STUDIES ON NITROGEN MANAGEMENT PRACTICES FOR RICE GENOTYPES AND THEIR RESIDUAL EFFECT ON FODDER LEGUME

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Affectionately

Dedicated to

My Parents

Sri L. Narapu Reddy

and

Smt. L. Parvathamma

DEPARTMENT OF AGRONOMY
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CERTIFICATE

This is to certify that the thesis entitled "STUDIES ON NITROGEN MANAGEMENT PRACTICES FOR RICE GENOTYPES AND THEIR RESIDUAL EFFECT ON FODDER LEGUME" submitted by Mr. L. RAGHUNADHA REDDY for the degree of MASTER OF SCIENCE (AGRICULTURE) in AGRONOMY of the University of Agricultural Sciences, Bangalore, is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

Bangalore

November ,1986

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

I. INTRODUCTION

Rice is the major cereal crop of India, occupying a little over 30 per cent of the total area under food grains and contributing about 44 per cent to the total food grain production. At present 37.07 per cent of the cultivated area under rice is irrigated. In Karnataka the area occupied by rice is 11.42 per cent of the cultivated area and the per cent irrigated area under rice is 60.12. Rice is mostly grown under canal and tank irrigation systems.

The production potential of rice under low land condition mainly depending upon the increase use of fertilizers. Among the major plant nutrients, nitrogen continues to be the most important for augmenting rice yield. The potential for nitrogen use for a major crop like rice towards stabilizing the mean grain yields in the country at 2.4 t/ha is estimated to be around 65 kg/ha (Stangal, 1977), as against the current level of nitrogen consumption which is less than 25 kg/ha.

Fertilizer nitrogen management in flooded soils is of greater significance because applied nitrogen subjected to maximum losses to the extent of 60-70 per cent (Khind and Datta, 1975; Stangal, 1977; De Datta, 1978; and Pillai, 1978). It is, therefore, not surprising that flooded rice has shown consistently lower recovery of added nitrogen as compared to other crops (Patrick and Mahapatra, 1968; De Datta *et al*., 1968; Rajendra Prasad *et al*., 1970; Broadbent and Tusneem, 1971; Pande and Adik, 1971 and Reddy and Patrick Jr. 1975). Improving the physical condition of urea either by coating urea with the materials which can inhibit nitrification (Simsiman *et al*., 1967; Rajendra Prasad *et al*., 1971; Rajale and Prasad,1970; Reddy and Freeman, 1973; Subbaiah *et al*., 1979; Pillai and Krishnamurthy, 1983 and Rambabu, 1980), or increasing the size of urea granules for deep placement in the reduced zone to slow down the dissolution rate (Simsiman *et al*., 1967; Mac Rae and Ancajas, 1970; Reddy and Freeman, 1973; Nommik, 1976; Craswell, 1978; Pillai and Vamadevan, 1978; Vlex and Craswell, 1979; Rambabu, 1980) may help the plants to use before applied nitrogen is subjected to various losses.

Hence, there is a need to assess the relative efficiency of various modified urea materials and their method and time of application in rice genotypes of early and long duration. It is also felt that the information on residual effect of these modified urea materials on succeeding crops grown in quick succession after *kharif* rice with residual moisture is very much relevant and will go a long way in increasing the total output per unit area and time through increased nitrogen use efficiency and residual soil moisture.

With this in view an investigation was initiated at Wet land block of Main Research Station, University of Agricultural Sciences, Bangalore, with the following objectives:

1. To study the response of rice genotypes of early and long duration to different sources, time and method of nitrogen application;
2. To evaluate the relative efficiency of modified urea materials in influencing the growth, grain yield as well as nitrogen use efficiency of rice genotypes of early and long duration;
3. To assess the residual effect, if any, of different sources, time and method of nitrogen application in *kharif* rice on the growth of a succeeding fodder legume.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

2.1. Performance of rice genotypes

Panda and Leeewrik (1972) working on rice genotypes reported that Jaya gave higher grain yield (6350 kg/ha) compared to IR-8 (5710 kg/ha) and TN-1 (5160 kg/ha) and the lowest grain yield was obtained with Bala (4030 kg/ha). Further, they reported that TN-1 recorded higher number of panicles and panicle weight per square meter, while IR-8 gave higher number of fertile spikelets. Whereas Jaya had the higher test weight. Veeraraja Urs and Mahadevappa (1972) noticed difference in grain yield among rice genotypes. Highest grain yield was obtained with IR-8 (4932 kg/ha), followed by Jaya (4505 kg/ha) and IR-5 (3490 kg/ha). The lowest yield with IR-5 may be due to higher number of immature panicles, spikelets, shorter panicle length, low test weight and sterility per cent was also more.

Panchaksharaiah et al. (1972) working at Mandya reported that Jaya performed better (4998 kg/ha) as compared to Padma (4543 kg/ha) and S-705 (2709 kg/ha). In another trial at Mandya, Gopala Reddy et al. (1978) reported that IET-2254 gave higher grain yield (8087 kg/ha) compared to MR-301 (7276 kg/ha), Vani (6421 kg/ha),MR-272, i.e., Mangala (6002 kg/ha), Sona (5952 kg/ha), MR-81 (5420 kg/ha), Intan (5156 kg/ha) and S-317 (4872 kg/ha).

2.2. Importance of nitrogen to rice

Nitrogen is of paramount importance for promoting growth and yield of rice. It exerts the most significant influence, in a wide range of situations. Response of rice to nitrogen can be attributed to the response of individual growth and yield characters.

Singh and Modgal (1978) noticed a steady increase in dry weight of rice plants as the amount of nitrogen increased. Muthuswamy et al. (1973) working on rice reported that increased fertilizer application caused a significant increase in dry matter production only upto 120 kg nitrogen/ha beyond which the increase was not significant. Total dry matter production increased with addition of nitrogen fertilizer to both tall and dwarf genotypes (Sahu and Murthy, 1975; Srivastava and Mahajan, 1977 and Syamasundara Murthy and Satyanarayana Murthy, 1978). Prathap Reddy (1982) obtained increased dry matter production with every successive increment in the level of nitrogen from 0 to 120 kg/ha.

Increase in plant height with application of nitrogen was reported by several research workers (AICRIP, 1971; Singh, 1971; Lenka et al., 1976; Sharma and Rajat De, 1976; Srivastava and Mahajan, 1977). Raju (1979) studying on the response of dwarf indica rice to varying levels of nitrogen obtained a significant increase in plant height due to application of nitrogen fertilizers. Vijayakumar (1979) recorded 6.9 per cent increase in plant height in Tellahamsa when nitrogen application increased from 50 to 100 kg/ha.

Increase in panicles owing to increase in nitrogen levels has been reported by several workers (Sanchez, 1972; Veeraraja Urs and Mahadevappa, 1972; Lenka et al., 1976; Shivananjegowda et al., 1976; and Vinaya Rai and Murthy, 1979). Devandrappa (1982) and Thimmegowda (1985) also obtained increase in panicle number due to nitrogen application.

Lenka et al. (1976) observed significant and progressive increase in panicle length as the nitrogen level increased from 60 to 180 kg nitrogen/ha. Vijayakumar (1979) recorded increase in panicle length from 18.8 cm to 22.2 cm with 100 kg nitrogen application when compared to 50 kg nitrogen/ha. Similar increase in panicle length as the nitrogen level increased was observed by Devendrappa (1982) and Thimmegowda (1985).

Pande and Mittra (1970) and Venkatesan and Thiagarajan (1974) recorded increase in grain number/panicle due to nitrogen application. According to Lenka et al. (1976)

grain number/panicle increased from 69 in control to 75 in 60 kg nitrogen/ha. Further increase in nitrogen resulted in significant reduction in grain number per panicle. Vijayakumar (1979) obtained significant increase in grain number/panicle due to nitrogen application. At 40 kg nitrogen/ha, the number of grains/panicle were 81 and these increased to 95 at 100 kg nitrogen/ha. However, Vinaya Rai and Murthy (1979) did not observe any significant increase in this attribute when nitrogen level increased from 40 to 80 kg/ha.

Shivananjegowda _et al_. (1976) reported that increase in nitrogen level from 0 to 125 kg nitrogen/ha increased test weight by eight per cent. Singh and Modgal (1978) observed that application of 200 kg nitrogen/ha resulted in higher test weight than zero level of nitrogen. Raju (1979) and Prathap Reddy (1982) obtained significant increase in test weight due to nitrogen application. Thimmegowda (1985) working on Vani genotype reported that there was increase in test weight when nitrogen level was increased from 40 to 80 kg nitrogen/ha.

Increase in grain and straw yield due to nitrogen application was reported by several workers (AICRP, 1971; Munegowda and Lanikar, 1977; Pillai and Rajat De, 1979; and

Kupkanchanakul and Vergara, 1980). Prathap Reddy (1982) recorded significant increase in grain and straw yield of rice with increase in nitrogen level from 0 to 112 kg/ha. Pham-Sy-Tan (1982) also obtained progressive and significant increase in grain and straw yields when nitrogen level was increased from 0 to 112 kg nitrogen/ha. Similar observation was made by Devendrappa (1982) and Thimmegowda (1985).

Higher dry matter production normally indicates their potentiality to yield higher economic product provided there is proper partitioning in the dry matter distribution (Arnon, 1975).

Murthy _et al_. (1975) working on rice reported that harvest index differed considerably between varieties even in the same duration group and it was reduced significantly under high nitrogen rate. The early cultivars showed high harvest index than mid season types and the semi-dwarfs exhibited greater harvest index than the traditional tall types. The depression in harvest index due to longer crop duration (Vergara _et al_., 1964) is probably on effect of heavy vegetative growth or light relationships with a canopy which adversely affect grain development (Donald and Hamblin, 1976).

