	2.08				
116	67	Y.S.Ganganna	Mogilipet	Sandy clay loam	0.96	108.62	1.21				
117	68	B.Rajanna	Mogilipet	Sandy clay loam	1.53	357.50	1.17				
118	121	Ch.Bheema Rao	Mohanraopet	Sandy clay loam	1.05	288.51	1.88	18	172	46	208
119	123	C.Mukund Rao	Mohanraopet	Sandy clay loam	1.14	219.00	1.46	21	121	26	192
120	125	B.Rajam	Mohanraopet	Sandy clay loam	0.90	128.58	1.57	19	138	46	175
121	124	B.Lingam	Mohanraopet	Sandy clay loam	1.07	97.22	1.43	21	140	50	180
122	51	B.Venkanna	Muthyampet	Sandy clay loam	1.11	109.76	1.42	26	102	10	192
123	53	M.Anadhaiah	Muthyampet	Sandy clay loam	1.21	107.00	0.58	29	129	13	180

124	52	E.Raghava Reddy	Muthyampet	Sandy clay loam	1.08	121.10	1.29	24	184	16	173
125	64	Venkata Rao	Nadukude	Sandy clay loam	0.77	120.22	1.32				
126	65	K.Raji Reddy	Nadukude	Sandy clay loam	0.96	119.02	1.46				
127	61	Pansha Goud	Nadukude	Sandy clay loam	1.08	153.66	2.03				
128	62	R.Linganna	Nadukude	Sandy clay loam	1.02	106.62	1.64				
129	166	A.Lingaiah	Narayanpur	Sandy clay loam	0.33	101.23	2.41	24	212	18	306
130	170	A.Chinna Rajaiah	Narayanpur	Sandy clay loam	1.40	159.94	2.59	15	152	31	298
131	198	G.Rajalingam	Parepally	Sandy clay loam	0.55	156.11	1.66	18	138	52	432
132	159	K.Ramulu	Peddabankur	Sandy clay loam	0.96	191.30	1.85	16	120	22	288
133	160	Sriram Ramayya	Peddabankur	Sandy clay loam	0.99	94.08	2.12	12	172	26	296
134	158	S.Ramayya	Peddabankur	Sandy clay loam	0.81	147.39	1.35	12	231	19	268
135	156	C.Nambaiah	Peddabankur	Sandy clay loam	1.04	109.76	1.80	20	148	29	415
136	151	K.Subba Reddy	Peddapally	Sandy clay loam	1.14	137.98	1.79				
137	153	C.P.Narasaiah	Peddapally	Sandy clay loam	1.13	313.60	1.84				
138	154	M.V.Ramana Reddy	Peddapally	Sandy clay loam	0.87	116.03	2.01				
139	152	Rami Reddy	Peddapally	Sandy clay loam	0.93	736.96	1.98				
140	155	M.Mallesham	Peddapally	Sandy clay loam	1.20	87.81	1.52				
141	16	K.Rajaiah	Pegadapally	Sandy clay loam	1.44	109.76	2.01	50.4	218	13	106
142	77	M.Venkati	Polasa	Sandy clay loam	1.04	109.76	2.10	18	176	12	342
143	78	N.Rajanna	Polasa	Sandy clay loam	0.93	116.03	1.40	20	126	12	290
144	76	D.Narasaiah	Polasa	Sandy clay loam	0.69	206.98	1.45	25	182	14	200