Significant correlation between soil fertility and harvest index was reported by Venkateswarlu et al. (1975). They observed positive correlation between harvest index and grain yield of short and medium duration varieties. According to Vinaya Rai and Murthy (1979) excess application of nitrogen may prove deterimental to grain yield due to reduced harvest index. When nitrogen level increased from 40 to 80 kg nitrogen/ha, the harvest index fell from 43.3 to 41.2 per cent and the difference was significant. Kupkanchanakul and Vergara (1980) stated that there was no increase in harvest index when nitrogen level was increased from 0 to 180 kg nitrogen/ha.

2.3. Rice genotypes and response to nitrogen

Among the various factors affecting nitrogen response in rice, varietal characters is of particular significance.

Tall indica rice produced generally equal or more total dry matter than dwarf indica, but produced more straw than grain (Mahapatra and Panda, 1972). Brady et al. (1974) stated that high yielding dwarf tropical varieties not only yield more when fertilizer was applied but also the difference widened as the fertilizers rate increased. Mahapatra and Bapat (1971) opined that high yielding varieties of rice respond better than local varieties to nitrogen application. According to them at 120 kg nitrogen/ha cultivar Jaya gave a grain yield response of 14 kg/kg of nitrogen compared to 7 kg/kg of nitrogen in case of a local variety.

Sumbali and Gupta (1972) recorded highest grain yield of Jaya variety at 155 kg nitrogen/ha and the economic optimum level was 125.5 kg nitrogen/ha. In a varietal and nitrogen study Yogeshwara Rao <u>et al</u>. (1974) obtained significantly higher yield (5240 kg/ha) with Jaya. This variety was superior to Tellahamsa. According to Harihara Reddy (1977), Jaya responded better than Tellahamsa even at lower level of nitrogen. Mangal Prasad and Rajendra Prasad (1980) revealed increased yield with medium duration (135 days) genotype than a short duration (105 days) genotype. Prathap Reddy (1982) studied the nitrogen use efficiency in Tellahamsa, Jaya and Mahsuri genotypes. The yield level in all these genotypes was comparable, but optimum nitrogen with split application of nitrogen as urea was 127, 144 and 80 kg nitrogen/ha for Tellahamsa, Jaya and Mahsuri, respectively.

2.4. Nitrogen loss in rice crop

Rice, cultivated in 23.63 per cent of the total cropped area in our country consumes nearly 40 per cent of the fertilizer nitrogen (Tandon <u>et al</u>., 1981). Urea form is the main source of nitrogen for rice and its efficiency is low due to (1) ammonia volatilization, (2) nitrification-denitrification, (3) leaching, (4) Run-off (De Datta et al., 1974; Craswell and Vlex, 1978).

2.4.1 Loss of nitrogen due to ammonia volatilization

Ammonia, a nitrogen transformation product found continuously in wet land soils and also following application of ammonium containing or farming nitrogen fertiliser, is subjected to volatilization loss in considerable quantities.

Gupta a (1955) recorded 21 per cent loss in applied nitrogen due to volatilization in alkaline soils. Experiments conducted by Ventura and Yoshida (1977) revealed that under field conditions 8.2 per cent nitrogen loss occurred through ammonia volatilization during the first 21 days after application in Maahas clay soil. According to Mikkelsen and De Datta (1978), ammonia volatilization losses may vary from 0.25 to 20 per cent depending on nitrogen application methods, the least loss being reported from 10-12 cm deep placement. Reduced conditions of flooded soil favours continuous production of ammonia and the quantity in excess of the absorbing capacity of the flood water is lost through volatilization which may range from 9.7 to 22.7 per cent under field conditions (Mahapatra, 1981).

Sahrawat (1980) reviewing nitrogen loss in rice soils listed pH, CEC, exchangeable cations, texture, temperature, water content, source of ammonia, rate and methods of application as important factors that influence ammonia volatilization from soils.

2.4.2 Loss of nitrogen due to denitrification

Flooded soils develop a thin layer of oxidised soil immediately below the water underlying which is the reduced zone. These two are responsible for nitrification-denitrification losses from ammonium or ammonium forming fertilizers when applied to flooded rice soils.

According to Focht (1979), Shioiri was the first to conclude that losses of nitrogen occur in flooded soils through nitrification-denitrification. Abichandani and Patnaik (1959) observed that denitrification loss ranged from 20-40 per cent of applied nitrogen. Studies made in Japan indicated nearly one third of the applied nitrogen was lost due to denitrification alone (Yamada et al.,1979). In a field study with labelled nitrogen at All India Co-ordinated Rice Improvement Project (AICRP), Hyderabad, nearly 14.4 per cent of nitrogen was lost due to denitrification (Mahapatra, 1981).

Several factors seem to influence nitrification-denitrification losses. Patrik and Wyatt (1964) stated that soil water regimes critically influences denitrification losses by promoting nitrification during the drained or aerobic phase and subsequent denitrification during water logged phase. Reddy and Patrick (1978) recorded denitrification losses to a maximum of 63 per cent of added ammonium nitrogen in an intermittently flooded soil. Nommik (1970) reported that pH influences nitrification-denitrification and optimum pH for denitrification was in the range of pH 7 to 8. Craswell and Vlex (1979) stated that while nitrification is very sensitive to a number of ecological and environmental factors, denitrification is regulated by temperature and the amount of organic substate available to the heterotrophic bacterial population. Meelu (1980) opined that nitrogen loss due to denitrification could be 24.1 to 53.7 per cent depending on the soil type, source of fertilizers, method and time of fertilizer application.

2.4.3 Loss of nitrogen due to leaching

In flooded soils, movement of fertilizer nitrogen along with percolation water poses a major threat especially in light textured soils.

Work of De and Digar (1955) revealed 10.4 and 15.4 per cent loss of nitrogen from surface applied ammonium sulphate from a sandy loam and a stiff clay soil respectively. Pande and Adik (1971) reported 45 to 60 per cent nitrogen loss due to leaching when fertilizer was applied basal, but these losses were reduced to 11-33 per cent in split application. According to Craswell and Vlex (1979) who exhaustively reviewed field lysimeter experiments in Japan conducted between 1928 and 1971 and reported 3.4 to 25.4 per cent loss of applied nitrogen due to leaching.

Soil texture strongly influences the rate of nitrogen loss. Meelu (1980) observed the nitrogen loss due to leaching to be 69.5 per cent in light soils of Punjab. In a sandy loam alluvial soils at Cuttack percolating at the rate of 10-15 mm per day, nearly 43 and 16 per cent of nitrogen applied through labelled urea and ammonium sulphate respectively was lost through leaching during 11 weeks of crop growth while from a vertisol at Hyderabad percolating at the rate of 1-2 mm per day the loss of basal applied labelled urea nitrogen (100 kg nitrogen/ha) was only 6.8 per cent during the first crop season. In alluvial and laterate soils leaching losses of nitrogen were 44.4 and 60.4 per cent of applied nitrogen respectively. Over 90 per cent of nitrogen leached from submerged soils was in ammonical form (Mahapatra, 1981).

2.4.4 Loss of nitrogen due to run-off

There is a considerable nitrogen loss through surface water and is depending on source, method, time of application and rate of flow of water.

Studies conducted by Abichandani and Patnaik (1959) revealed 6 to 30 per cent of applied ammonical nitrogen was present in surface run-off water upto 10 days after application. Experiments conducted at IRRI (1978) revealed that 5.7 and 7.0 per cent of applied nitrogen was lost through out-flow of water during *kharif* and *rabi* respectively. Bilal *et al*. (1979) stated that the total loss of inorganic nitrogen (NH_4, NO_2, NO_3) through surface run off ranged from 11 to 22 per cent of 168 kg nitrogen/ha applied as ammonium sulphate.

2.5. Methods of increasing nitrogen use efficiency

Split application of nitrogen at critical stages of plant growth, so as to synchronise with periods of most efficient utilisation by the crop, deep placement of nitrogen in the active rooting zone of the rice plant much below the oxidised zone from the surface and the use of modified urea materials are the major approaches now being followed for increasing the fertilizer nitrogen use efficiency of rice.

2.5.1 Basal surface application

Significant reduction in plant height (Rajagopalan *et al*., 1971; Prathap Reddy, 1982), number of panicles/m^2, panicle weight (AICRP, 1971) and number of spikelets/panicle (Rajagopalan *et al*., 1971), were reported due to all basal application of nitrogen compared to split application.

Grain and straw yields were generally low in broadcast application of nitrogen compared to split application (Broadbent and Mikkelsen, 1968; Brady *et al*., 1974; Pillai and Rajat De, 1979). Sahrawat (1980) reported reduction in grain and straw yields of rice by 249 and 448 kg/ha respectively due to all basal application of urea compared to split application.

2.5.2 Split application

Increasing the nitrogen content of leaves to a desired level while keeping an optimum leaf area is what is precisely needed to be achieved in the nitrogen management of rice for increased grain yields and better nitrogen use efficiency. This is facilitated by need based application of nitrogen under varying soil and environmental situations and it is perhaps the simplest agronomic solution for improving the nitrogen use efficiency of rice. Split application of nitrogen minimises nitrogen loss and provides a continuous supply of nitrogen for proper growth and nutrition of rice plant (Evatt, 1965).

According to Tanaka et al. (1959) the best time of application depends on the growth duration, plant type and growing season. More recently Pillai (1981) reviewing data from AICRP, Hyderabad concluded that incorporation of basal nitrogen followed by two top dressings at tillering and week before panicle initiation (PI) would be ideal for most rice conditions in India. Bacha and Lopes (1983) recorded increased grain yield in rice with increasing level of nitrogen from 0 to 120 kg/ha and nitrogen was applied in three split doses, 33 per cent at planting, 33 per cent at tillering and the remaining at flower initiation stage. Chandrasekharappa (1985) reported higher grain and straw yields when 100 kg nitrogen was applied in three splits, i.e., 50 per cent at planting, 25 per cent at 25 days after transplanting and 25 per cent at 50 days after transplanting.