145	79	K.Bheemaiah	Polasa	Sandy clay loam	0.68	388.86	1.52	19	168	48	302
146	80	S.Mondaiah	Polasa	Sandy clay loam	0.72	261.10	1.33	20	180	19	294
147	229	P.Devender Reddy	Pothareddypet	Sandy clay loam	1.48	209.08	1.48	21	192	12	112
148	230	P.Ravindra Reddy	Pothareddypet	Sandy clay loam	0.40	232.06	1.78	23	196	25	204
149	226	G.Malla Reddy	Pothareddypet	Sandy clay loam	0.62	161.11	1.91	20	152	26	192
150	228	G.Niranjan Reddy	Pothareddypet	Sandy clay loam	1.29	231.16	1.62	26	190	10	118
151	211	I.Mandaiah	Puttapaka	Sandy clay loam	1.02	97.22	2.62				
152	212	Ganga Raju	Puttapaka	Sandy clay loam	0.27	141.12	1.79				
153	215	Md.Chandbee	Puttapaka	Sandy clay loam	0.42	263.42	0.58				
154	99	P.Linga Reddy	Raikal	Sandy clay loam	1.32	285.38	2.30				
155	97	N.Bhoomi Reddy	Raikal	Sandy clay loam	1.21	108.00	2.02				
156	100	B.Gangaram	Raikal	Sandy clay loam	1.08	249.18	1.47				
157	98	Abdul Nabiz	Raikal	Sandy clay loam	1.04	84.67	2.70				
158	28	G.Purushotham	Rapalle	Sandy clay loam	0.63	109.76	2.64	26	169	28	265
159	29	M.Thirupathi Goud	Rapalle	Sandy clay loam	1.77	94.08	2.19	18	182	28	278
160	26	K.Suguna Rao	Rapalle	Sandy clay loam	1.10	163.07	1.40				
161	27	G.Srinivasa Rao	Rapalle	Sandy clay loam	1.49	203.84	1.56	26	169	28	265
162	111	S.Ganga Reddy	Sangam	Sandy clay loam	1.02	166.21	2.52	20	211	26	287
163	114	Y.Kishan Rao	Sangam	Sandy clay loam	1.02	128.58	1.78	23	196	32	356
164	115	B.Balaiah	Sangam	Sandy clay loam	0.77	125.44	1.87	19	159	29	402
165	189	B.Rayamallu	Sayampet	Sandy clay loam	0.92	101.22	1.69	45	205	45	268
166	24	G.Rajaram	Thirumalapur	Sandy clay loam	0.78	128.46	1.90				
167	23	K.P.Rajaiah	Thirumalapur	Sandy clay loam	0.65	141.12	2.03	52	124	26	246
168	142	K.Lingam	Thirumalapur	Sandy clay loam	0.98	102.11	1.26				
169	141	G.gangaram	Thirumalapur	Sandy clay loam	1.37	97.22	1.70				
170	145	K.Bheemaiah	Thirumalapur	Sandy clay loam	1.20	196.21	2.16				
171	143	M.Ashalu	Thirumalapur	Sandy clay loam	1.12	146.02	1.45				
172	144	D.Gangaram	Thirumalapur	Sandy clay loam	1.21	151.00	3.02				
173	48	Nanda Kumar	Vellulla	Sandy clay loam	1.14	94.08	0.89	34	62	8	180

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174	47	D.Venkata Ramana	Vellulla	Sandy clay loam	0.92	141.12	1.68	28	128	12	198
175	46	D.Ramachandran	Vellulla	Sandy clay loam	0.99	120.15	2.50	29	108	9	268
176	45	A.Muthyam Reddy	Vempet	Sandy clay loam	0.94	154.19	1.34	40	171	11	302
177	43	K.Raji Reddy	Vempet	Sandy clay loam	1.05	119.17	0.91	28	286	36	294
178	41	K.Shankar Reddy	Vempet	Sandy clay loam	1.07	100.35	1.89	21	116	29	378
179	42	A.Linga Reddy	Vempet	Sandy clay loam	1.24	109.76	1.50	30	88	28	346
180	171	K.Venkataiah	Wadkapur	Sandy clay loam	1.30	94.08	1.56	20	198	24	306
		No.of farmers			123	123	123	70	70	70	70
		Mean			0.99	159.02	1.81	26.23	166.57	26.81	259.53
		S.D.			0.28	84.39	0.50	10.72	40.29	12.55	82.33
		C.V. (%)			153.13	80.59	41.97	0.00	0.00	0.00	0.00
181	108	T.Ram Gangaram	Alipoor	Sandy loam	1.44	238.34	1.76				
182	14	G. Madhava Reddy	Aravally	Sandy loam	0.86	247.74	1.75	48	182	14	126
183	15	M.Mallaiah	Aravally	Sandy loam	1.25	147.39	1.82	52	178	13	121
184	82	S.Narayana	Beerpur	Sandy loam	0.78	191.19	1.98	26	188	55	246
185	83	B.Narayana Rao	Beerpur	Sandy loam	0.69	186.22	1.30	25	162	60	252
186	75	P.Papaiah	Chelgal	Sandy loam	1.12	360.78	1.72	35	198	14	270
187	163	M.Chandraiah	Chinnakoluvala	Sandy loam	0.68	112.90	2.80	28	170	21	374
188	1	G.Shankar	Dharmapuri	Sandy loam	0.86	75.26	1.70	18	142	44	329
189	2	R.Rajaiah	Dharmapuri	Sandy loam	0.46	87.81	1.17	15	116	42	296
190	4	K.Narasaiah	Dharmapuri	Sandy loam	0.96	90.94	1.45	18	261	31	288
191	3	R.Rajalingaiah	Dharmapuri	Sandy loam	0.92	85.62	1.10	20	174	39	509
192	10	M.Gangaram	Donnur	Sandy loam	1.23	141.12	1.40				
193	8	P.Mallaiah	Donnur	Sandy loam	1.14	153.66	1.21				
194	9	M.Rameshwar	Donnur	Sandy loam	1.17	141.12	1.36				
195	33	K.Sambi Reddy	Gollapalli	Sandy loam	0.55	97.22	1.57	20	189	25	208
196	150	V.Narsa Reddy	Gudur	Sandy loam	0.77	177.26	2.02				
197	223	M.Ailayya	Huzurabad	Sandy loam	0.58	62.72	1.58				
198	222	N.Raghotham Reddy	Huzurabad	Sandy loam	0.65	213.25	2.38	20	216	18	190
199	95	Badayam Reddy	Itkyal	Sandy loam	1.08	112.11	2.41				
200	234	M.Kanakaiah	Jammikunta	Sandy loam	1.17	297.92	2.68	20	219	18	312
201	233	A.Yadi Reddy	Jammikunta	Sandy loam	0.89	269.70	3.20	20	178	46	268
202	132	K.Gangaram	Komati Kondapur	Sandy loam	0.56	99.02	1.02				
203	131	P.Ankulam	Komati Kondapur	Sandy loam	0.68	89.11	1.10				
204	66	Akula Sayeb	Mogilipet	Sandy loam	1.01	122.30	1.09				
205	122	P.Venkata Narasaiah	Mohanraopet	Sandy loam	1.21	206.16	1.09	20	116	52	193
206	55	E.Raghava Reddy	Muthyampet	Sandy loam	1.05	163.07	1.88				
207	63	A.Dharmaji	Nadukude	Sandy loam	0.68	110.96	1.29				
208	169	V.Mallaiah	Narayanpur	Sandy loam	1.13	178.75	1.99	15	144	27	312
209	168	A.Chinna Lingaiah	Narayanpur	Sandy loam	1.12	108.11	2.31	14	124	29	439
210	157	K.Veeresham	Peddabankur	Sandy loam	0.87	68.99	3.04	18	270	26	281
211	20	G.Pramila	Pegadapally	Sandy loam	1.22	106.62	1.21	48	147	11	198
212	56	G.Devanna	Raghavapet	Sandy loam	1.47	188.16	2.24	26	168	21	168
213	60	C.Balaiah	Raghavapet	Sandy loam	0.89	140.02	1.56				
214	57	P.Devanna	Raghavapet	Sandy loam	0.98	162.04	1.89				
215	21	J.Ramaswamy	Thirumalapur	Sandy loam	0.89	188.16	1.36	52.8	178	12	182
216	44	K.Raji Reddy	Vempet	Sandy loam	1.19	112.04	0.87	42	92	29	341
		No.of farmers			36	36	36	22	22	22	22
		Mean			0.95	153.72	1.73	27.31	173.27	29.41	268.32
		S.D.			0.25	67.35	0.58	12.54	42.89	14.57	93.65
		C.V. (%)			26.56	43.81	33.79	45.93	24.75	49.53	34.90