Rajagopalan et al. (1971) and Prathap Reddy (1982) recorded increase in plant height due to split application, compared to basal application of nitrogen. Increase in dry matter production was reported by Singh and Modgal (1978) and Chandrasekhara Reddy et al. (1979).

Several workers reported the superior performance of split applied nitrogen in increasing yield attributes. Increases in panicles/M^2, panicle weight (AICRIP, 1971), De Datta (1981) stated that split application of nitrogen increased number of panicles and filled spikelets per panicle.

Rajagopalan et al. (1971) obtained 450 kg/ha increased grain yield due to split application of nitrogen compared to all at basal application. Results from AICRIP, Hyderabad indicated 3.8 per cent increase in grain yield when 110 kg nitrogen/ha was applied in splits against basal appliaation (AICRIP, 1971). Patel et al. (1973) and Pande et al. (1977) reported significant increase in straw yield due to split application of nitrogen. Studies of Pillai and Rajat De (1979) revealed 15 per cent increased yield when nitrogen was applied to rice Jaya in three or four splits compared to all nitrogen application at transplanting. Experiments conducted by Sahrawat (1980) revealed an increase of 4.3 and 5.9 per cent respectively in grain and straw yields of rice IR-8 due to split application of nitrogen compared to basal application.

2.5.3 Modified urea materials

The slow release fertilizers in general offer great potential towards increasing fertilizers use efficiency by decreasing the cost of application, minimising the losses by leaching, decomposition or by fixation and by minimising luxury consumption (De Datta, 1981). Slow release fertilizers which release nitrogen that coincides with the requirements of growing plant. Modified urea materials are usually made by synthesis of chemical compounds with inherently slow rate of dissolution and/or by getting conventional soluble fertilizers coated to reduce their dissolution rates.

Among the modified urea materials, sulphur coated urea (SCU) and Isobutylidene di-urea (IBDU) have been widely tested for rice in India. The experiments conducted by the AICRIP have b shown that sulphur coated urea gave 25-30 kg grain/kg nitrogen as compared to 16-20 kg grain/kg nitrogen with urea applied in split doses (Rajendra Prasad and De Datta, 1979).

Due to the non-availability of sulphur to coat the urea, greater attention has been diverted to find out other materials which can reduce the solubility of urea as a result we can increase the efficiency of applied nitrogen.

Among the indigeneous methods of coating, Bains *et al*. (1971) and Rajendra Prasad *et al*. (1980) observed *neem* cake coating of urea to be very effective in retarding nitrification of urea for two weeks and they reported an increase of 24 per cent in grain yield by applying urea coated with 20 per cent by its weight of *neem* cake. Results of an experiment conducted by Vijayakumar (1979) indicated significant increase in plant height, number of tillers/M^2 and total dry matter due to *neem* cake coated urea compared to split application of urea, by 8.8, 13.3 and 3.8 per cent, respectively.

Nayak *et al*. (1981) compared split application of urea and neem cake coated urea. They obtained 33.8 per cent increase in grain yield due to *neem* cake coated urea compared to urea split application. Rabindra and Rajappa (1981) also reported similar results. Recently data from an experiment conducted by Joshi *et al*. (1982) showed 7.1 and 20.5 per cent increased grain and straw yield due to *neem* cake coated urea compared to oridinary urea, confirming the earlier results.

More recently, urea was coated with Rock phosphate and Gypsum to reduce the solubality of urea. Experiments conducted at Bhuvaneswar showed that nitrogen applied as rock phosphate coated urea was quite comparable to urea applied in split doses during <u>kharif</u> and it gave a significant residual response of 400 kg/ha over basal application of nitrogen as urea. Nitrogen applied as urea gypsum during <u>kharif</u> also gave more than 400 kg/ha of extra grain yield of rice during <u>rabi</u> season. However, urea in split doses proved to be the best treatment to realise a significant response (AICARP, 1982 and 1983).

In the medium black soils of Nandyal, the response to nitrogen was maximum at 120 kg nitrogen/ha and the best results were observed with split application of nitrogen which was closely followed by <u>neem</u> cake coated urea, urea gypsum and urea super granules. At Bhuvaneswar, in laterate soils urea super granules and split application of prilled urea had proved more effective in terms of grain yield over urea gypsum at 120 kg nitrogen/ha. Whereas at Rajendranagar, in medium black soils urea gypsum proved 4.5 per cent and 5.6 per cent more grain yield over that of split application of urea and deep placement of urea supergranules at 120 kg nitrogen/ha (AICARP, 1983 and 1984).

Subbaiah (1983) reported that among the sources lac coated urea registered the highest grain yield of

6082 kg/ha and it was on par with rock phosphate coated urea, urea gypsum and urea briquettes application of 120 kg nitrogen/ha.

2.5.4 Root zone placement

Root zone placement of ammonium containing or ammonium forming fertilisers increase fertilizer use efficiency considerably due to reduction in volatilization and nitrification-denitrification losses. It also makes nitrogen available to rice plant over a longer period of time. Even though this was recognised as early as 1941 (Yamada *et al*., 1979), manufacturing of urea supergranules in recent years, made root zone placement a practical and economic feasibility.

Comparing surface application of nitrogen with deep placement at 8 cm Enyi (1963) recorded taller plant height and tiller production due to deep placement of nitrogen. Simsiman *et al*. (1967) recorded 31.6 per cent more dry matter when nitrogen was placed at 15 cm than with surface application. Rambabu (1980) reported significant increase in plant height and dry matter production at 90 days when urea supergranules were deep placed to supply 108 kg nitrogen/ha compared to *neem* cake coated urea and broadcast application of urea. Prathap Reddy

(1982) obtained significant increase in plant height, number of tillers/M^2 and dry matter at harvest with deep placement of urea super granules compared to split application of urea.

Studying the efficiency of modified urea materials for a short duration rice crop, Singlachar et al. (1979) recorded higher panicles/M^2 and grain number/panicle due to deep placement of 60 kg nitrogen/ha as urea super-granules compared with split application, basal application of urea or neem cake coated urea. Test weight did not differ due to different sources. At Hyderabad, Pham-sy-Tan (1982) obtained significant increase in number of spikelets due to deep placement of nitrogen as urea super-granules. Rajendra Prasad et al. (1982) reported significant increases in panicles/M^2 and number of grains/panicle with deep placement of urea super-granules compared to urea and neem cake coated urea application.

Studying the effect of sub-surface placement of nitrogen Abichandani and Patnaik (1959) recorded 61 per cent increase in rice yield due to sub-surface placement of ammonium sulphate at planting. Simsiman et al. (1967) obtained significant increase in grain yield of rice due to nitrogen fertilizer placement at 15 cm depth compared to broadcast and incorporation treatment.

After the development of urea supergranules by the International Fertilizer Development Centre (IFDC), Alabama, USA, deep basal application of nitrogenous fertilizer became easy (Yamada <u>et al</u>., 1979) and experiments with urea supergranules were initiated throughout the world since the crop year 1978-79 (Rajendra Prasad <u>et al</u>., 1982). According to Pillai (1978) deep placement of urea supergranules was very much promising. He recorded a grain yield response of 23 kg/kg of nitrogen with urea supergranuales when it was only 16 kg/kg of nitrogen in split application. Average over seven locations deep placement of urea supergranules at 54 and 81 kg nitrogen/ha recorded mean grain yield of 4000 and 4300 kg/ha as against 3600 and 3900 kg/ha with best split application. The mean response in kg grain/kg of nitrogen was also higher when urea supergranules were deep placed (AICRIP, 1979). Results of 16 field experiments conducted in eight countries under INPUTS Project indicated that single deep placement of urea supergranules were remarkably superior to conventional broadcast method of application and on an average about one-third of nitrogen required for conventional application of urea can be saved by using urea supergranules. Singlachar <u>et al</u>. (1979) recorded 13.0, 17.3 and 32.6 per cent increases in grain yield due to application of 60 kg nitrogen/ha as urea supergranules compared to basal, split and neem cake coated urea application. Mean yield from 14 locations in a Co-ordinated trial indicated 14.9 and 6.7 per cent yield increase due to urea supergranules placement compared to basal and split application of urea. The increase in response of grain/kg of nitrogen ranged from 19-50 per cent (AICRIP, 1980). Similar results were also reported by Craswell and De Datta (1980) and Craswell *et al*. (1981).

Pillai and Vamadevan (1978) observed that the placement of nitrogen as urea briquettes recorded 66 and 57 per cent recovery of added nitrogen at 28 and 56 kg nitrogen/ha respectively and gave significant increase in yield as compared to split application of urea. According to Pyare Lal *et al*.(1981) urea supergranules application was superior to urea split application at 30 kg nitrogen/ha. Rajendra Prasad *et al*. (1982) tested different nitrogen carriers and their results confirmed the significant superiority of urea supergranules compared to urea and *neem* cake coated urea.

2.6. Nitrogen concentration and uptake

Padmaja (1977) reported that nitrogen concentration in both grain and straw of rice increased with increasing concentration of nitrogen in the root medium. Ramaswami and Subramanian (1978) reported that added nitrogen increased significantly the nitrogen content in grain and upword trend in the nitrogen content of grain (1.26 to 1.52) with increase in the level of applied nitrogen upto 80 kg/ha, was observed. Application of nitrogen significantly increased the nitrogen uptake at various stages of crop growth (Devendrappa, 1982 and Thimmegowda, 1985).

Reviewing the results of trials conducted with tall indica, Ponlai and dwarf indica varieties of rice Mahapatra and Panda (1972) stated that dwarf indica has the highest percentage of nitrogen in plant at successive stages of growth, followed by Ponlai and tall indica varieties. Mangal prasad and Rajendra Prasad (1980) observed higher nitrogen uptake (109 kg/ha) and per cent recovery of applied nitrogen (43.0) in a medium duration variety when compared to a short duration variety which recorded nitrogen uptake of 91 kg/ha and 37.5 per cent recovery of applied nitrogen. Prathap Reddy (1982) did not record any difference in applied nitrogen recovery by three rice cultivars viz: Tellahamsa, Jaya and Mahsuri but a significant difference in nitrogen uptake in straw was observed. Tellahamsa recorded an uptake of 18.5 kg nitrogen/ha while in Jaya and Mahsuri the nitrogen uptake was 19.82 and 21.30 kg/ha respectively.

Sahrawat (1980) observed reduction in nitrogen uptake by 4 kg/ha and apparent recovery of applied nitrogen by 5.4 per cent due to basal application of nitrogen compared to split application. Studying the transformation and balance of nitrogen in Japanese paddy fields under flooded conditions Koyama (1981) recorded 22-27 per cent of basally applied nitrogen as crop recovery, 18-21 per cent in immobilised form, and 52-60 percent unaccounted for, the latter two being higher compared to top dressed treatment.

Studies conducted by Datta and Venkateswarlu (1968) revealed higher amount of nitrogen in rice leaves and grain due to split application compared to basal surface application. Sahrawat (1980) obtained 3.5 and 18.9 percent increase in nitrogen uptake and apparent recovery of applied nitrogen in IR-8 rice variety due to split application compared to all basal application. According to Koyama (1981) rice crop recovered 25-60 per cent of top dressed nitrogen under flooded paddy conditions. Greenwood (1981) stated that the reovery of added nitrogen in split application was higher (27 per cent) while it was only 21 per cent in surface incorporated treatment. Thus, split application of nitrogen appears to be superior compared to broadcast application but practical problems like delay in first application until 2-3 weeks after planting (Craswell et al., 1981) and the occurrence of physical barriers like moisture scarcity or floods make top dressing impossible (Pillai, 1978).

According to Simsiman et al. (1967) 68 per cent of applied fertilizer nitrogen was recovered when deep placed and 38 per cent only in broad-cast and incorporated treatment. They also observed greater reserve of mineral nitrogen in the flooded soil at all stages of growth when nitrogen fertilizer was deep placed. Greater uptake and recovery of nitrogen due to urea supergranules placement compared to urea and neem cake coated urea (Mangal Prasad and Rajendra Prasad, 1980) and greater recovery by 209.5 and 140.7 per cent due to urea supergranules placement compared to surface incorporation and split application of urea respectively (Greenwood, 1981). Studying the time and mode of nitrogen fertilizer application to tropical wet land rice, Craswell et al. (1981) recovered 83 per cent of applied nitrogen from urea supergranules treatment and only 35 per cent from urea applied in best splits.

They suggested urea supergranules application to be taken up early and at a reduced rate than normal urea. More recently Savant *et al*. (1982) recovered at final harvest 50-61 per cent of nitrogen when deep placed and only 25-34 per cent in split applied urea. According to these authors during the first 20 days after transplanting deep placed nitrogen was physically or spatially non-available and negligible uptake occurred.

2.7. Residual effect of added nitrogen due to management practices on the succeeding crops

Since farmer does not grow a crop in isolated but in a cropping system, residual influence of applied major nutrients and modification in fertilizer recommendation for a crop in rotation are engaging the attention of research workers in recent years. It has been known for many years that crops have a decided influence through the amount of water or available nutrients they leave behind in the soil and their residues which may be either beneficial or harmful (Ripley, 1941 and Russell and Russell, 1961).

Cowpea genotypes tried in rice fallow at Bangalore (1983) for fodder purpose indicated that genotype. Lolitha gave 4209 kg/ha/cut compared to Iran grey (4000 kg/ha/cut) and Mississipi (4000 kg/ha/cut).

Reddy and Rajendra Prasad (1977) obtained significant grain yield response in wheat, due to application of urea and different coated urea when applied to supply 100 kg nitrogen/ha to rice crop. Wheat yield increase was 450 kg/ha with urea application.

Studying nitrogen management and its economics in rice-wheat rotation, Mangal Prasad and Rajendra Prasad (1980) reported significant residual effect of nitrogen applied to rice, on grain and straw yields of wheat. Application of 100 kg nitrogen/ha to rice produced 960 and 1340 kg/ha more grain and straw yields, respectively over control. A field study conducted at Pune farm to know the residual effect of urea gypsum and urea supergranules, confirmed that 15.8 and 11.4 per cent increase in the yield of wheat over the control by application of urea gypsum and urea supergranules to rice AICARP (1983 and 1984). Tiwari et al. (1980) reported that succeeding crop of wheat benefitted to residual fertility remained after taking the rice. This is in agreement with the work of Chakravarti et al. (1980).

Instances of non-significant residual response to applied nitrogen were also reported. Studying the fertilizer nitrogen (15 N labelled) for rice, De Datta *et al*. (1968) recorded no difference between fertilized and non-fertilized plots in the amount of mineral nitrogen remaining in Maahas clay after harvest and concluded that there was no residual effect in the form of mineral nitrogen even following the sub-surface placement of nitrogen. Application of urea, urea super-granules and rock phosphate coated urea, at 40 to 200 kg/ha to rice has not recorded any residual effect on the succeeding wheat either due to sources or levels AICARP (1980 and 1981). According to Subbaiah and Sachidev (1983) in a cereal based cropping system and also where a grain legume is included the residual effect of nitrogenous fertilizer are either small or negligible.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The details of the material used and methods followed during the course of the investigation are explained in this chapter.

3.1. Location

Field experiments were conducted at Main Research Station, University of Agricultural Sciences, Hebbal, Bangalore during July 1984 to March 1985. The Main Research Station is situated at a latitude of 12°58' North, longitude of 77°35' East and an altitude of 899 meters above the mean sea level.

3.2 Climate

The normal weather data as well as the weather data for the period under study and the deviation from the normal in respect of rainfall, evaporation, mean temperature (maximum and minimum) average relative humidity and hours of bright sunshine are presented in Table 1 and Fig.1 and 2.

3.2.1 Normal climatic conditions

The annual rainfall is 799 mm and the major portion of the precipitation is received during June to October.

Maximum temperature varied from 25.9°C to 33.9°C. April is the hottest month (33.9°C), and November and December (26.7°C and 25.9°C) are the coldest months. Maximum daily bright sunshine hours were recorded during February (10 h), while the lowest in the month of July (4.8 h) and August (5.3 h). Maximum mean relative humidity of 76 percent was observed during August.

3.2.2 <u>Climatic data prevailed during crop growth</u>

The rainfall during crop growth period was less than normal during June (22.1 mm), August (42.9 mm), September (3.2 mm), November (42.8 mm) and December (4.0 mm). While it was more than normal during July (69.8 mm), October (42.4 mm) and January (27.4 mm). There was no rainfall during February and March.

The maximum temperature during July (28.1°C), September (28.1°C), October (27.7°C) and November (26.2°C) was less than normal while, it was more than normal during June (30.5°C), August (28.6°C), December (26.9°C), January (28.6°C), February (30.6°C) and March (33.4°C). The maximum mean temperature was less than normal during all the months of crop growth period except in July, January and February. Maximum sunshine was recorded in

Table 1. Mean monthly meteorological data at Hebbal, Bangalore

Month	Rainfall (mm)			Temperature °C						Sunshine hours/ day			Relative humidity		
				Maximum			Minimum								
	N 1974-1983	A 1984-1985	D	N 74-83	A 84-85	D	N 74-83	A 84-85	D	N 1974-1983	A 1984-1985	D	N 1974-1983	A 1984-1985	D
Jun.	78.1	56.0	-22.1	29.7	30.5	+0.8	19.9	19.8	-0.1	6.2	5.8	-0.4	71.5	66.0	-5.5
Jul.	96.1	165.9	+69.8	28.7	28.1	-0.6	19.4	19.6	+0.2	4.8	4.1	-0.7	73.0	74.0	+1.0
Aug.	103.5	60.6	-42.9	28.0	28.6	+0.6	19.3	19.1	-0.2	5.3	6.5	+1.2	76.0	69.0	-7.0
Sept.	197.1	193.6	- 3.2	28.2	28.1	-0.1	19.2	19.1	-0.1	6.0	6.1	+0.1	75.5	69.0	-6.5
Oct.	99.3	141.7	+42.4	28.1	27.7	-0.6	18.7	18.6	-0.1	6.9	6.5	-0.4	75.0	69.5	-5.5
Nov.	76.1	33.3	-42.8	26.7	26.2	-0.5	16.9	16.7	-0.2	7.5	7.5	0.0	71.0	68.0	-3.0
Dec.	8.0	4.0	- 4.0	25.9	26.9	+1.0	15.0	13.8	-1.2	8.0	8.7	+0.7	68.2	62.0	-6.2
Jan.	0.1	27.5	+27.4	27.0	28.6	+1.6	13.6	14.0	+0.4	9.5	8.8	-0.7	63.0	61.0	-2.0
Feb.	6.9	0.0	- 6.9	29.9	30.6	+0.7	15.5	15.7	+0.2	10.0	9.8	-0.2	57.5	55.0	-2.5
Mar.	11.7	0.0	-11.7	32.4	33.4	+1.0	18.3	17.2	-1.1	9.9	9.7	-0.2	53.5	52.0	-1.5
Jul.-Nov.	650.2	651.1	+ 0.9	28.2	28.2	0.0	18.9	18.8	-0.1	6.1	6.1	0.0	73.7	69.3	-4.4
Dec.-Mar.	26.7	31.5	+ 4.8	28.8	29.9	+1.1	15.6	15.2	-0.4	9.4	9.4	0.0	60.6	57.5	-3.1

N = Normal; A = Actual; D = Deviation.