217	221	C.Rajaiah	Husurabad	Silt clay loam	1.48	142.06	2.50	16	168	16	546
218	208	B.Venkata Reddy	Nagaram	Silt clay loam	0.55	153.66	1.87				
219	227	C.Papi Reddy	Pothareddypet	Silt clay loam	0.70	200.05	1.76	20	189	20	202
220	161	K.Thirupathi Rao	Chinnakoluvala	Silt clay loam	0.92	175.62	2.03	24	138	19	542
		No.of farmers			4	4	4	3	3	3	3
		Mean			0.91	167.85	2.04	20.00	165.00	18.33	430.00
		S.D.			0.35	22.16	0.28	3.27	20.93	1.70	161.23
		C.V. (%)			38.69	13.20	13.84	16.33	12.68	9.27	37.50
221	220	P.Rajaiah	Dandepally	Silt loam	0.50	121.19	1.62	24	170	20	118
222	205	P.Chandraiah	Gundaram	Silt loam	0.87	134.85	1.21				
223	225	N.Linga Reddy	Huzurabad	Silt loam	0.42	78.40	2.03	24	160	12	172
224	139	P.C.Rajanna	Ibrahimpatnam	Silt loam	1.68	116.09	0.81				
225	235	Ranga Laxmaiah	Jammikunta	Silt loam	0.91	254.02	2.15	16	190	34	326
226	182	D.Narendra	Lokapet	Silt loam	0.96	78.40	2.11				
227	69	Y.S.B.Linganna	Mogilipet	Silt loam	1.29	265.16	1.02				
228	112	N.Muthaiah	Sangam	Silt loam	1.14	181.89	2.03	20	126	21	256
229	186	B.Rami Reddy	Sayampet	Silt loam	1.20	108.26	0.96	18	243	48	198
230	173	I.Mallaiah	Wadkapur	Silt loam	1.08	269.70	1.73	16	231	18	329
		No.of Obsevations			10	10	10	6	6	6	6
		Mean			1.00	160.80	1.57	19.67	186.67	25.50	233.17
		S.D.			0.35	72.43	0.50	3.35	40.45	12.02	78.06
		C.V.(%)			34.83	45.05	31.66	17.03	21.67	47.15	33.48