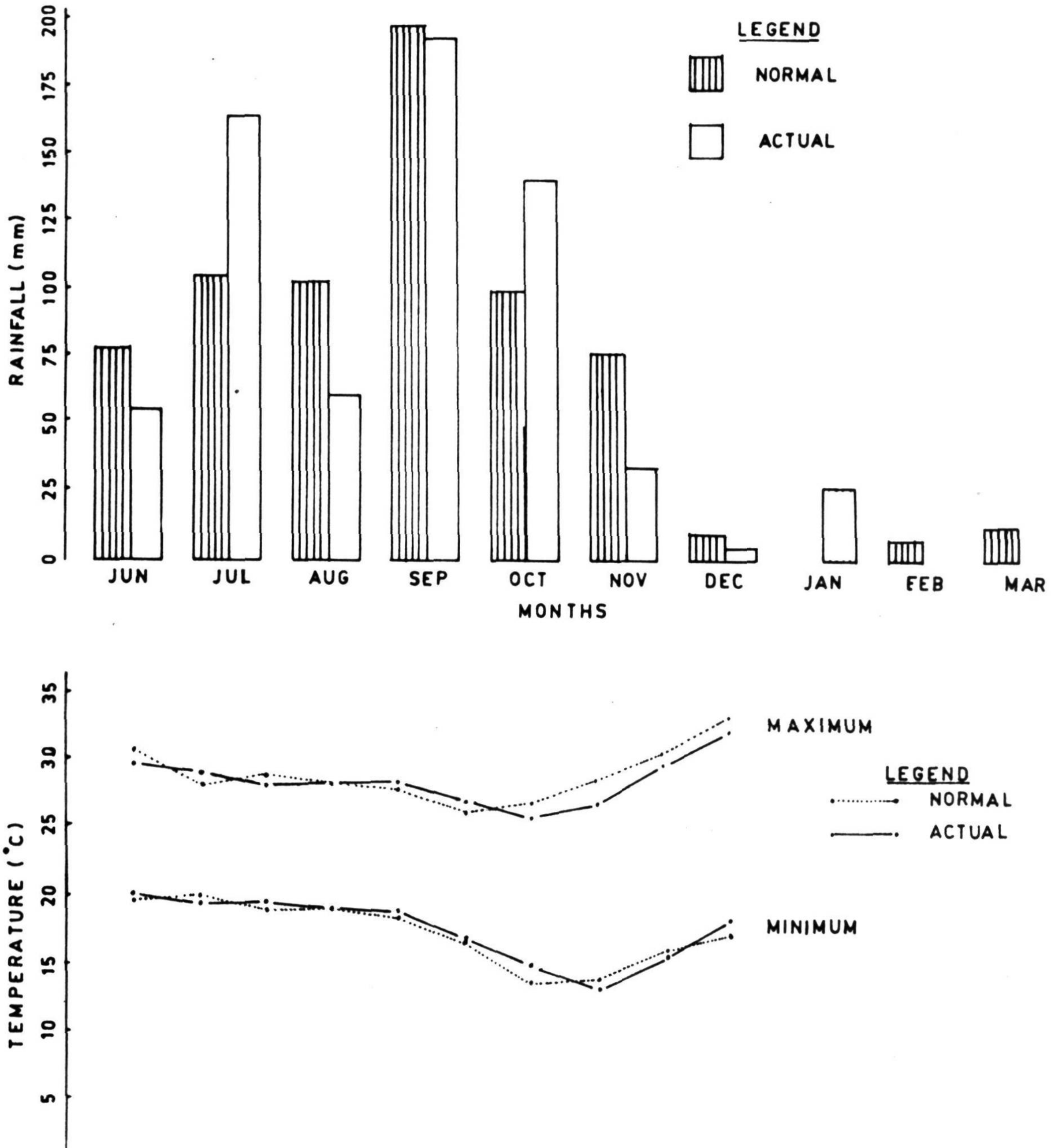


FIG.1. MONTHLY MEAN RAINFALL(mm), MAXIMUM AND MINIMUM TEMPERATURES(°C) PREVAILED DURING 1984-85 AND AVERAGE OF 10 YEARS (1974-83) AT THE MAIN RESEARCH STATION, HEBBAL, BANGALORE.

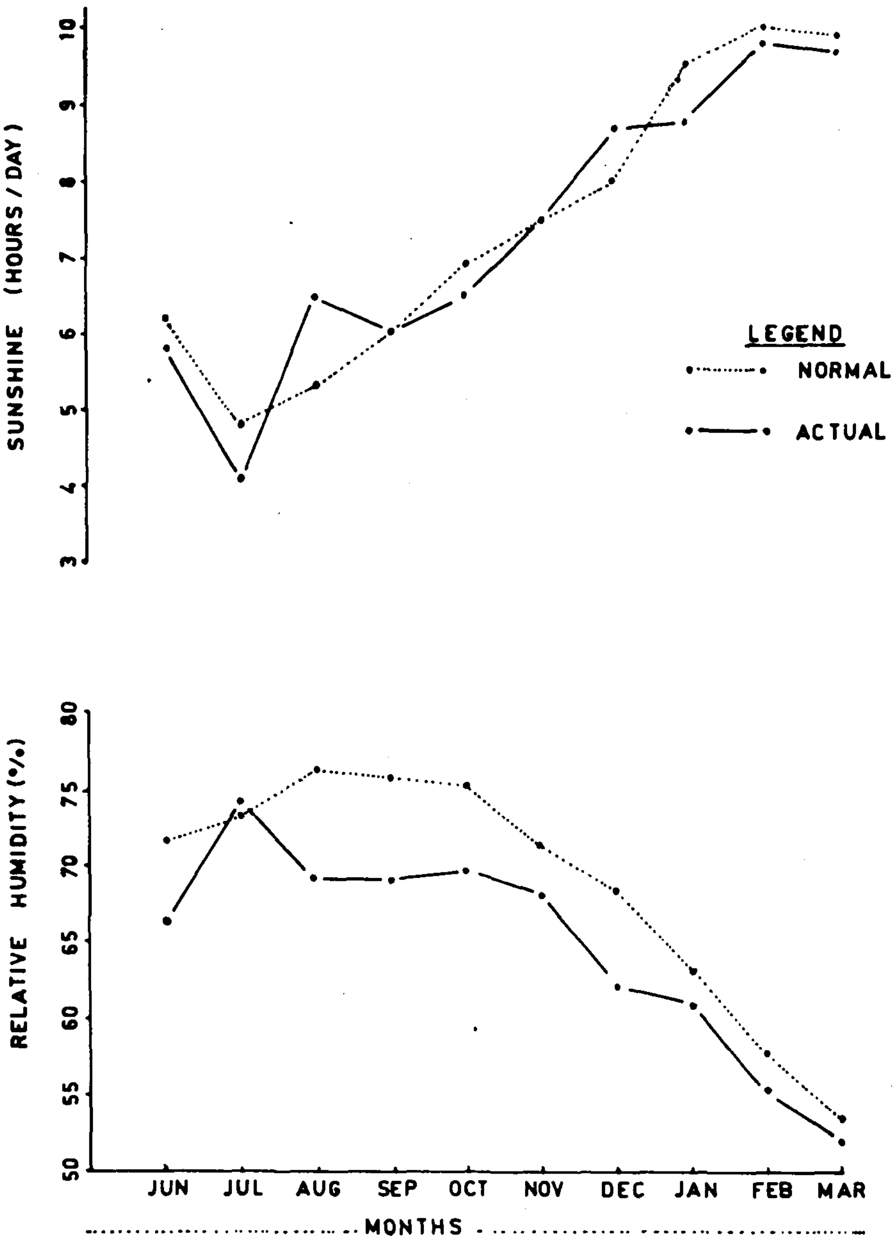


FIG.2. MONTHLY MEAN SUNSHINE HOURS PER DAY AND RELATIVE HUMIDITY (%) PREVAILED DURING 1984_85 AND AVERAGE OF 10 YEARS (1974_83) AT THE MAIN RESEARCH STATION, HEBBAL, BANGALORE.

the month of February (9.8 h) followed by January (8.8 h) which was less than the normal. August (1.2 h) and December (0.7 h) months recorded higher sunshine period as compared to normal. The lowest sunshine was observed during June (5.8 h), July (4.1 h) and October (6.5 h). The mean relative humidity throughout the crop growth period was less than the normal except in the month of July.

3.3 Experimental details

3.3.1 Site

Experiment was conducted in Range "A" (Plot 6) of wet land block. The physical and chemical properties of the experimental site are given in Table 2. The soil was sandy clay loam in texture with 27.6 per cent coarse sand, 24.5 per cent fine sand, 13.4 per cent silt and 34.5 per cent clay. Soil was acidic in reaction (pH 6.8) with electrical conductivity of 0.51 M mhos/cm. The area was even and there was no drainage problem, Normally bulk rice crop used to be raised in this field.

3.3.2 Treatment details

Kharif rice

A. Genotypes (2)

V_1 - Mangala
V_2 - Jaya

Table 2. Physico-chemical characteristics of the experimental site

Soil characteristics	Mean value	Method of estimation
A. Physical characteristics		
1. Mechanical composition		International Pipette Method (Piper, 1966)
a) Coarse sand (%)	27.6	
b) Fine sand (%)	24.5	
c) Silt (%)	13.4	
d) Clay (%)	34.5	
2. Bulk density (g/cc)	1.3	Core Sampler Method (Baker *et al*., 1976)
B. Chemical characteristics		
1. Electrical conductivity (M mhos/cm at 25°C)	0.51	Conductivity Bridge (Piper, 1966
2. pH (1:2.5)	6.8	Glass electrode pH Meter (Piper, 1966)
3. Cation exchange capacity (me/100 g)	11.0	Neutral N NH_4 OAC (Jackson, 1973)
4. Organic carbon (%)	0.8	Wet oxidation (Piper, 1966)
5. Available nitrogen (kg/ha)	249.0	Alkaline permanganate (Jackson, 1973)
6. Available phosphorus (kg/ha)	20.0	Bray's (Piper, 1966)
7. Available potassium (kg/ha)	300.0	Neutral N NH_4OAC (Jackson, 1973)

B. Nitrogen management practices (9)

T_1 - Control (no nitrogen)

T_2 - 112 kg/ha as urea all basal application

T_3 - 112 kg/ha as urea applied in split doses (50% at planting + 25% at tillering + 25% at panicle initiation stage)

T_4 - 112 kg/ha as rock phosphate coated urea all basal application

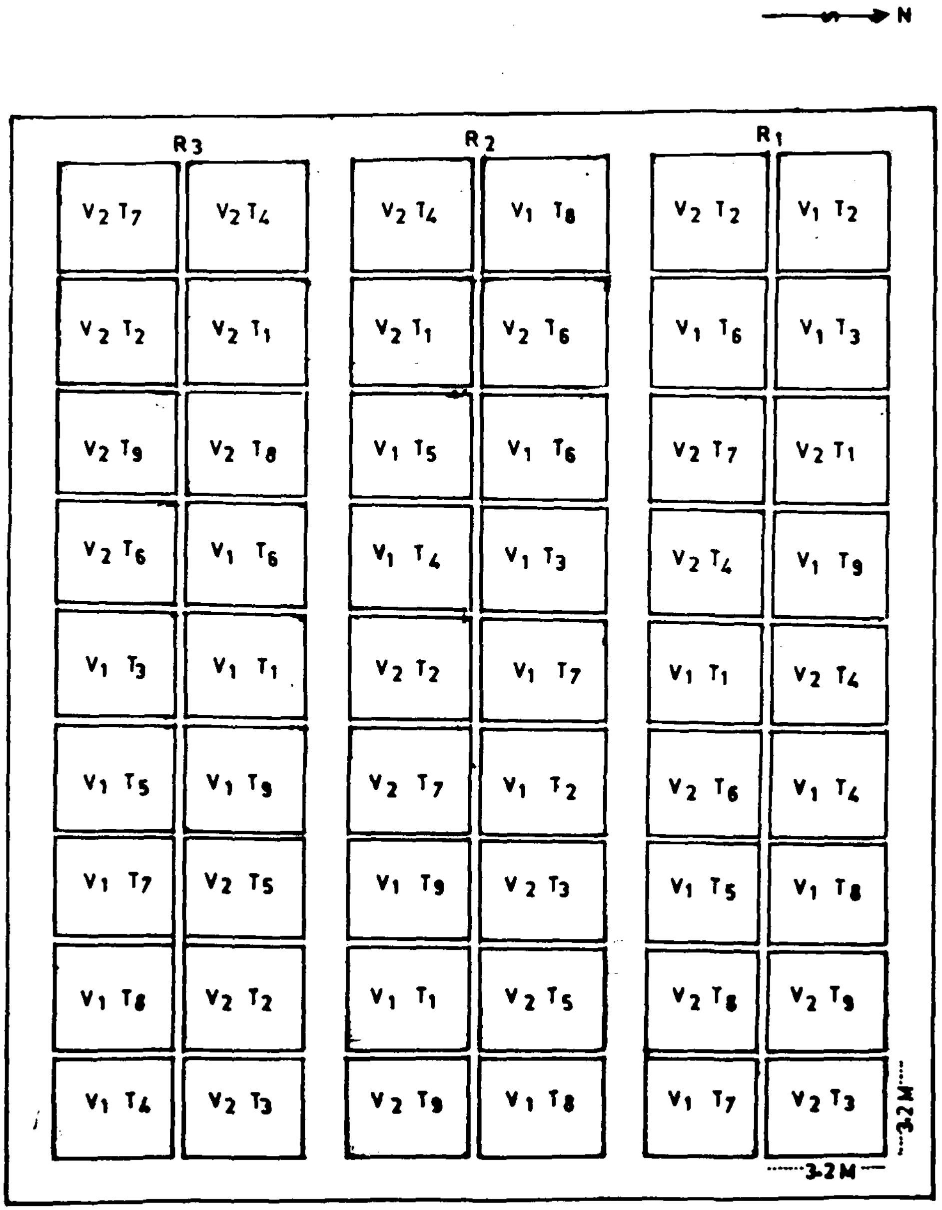
T_5 - 112 kg/ha as urea gypsum all basal application

T_6 - 112 kg/ha as urea super granules - root zone placement

T_7 - 56 kg/ha as rock phosphate coated urea basal application + 56 kg/ha as urea in two split as in T_3

T_8 - 56 kg/ha as urea gypsum basal application + 56 kg/ha as urea in two splits as in T_3

T_9 - 56 kg/ha as urea super granules root zone placement + 56 kg/ha as urea in two splits as in T_3



LEGEND

A. GENOTYPES

V_1 : MANGALA
V_2 : JAYA

B. NITROGEN MANAGEMENT PRACTICES

T_1 : CONTROL (NO NITROGEN)
T_2 : 112 Kg/ha AS UREA ALL BASAL.
T_3 : 112 Kg/ha AS UREA IN THREE SPLITS
T_4 : 112 Kg/ha AS RPCU ALL BASAL
T_5 : 112 Kg/ha AS UG ALL BASAL
T_6 : 112 Kg/ha AS USG ROOT ZONE PLACEMENT
T_7 : 56 Kg/ha AS RPCU BASAL +56 Kg/ha AS UREA IN TWO SPLITS
T_8 : 56 Kg/ha AS UG BASAL + 56 Kg/ha AS UREA IN TWO SPLITS
T_9 : 56 Kg/ha AS USG ROOT ZONE PLACEMENT + 56 Kg/ha AS UREA IN TWO SPLITS.

FIG.3. LAYOUT PLAN OF EXPERIMENT.

Design : Factorial randamised block design

Replications: Three

Treatment combinations: 18

Plot size:

Gross : 3.2 M x 3.2 M

Net : 2.4 M x 2.4 M

Spacing : 20 cm x 10 cm

Date of planting : 29-7-1984

Date of harvest : Mangala : 2-11-1984

Jaya : 5-12-1984

Cowpea after kharif rice

The genotype C-152 was raised and harvested for fodder purpose after *kharif* rice to utilise residual soil fertility and moisture.

Spacing : 40 cm x 10 cm

Date of sowing: 11-1-1985

Date of harvesting: 1-3-1985

Plan and layout for both *Kharif* rice and succeeding fodder cowpea is given in Fig.3.

3.4. Salient features of genotypes used

3.4.1 Rice (*Oryza sativa* L.)

Jaya: It is a high yielding dwarf, medium duration genotype. It is a cross between T (N)1 and T 141. Released by the Central varietal Release Committee during 1968. It comes to maturity in about 130 days. Grain is white, long, bold and having fine cooking quality. It yields about 7000 kg/ha under good management conditions.

Mangala: (MR-272)- This genotype was developed by the University of Agricultural Sciences, at the Regional Research Station, Mandya in 1975 by crossing Jaya and S-317. Early maturing (about 105 to 115 days) with a height of 85 to 90 cm and moderately resistant to salinity and low temperature. Yield potential is 6000 to 6500 kg/ha. The grain is medium slender.

3.4.2 Cowpea (*Vigna unguiculata* (Linn.) Wale)

C-152: It is a selection from germplasm collection from Iran material at IARI, Regional Station, Coimbatore. It is semi-erect with small sized ovate leaves. This variety grows to a height of 35 to 40 cm. The crop, for fodder, will be ready for cutting around 50 days, i.e. at 50 per cent flowering.

3.5. Description of the urea sources used

3.5.1 Urea (Commercial Urea)

The commercial urea available in the market was used. The stated nitrogen content of the urea was 46.0 per cent.

3.5.2 Urea supergranules (USG)

The Indian Farmers Fertilizer Co-operative Ltd., (IFFCO), New Delhi, manufacturing urea supergranules on a pilot basis for research purpose. The average weight of each granule was 1 gram with 46.0 per cent nitrogen content.

3.5.3 Rock phosphate coated urea (RPCU)

Madras Fertilizers Limited (MFL), Madras, manufacturing rock phosphate coated urea for experimental purpose. It is just small granules of black colour with 31.2 per cent nitrogen and 4.4 per cent P_2O_5.

3.5.4 Urea gypsum (UG)

Madras Fertilizers Limited, Madras, manufacturing urea gypsum and it contains 31 per cent nitrogen, 5.8 per cent sulphur and 7.4 per cent calcium.

3.6. Crop Husbandry

3.6.1 Kharif rice

Preparation of nursery

Nursery was raised in a well puddled, levelled and weed free seed beds. Before sowing of seeds basal dose of fertilizers were incorporated at the rate of 1 kg N, 0.5 kg P_2O_5 and 0.5 kg K_2O per 100 sq.m. Pre-germinated seeds (seeds were soaked for 24 hours and incubated in warm condition for 48 hours) were uniformly spread on the nursery bed. Maintained moist condition for 3 days by sprinking water frequently on the beds and then beds were submerged in shallow layer of water. One week before transplanting beds were top dressed with 0.6 kg N per 100 sq.m.