Appendix - 6

Replication wise data of yield, soil test values and plant uptake at Jagtial during kharif 1996

TN	FP	FK	GY	OC(PI)	KM(PI)	CA(PI)	OL(PI)	AM(PI)	OC(PH)	KM(PH)	CA(PH)	OL(PH)	AM(PH)	Total N	UN	UP	UK
Replication-I																	
0	0	0	1053	0.07	104	81	16	280	0.09	163	130	21	172	1026	27	3.7	17
0	60	50	1364	0.17	103	83	35	315	0.22	147	118	50	193	858	58	4.1	28
60	60	50	1832	0.19	231	168	13	282	0.26	332	266	18	176	1419	45	6.6	35
120	60	50	2599	0.14	110	88	12	298	0.19	157	125	17	181	975	61	9.1	59
180	60	50	3424	0.12	99	76	9	270	0.18	147	113	13	164	944	127	18.4	60
120	0	50	2040	0.18	274	214	12	305	0.26	436	348	17	185	1384	80	9.1	38
120	30	50	2468	0.12	94	76	10	281	0.16	135	108	27	176	876	91	9.1	53
120	30	50	3130	0.33	79	63	38	281	0.45	113	90	48	134	788	103	6.9	52
120	60	0	2865	0.12	95	77	21	222	0.16	130	110	23	147	806	105	7.4	49
120	60	25	2887	0.24	101	81	20	230	0.32	144	115	30	202	946	76	8.7	55
120	60	75	1010	0.41	110	87	18	333	0.54	157	125	19	180	1020	57	7.0	43
180	90	75	3417	0.19	271	190	25	312	0.26	387	308	27	193	2104	126	13.3	85
80	60	0	2589	0.08	81	65	11	256	0.11	116	93	13	155	760	65	6.6	43
120	60	30	1754	0.34	98	72	14	284	0.45	129	103	17	172	840	78	6.2	53
Replication-II																	
0	0	0	1345	0.07	94	76	14	284	0.10	135	108	20	172	928	32	3.7	22
0	60	50	2560	0.22	120	89	30	324	0.29	160	128	48	186	1006	78	7.4	50
60	60	50	1988	0.31	112	91	15	278	0.42	160	130	16	169	1049	50	6.1	38
120	60	50	2469	0.14	90	72	11	299	0.18	129	103	15	181	882	53	7.4	52
180	60	50	1741	0.30	94	76	11	288	0.42	135	108	16	175	896	82	7.5	48
120	0	50	2417	0.36	97	77	13	280	0.48	130	110	18	170	1008	88	7.5	42
120	30	50	2079	0.06	68	53	16	281	0.08	94	75	25	184	624	73	7.8	40
120	30	50	3002	0.17	75	62	31	304	0.22	110	88	42	138	786	98	6.7	38
120	60	0	2807	0.10	90	72	16	228	0.13	129	103	17	136	848	98	8.2	43
120	60	25	2338	0.54	77	62	26	225	0.73	110	88	26	211	706	65	10.2	57
120	60	75	1702	0.43	92	74	15	348	0.57	132	105	16	198	1011	47	6.9	39
180	90	75	2716	0.26	83	67	20	314	0.35	119	95	21	186	986	131	10.8	60
80	60	0	2365	0.21	77	61	12	264	0.29	110	88	15	169	785	58	6.9	46
120	60	30	1183	0.24	86	68	15	284	0.32	122	98	15	172	868	42	4.0	24
Replication-III																	
0	0	0	1059	0.06	81	65	16	279	0.10	116	93	21	170	870	24	4.0	20
0	60	50	949	0.19	70	55	24	310	0.26	100	80	46	189	962	28	3.7	17
60	60	50	2216	0.25	184	127	16	282	0.33	246	197	20	172	1205	51	6.9	34
120	60	50	2287	0.15	100	88	13	296	0.20	143	114	19	179	827	50	8.5	58
180	60	50	3691	0.21	97	76	11	271	0.28	130	110	15	166	905	119	12.3	58
120	0	50	1774	0.28	185	161	13	307	0.37	287	228	18	186	1124	73	7.8	43
120	30	50	2586	0.08	80	64	17	302	0.11	114	92	28	171	870	67	11.1	54
120	30	50	1062	0.25	78	60	41	282	0.33	111	89	41	142	805	70	9.4	45
120	60	0	1806	0.11	91	75	18	244	0.14	133	107	19	142	896	63	10.7	43
120	60	25	2157	0.30	88	71	24	234	0.53	127	102	24	206	846	52	13.3	54
120	60	75	2378	0.42	101	81	17	339	0.56	144	115	18	192	1128	57	9.5	43
180	90	75	2651	0.23	177	131	26	317	0.30	253	202	28	201	1487	107	11.0	62
80	60	0	3000	0.15	79	63	10	261	0.20	113	90	13	150	684	76	8.3	43
120	60	30	2339	0.29	88	70	10	282	0.38	125	100	16	171	865	78	7.5	47
Mean			2260	0.22	108	86	19	285	0.29	158	126	23	174	973	71	8.0	45
S.D.			653	0.11	48	36	6	30	0.15	74	59	10	18	253	26	2.4	12
C.V.(%)			28.9	52.3	44.8	42.0	41.9	10.5	52.4	47.1	47.1	43.1	10.0	26.0	36.6	30.6	27.1