Land preparation

The experimental site was ploughed twice with mould board plough followed by wet ploughing, passing cultivator twice and levelling the plots with the help of leveller. Each plot was enclosed by bunds of 20 cm width and 15 cm height and provided a separate channel for each plot. The individual plots were levelled thoroughly for maintaining a thin sheet of water.

Fertilizer application

Phosphorus and potassium were applied in the form of single superphosphate and murate of potash, respectively at the rate of 50 kg P_2O_5 and 50 kg K_2O /ha to all treatments. The quantity and form of nitrogen applied was as per the treatments. Urea super granules were placed at 7 to 8 cm depth 7 days after transplanting between the two rows as shown in Fig.4.

Transplanting

Twenty six days old seedlings were uprooted from nursery bed and transplanted. Two seedlings per hill were maintained and care was taken to obtain shallow planting.

After care

Gap filling and weeding

Gap filling was done 8 days after transplanting to replace the missing seedlings. Hand weeding was done twice i.e. before first top dressing and second top dressing.

Water management

Thin sheet of water level was maintained during first ten days from planting. To avoid movement of fertilizer from one plot to another, each plot was irrigated separately and independently. The water was drained out

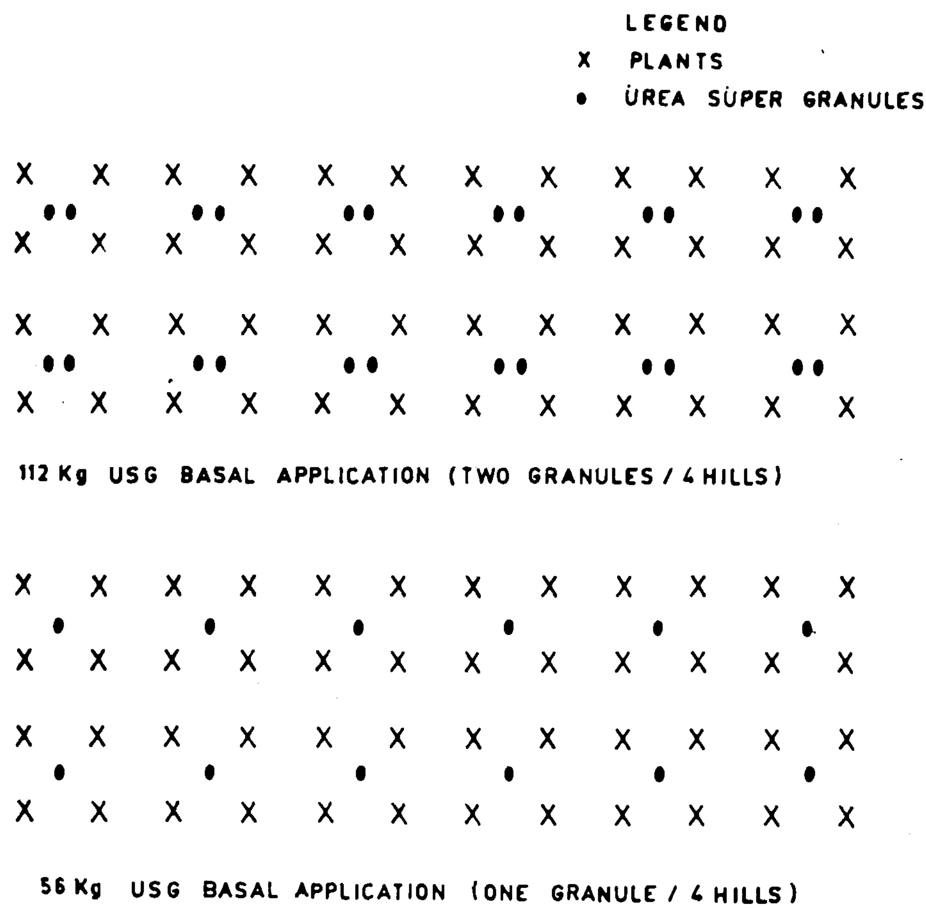


FIG. 4. PLACEMENT OF UREA SUPER GRANULES.

from the field a day before fertilizer top-dressing and flooded on the next day of fertilizer application. In general, 3-5 cm of water was maintained upto ten days before harvesting.

Pest and disease management

The crop was sprayed with Dimethoate and Zineb at recommended rate at three weeks after transplanting as a prophylatic measure against pests and diseases.

Harvesting

Crop was harvested when the maturity was indicated by drying of panicle.

3.6.2 Succeeding cowpea crop

Land preparation and sowing

After harvest of *kharif* rice field was allowed few days for drying and then stubbles and weeds were removed. The plots were prepared by digging without disturbing the bunds so as to keep the plots intact. Clods were crushed, levelled and then cowpea seeds were sown in the furrows opened with the help of pickaxe following a spacing of 40 cm x 10 cm (at the rate of 40 kg per ha).

Fertilizer application

Only phosphorus at the rate of 20 kg P_2O_5 per ha was applied in the form of single superphosphate at sowing.

After care

Wherever the seeds failed to germinate, gap filling was done 10 days after sowing and when two seedlings were present, in a hill were thinned out to one.

Harvesting

Crops was harvest at 50th day from sowing for green fodder.

3.7. Observations on growth and yield parameters

3.7.1 Kharif rice

Dry matter accumulation

Ten plants were uprooted at random from the rows adjacent to net plot rows excluding border rows at panicle emergence and at harvest. The root portion of the plants were discorded, then plants were washed in water and then oven dry weight of plants was taken and dry weight per plant was worked out.

Plant height

Height was measured from the ground level to the tip of the top most leaf at panicle initiation stage. At harvest, plant height was measured from ground level to the top of the panicle.

Number of shoots per hill

Total number of shoots per hill were counted at panicle initiation stage and ear bearing shoots at harvest from five hills marked for the purpose from the lines on either side leaving one line border on each side. The shoots were then converted to shoots number per hill.

Panicle length

Panicle length from five plants selected at random in each plot was recorded from base to tip of the panicle.

Number of grains per panicle

The mean number of grains per panicle was determined by counting the grains from five randomly selected panicles. Filled and unfilled grains were counted separately.

Thousand grain weight

Cleaned, randomly selected one thousand grains were counted, weighed, and expressed in grams.

Grain yield

Crop from each net plot was harvested and threshed. The grains obtained were sun dried and the weight was recorded per plot and was expressed in kg/ha.

Straw yield

Plants obtained after threshing grains were sun-dried and weight was recorded per plot and was expressed in kg/ha.

Total dry matter

The total dry matter was calculated as the summation of both grain and straw yields obtained from each plot and expressed in kg/ha.

Grain to straw ratio

The grain to straw ratio was calculated by using the formula:

$$\text{Grain to straw ratio} = \frac{\text{Grain weight}}{\text{Straw weight}}$$

Harvest Index

It is the ratio of grain yield (economic yield) to total dry matter (grain + straw yield) produced by the plant. It is calculated by using the following formula:

$$\text{Harvest Index} = \frac{\text{Grain yield}}{\text{Total Dry matter}} \times 100$$

Light absorption(%)

Light intensity readings were taken with the help of Lux meter at 10 A.M. and 2 P.M. in each plot and average was taken into consideration. Light absorption per cent was calculated by using the following formula.

$$\text{Light absorption}(\%) = \frac{\text{Radiation at top of the canopy} - \text{Radiation at ground surface} + \text{radiation reflected}}{\text{Radiation at top of the canopy}} \times 100$$

Uptake of nitrogen at harvest

Uptake of nitrogen by rice at harvest both in grain and straw wass computed by using the following formula and expressed in kg/ha.

$$\text{Nitrogen uptake} = \frac{\text{Nitrogen per cent in grain or straw} \times \text{Sundry weight of grain or straw}}{100}$$

Apparent recovery of nitrogen

Apparent recovery of nitrogen was computed by using the following formula (Pillai, 1983).

$$\text{Apparent recovery of nitrogen } (\%) = \frac{\text{Nitrogen uptake in a particular treatment} - \text{Nitrogen uptake in control}}{\text{Quantity of nitrogen applied per treatment}} \times 100$$

3.7.2. <u>Succeeding cowpea</u>

<u>Plant height</u>

Plant height was recorded at harvest from ground to the tip of the last leaf in five plants. It was expressed as a mean of five plants.

<u>Number of branches per plant</u>

Number of branches per ~~pa~~ plant were recorded from randomly selected five plants which were used for measuring the plant height and then average number per plant was worked out.

<u>Fodder yield</u>

Weight of green fodder from each net plot was recorded immediately after harvest and expressed in kg/ha.

3.8. <u>Plant analysis</u>

Nitrogen content at harvest both in grain and straw of rice and nitrogen content of fodder at harvest in the fodder cowpea was estimated by using Microkjeldhal method (Jackson, 1973).

3.9. Statistical analysis

The experimental data obtained were subjected to standard statistical analysis adopting Fisher's method of "Analysis of variance" as outlined by Cochran and Cox (1965). The level of significance used in 'F' test was both at one per cent and at five per cent. Critical difference (C.D.) values were given in the table at five per cent level of significance wherever the 'F' test was significant.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results of the "Studies on nitrogen management practices for rice genotypes and their residual effect on fodder legume" are presented in this chapter.

4.1. Kharif rice

4.1.1 Dry matter accumulation (DMA)

DMA at panicle emergence

The data on the DMA per hill at panicle emergence due to genotypes and nitrogen x management practices are presented in Table 3.

Over the nitrogen management practices, there was no significant difference in DMA due to genotypes. However, higher DMA (18.2 g/hill) was obtained with Jaya (V_2). The lowest DMA (17.2 g/hill) was recorded with Mangala (V_1).