PI : Panicle initiation stage
PH : Post-harvest stage
GY : Grain yield (kg/ha)
OC : Organic carbon (%)
KM : Alkaline permanganate N (kg/ha)
CA : Calcium hydroxide K (kg/ha)
OL : Olsen's P (kg/ha)
AM : Ammonium acetate K (kg/ha)
UN : Uptake N (kg/ha)
UP : Uptake P (kg/ha)
UK : Uptake K (kg/ha)

Appendix - 7

Warangal : Rice : Kharif 1996

Relication wise data of yield, soil test values and plant uptake at Warangal during Kharif 1996

FN	FP	FK	GY	OC(PI)	KM(PI)	CA(PI)	OL(PI)	AM(PI)	OC(PH)	KM(PH)	CA(PH)	OL(PH)	AM(PH)	Total N	UN	UP	UK
Replication-I																	
0	0	0	2330	0.22	115	94	33.2	455	0.30	167	134	34.9	505	1090	37	4.5	34
0	60	50	2569	0.54	112	90	36.2	447	0.75	160	128	38.0	496	1041	50	5.4	36
60	60	50	3913	0.50	132	105	23.6	545	0.66	188	150	29.7	606	1225	43	7.0	43
120	60	50	3226	0.77	140	110	28.8	541	1.02	201	160	36.2	601	1310	74	5.9	48
180	60	50	3106	0.54	143	113	31.4	504	0.72	204	163	22.3	560	1326	59	6.4	40
120	0	50	3584	0.79	184	145	28.8	538	1.05	263	211	32.8	598	1708	100	7.6	60
120	30	50	3405	0.56	105	84	26.6	542	0.75	150	120	26.6	608	982	61	5.7	37
120	30	50	2927	0.41	217	175	26.2	538	0.54	351	281	30.6	598	2102	52	5.6	43
120	60	0	4062	0.61	138	112	28.8	538	0.81	201	160	29.7	598	1300	73	9.5	56
120	60	25	4002	0.68	129	107	23.6	544	0.90	182	149	36.2	605	1182	82	7.6	39
120	60	75	3405	0.63	136	105	27.1	514	0.84	194	155	36.7	571	1206	38	6.5	37
180	90	75	3256	0.61	196	160	34.9	509	0.81	282	226	35.8	565	1826	34	5.5	38
80	60	0	3554	0.56	120	106	21.8	520	0.75	185	148	24.9	588	1203	58	5.0	34
120	60	30	4719	0.09	116	93	29.7	473	0.12	166	133	37.1	525	1080	146	8.5	41
Replication-II																	
0	0	0	2479	0.16	119	95	34.9	473	0.21	170	136	36.7	525	1105	27	3.8	30
0	60	50	2210	0.59	78	91	34.1	524	0.78	163	130	35.8	582	1060	32	4.6	30
60	60	50	3256	0.52	134	107	19.7	565	0.69	191	153	24.5	628	1243	47	5.0	33
120	60	50	3525	0.27	144	115	27.5	540	0.36	206	165	34.5	599	1340	51	6.0	38
180	60	50	2927	0.27	147	119	33.2	486	0.36	210	170	19.2	559	1366	65	8.2	49
120	0	50	3823	0.23	176	141	27.1	525	0.30	251	201	31.0	586	1625	94	9.6	55
120	30	50	3644	0.43	99	81	23.1	555	0.57	141	115	23.1	616	941	80	6.5	46
120	30	50	3883	0.31	139	108	27.1	545	0.42	199	160	33.2	605	1594	53	6.3	35
120	60	0	3764	0.45	146	117	21.8	540	0.60	208	165	21.8	599	1340	96	10.0	49
120	60	25	3584	0.40	136	109	17.9	555	0.54	192	154	21.0	617	1249	75	8.6	36
120	60	75	3525	0.63	140	111	20.5	540	0.84	200	160	35.4	599	1291	121	8.1	41
180	90	75	3465	0.54	156	124	34.1	524	0.72	220	176	33.2	582	1435	54	5.9	41
80	60	0	3525	0.67	106	109	20.1	512	0.90	191	153	23.6	588	1242	52	5.6	32
120	60	30	3441	0.34	119	95	25.8	488	0.45	170	136	34.5	548	1106	126	7.2	30
Replication-III																	
0	0	0	2330	0.20	115	92	35.8	468	0.26	165	132	35.8	520	1066	38	4.0	29
0	60	50	2360	0.58	111	89	35.4	448	0.77	158	127	37.1	498	1029	46	4.9	35
60	60	50	3525	0.51	132	104	21.8	532	0.68	189	151	27.1	591	1230	51	5.4	40
120	60	50	3405	0.52	153	124	28.4	516	0.69	219	175	35.4	599	1425	66	6.5	49
180	60	50	2718	0.40	137	111	34.9	510	0.54	196	159	21.0	566	1276	52	5.7	39
120	0	50	2927	0.51	151	123	30.6	470	0.68	216	173	31.9	541	1392	57	6.6	42
120	30	50	3078	0.75	131	107	23.6	530	1.00	191	153	24.9	589	1219	66	5.5	39
120	30	50	3047	0.35	176	135	30.1	549	0.48	251	201	31.9	610	1632	47	5.1	34
120	60	0	3106	0.53	152	126	25.3	544	0.71	222	177	25.8	605	1442	55	8.4	41
120	60	25	3704	0.54	134	108	24.5	530	0.72	196	157	24.5	598	1275	45	7.8	38
120	60	75	3256	0.63	138	116	24.0	523	0.84	199	159	36.2	581	1226	48	7.8	36
180	90	75	3226	0.58	182	157	36.2	532	0.77	301	241	34.5	591	1956	53	7.4	37
80	60	0	3106	0.62	127	107	18.3	480	0.83	188	150	24.5	581	1223	71	5.3	29
120	60	30	3584	0.22	120	94	27.1	487	0.29	169	135	35.8	541	1098	69	8.2	31
Mean			3297	0.48	138	112	27.7	517	0.64	202	161	30.6	578	1310	63	6.5	39
S.D.			519	0.17	27	20	5.3	31	0.23	40	32	5.7	34	251	25	1.5	7
C.V.(%)			15.7	35.4	19.3	17.9	19.1	6.0	35.3	20.1	20.0	18.5	5.8	19.2	40.1	23.4	18.5

PI : Panicle initiation stage
PH : Post-harvest stage
GY : Grain yield (kg/ha)

OC : Organic carbon (%)
KM : Alkaline permanganate N (kg/ha)
CA : Calcium hydroxide N (kg/ha)

OL : Olsen's P (kg/ha)
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