Over the genotypes, the DMA varied significantly due to nitrogen management practices. Maximum DMA (21.6 g/hill) was obtained with 112 kg/ha through USG root zone placement (T_6) and was statistically on par with 112 kg/ha through UG all basal, i.e. T_5 (20.00 g/hill), 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9 (19.7 g/hill) and 112 kg/ha through RPCU all basal i.e. T_4 (19.1 g/hill). T_6 gave significantly higher DMA compared to 56 kg/ha through UG basal +

Table 3. Dry matter accumulation (g/hill) as influenced by genotypes and nitrogen management practices during panicle emergence

	Nitrogen management practices	Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	10.0	10.2	10.1
T_2	112 kg/ha as urea all basal	17.3	17.4	17.3
T_3	112 kg/ha as urea in 3 splits	16.1	15.1	15.6
T_4	112 kg/ha as RPCU all basal	17.5	20.6	19.1
T_5	112 kg/ha as UG all basal	19.5	20.4	20.0
T_6	112 kg/ha as USG root zone placement	22.0	21.1	21.6
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	16.7	18.7	17.7
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	17.4	19.2	18.3
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	18.7	20.8	19.7
	Mean	17.2	18.2	

	Genotypes	Nitrogen management	Interaction
'F' test	NS	**	NS
S.Em ±	0.436	0.925	0.719
C.D.(at 5%)	-	2.654	-

RPCU = Rock phosphate coated area
UG = Urea gypsum
USG = Urea super granules

56 kg/ha through urea in two splits, i.e. T_8 (18.3 g/hill), 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. T_7 (17.7 g/hill), 112 kg/ha through urea all basal i.e. T_2 (17.3 g/hill), 112 kg/ha through urea in three splits i.e. T_3 (15.6 g/hill) and no nitrogen i.e. T_1 (10.1 g/hill). However, there was no significant difference between T_5 and T_9, T_5 and T_4, T_5 and T_8, T_5 and T_7, T_5 and T_2, T_9 and T_4, T_9 and T_8, T_9 and T_7, T_9 and T_2, T_4 and T_8, T_4 and T_7, T_4 and T_2, T_8 and T_7, T_8 and T_2, T_7 and T_2, T_7 and T_3 and T_2 and T_3.

The interaction due to genotypes and nitrogen management practices did not have any significant effect on DMA during panicle emergence. However, maximum DMA (22 g/hill) was obtained with interaction of $V_1.T_6$ and the lowest DMA (10 g/hill) was obtained with interaction of $V_1.T_1$.

DMA at harvest

The data on DMA per hill at harvest due to genotypes and nitrogen management practices are presented in Table 4.

Over the nitrogen management practices, there was significant difference in DMA at harvest due to genotypes.

Table 4. Dry matter accumulation (g/hill) as influenced by genotypes and nitrogen management practices at harvest

	Nitrogen management practices	Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (No nitrogen)	14.6	15.4	15.0
T_2	112 kg/ha as urea all basal	19.3	21.3	20.3
T_3	112 kg/ha as urea in 3 splits	21.2	23.7	22.4
T_4	112 kg/ha as RPCU all basal	21.2	26.0	23.6
T_5	112 kg/ha as UG all basal	18.2	25.0	21.6
T_6	112 kg/ha as USG root zone placement	27.1	29.8	28.5
T_7	56 kg/ha as RPCU basal + 56 kg/ha urea in 2 splits	22.6	25.1	23.9
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	17.0	23.4	20.2
T_9	56 kg/ha as USG root zone placement + 56 kg/ha urea in 2 splits	24.4	27.5	26.0
	Mean	20.6	24.1	

	Genotypes	Nitrogen management	Interaction
'F' Test	**	**	NS
S.Em ±	0.519	1.100	1.017
C.D (at 5%)	1.487	3.155	-

RPCU = Rock phosphate coated urea
UG = Urea gypsum
USG = Urea super granules

Maximum DMA was recorded with Jaya i.e. V_2 (24.1 g/hill) and was statistically superior over Mangala i.e. V_1 (20.6 g/hill).

Over the genotypes, there was significant difference in DMA due to nitrogen management of practices. Maximum DMA was recorded with 112 kg/ha through USG root zone placement i.e. T_6 (28.5 g/hill) and was statistically on par with 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9 (26.0 g/hill). T_6 was significantly superior compared to 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. T_7 (23.9 g/hill), 112 kg/ha through RPCU basal i.e. T_4 (23.6 g/hill), 112 kg/ha through urea in three splits i.e. T_3 (22.4 g/hill), 112 kg/ha through UG all basal i.e. T_5 (21.6 g/hill), 112 kg/ha through urea all basal i.e. T_2 (20.3 g/hill), 56 kg/ha through UG basal + 56 kg/ha through urea in two splits i.e. T_8 (20.2 g/hill) and no nitrogen i.e. T_1 (15.0 g/hill). However, there was no significant difference between T_9 and T_7, T_9 and T_4, T_7 and T_4, T_7 and T_3, T_7 and T_5, T_4 and T_3, T_4 and T_5, T_3 and T_5, T_3 and T_2, T_3 and T_8, T_5 and T_2, T_5 and T_8 and T_2 and T_8.

The DMA at harvest not varied significantly due to interaction of genotypes and nitrogen management practices. However, maximum DMA (29.8 g/hill) was obtained with the interaction of $V_2 T_6$ and the lowest DMA (14.6 g/hill) was obtained with the interaction $V_1 T_1$.

4.1.2 Plant height

Plant height at panicle emergence

The data on the plant height at panicle emergence due to genotypes and nitrogen management practices are presented in Table 5.

Over the nitrogen management practices plant height at panicle emergence varied significantly due to genotypes. Maximum height was recorded with Mangala i.e. V_1(64.7 cm) and was significantly superior to Jaya i.e. V_2 (54.9 cm).

Over the genotypes, there was significant difference in plant height due to nitrogen management practices. Maximum plant height (71.2 cm) was obtained with 112 kg/ha through USG root zone placement (T_6) and was significantly superior to 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9 (64.8 cm), 112 kg/ha through urea all basal i.e. T_2 (61.4 cm), 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. T_7 (58.6 cm), 112 kg/ha through UG all basal i.e. T_5 (58.5 cm), 112 kg/ha through RPCU all basal i.e. T_4

Table 5. Plant height (cm) as influenced by genotypes and nitrogen management practices during panicle emergence

	Nitrogen management practices	Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	55.0	45.9	50.4
T_2	112 kg/ha as urea all basal	67.2	55.6	61.4
T_3	112 kg/ha as urea in 3 splits	62.4	53.2	57.8
T_4	112 kg/ha as RPCU all basal	59.3	56.5	57.8
T_5	112 kg/ha as UG all basal	62.7	54.2	58.5
T_6	112 kg/ha as USG root zone placement	77.4	65.1	71.2
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	66.5	50.6	58.6
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	61.8	53.2	57.5
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	69.6	59.9	64.8
	Mean	64.7	54.9	

	Genotypes	Nitrogen management	Inter action
'F' test	**	**	*
S.Em ±	0.555	1.177	1.773
C.D.(at 5%)	1.592	2.377	5.790

RPCU = Rock phosphate coated urea
UG = Urea gypsum
USG = Urea super granules

(57.8 cm), 112 kg/ha through urea in three splits i.e. T_3 (57.8 cm), 56 kg/ha through UG basal + 56 kg/ha through urea in two splits i.e. T_8 (57.5 cm) and no nitrogen i.e. T_1 (50.4 cm). However, there was no significant difference between T_2 and T_7, T_2 and T_5, T_7 and T_5, T_7 and T_4, T_7 and T_3, T_7 and T_8, T_5 and T_4, T_5 and T_3, T_5 and T_8, T_4 and T_3, T_4 and T_8 and T_3 and T_8.

Plant height varied significantly due to interaction of genotypes and nitrogen management practices. Highest plant height (77.4 cm) was recorded with the interaction of $V_1 T_6$ and was followed by $V_1 T_9$ (69.4 cm), $V_1 T_2$ (67.2 cm) and $V_1 T_7$ (66.5 cm). The least plant height (45.9 cm) was recorded with $V_2 T_1$ combination.

Plant height at harvest

The data on the plant height at harvest due to genotypes and nitrogen management practices are presented in Table 6.

Over the nitrogen management practices, plant height varied significantly due to genotypes. Maximum height (80.5 cm) was recorded with Mangala (V_1) and was significantly superior to Jaya i.e. V_2 (67.2 cm).

Table 6. Plant height (cm) as influenced by genotypes and nitrogen management practices at harvest

	Nitrogen management practices	Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	65.2	56.3	60.8
T_2	112 kg/ha as urea all basal	77.7	67.9	72.8
T_3	112 kg/ha as urea in 3 splits	79.7	69.8	74.7
T_4	112 kg/ha as RPCU all basal	79.7	68.1	73.9
T_5	112 kg/ha as UG all basal	82.2	66.7	74.4
T_6	112 kg/ha as USG root zone placement	88.3	71.5	79.9
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	84.7	65.8	75.3
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	81.3	68.9	75.1
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	85.4	70.1	77.8
	Mean	80.5	67.2	

	Genotypes	Nitrogen management	Interaction
'F' test	**	**	*
S.Em ±	0.547	1.161	1.759
C.D.(at 5%)	1.570	3.330	5.745

RPCU = Rock phosphate coated urea
UG = Urea gypsum
USG = Urea super phosphate

Over the genotypes, there was significant difference in plant height due to nitrogen management practices. Maximum plant height (79.9 cm) was obtained with 112 kg/ha through USG root zone placement (T_6) and was statistically on par with 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9 (77.8 cm). T_6 was significantly superior to 56 kg/ha through RPCU basal + 56 kg/ha through xx urea in two splits i.e. T_7 (75.3 cm), 56 kg/ha through UG basal + 56 kg/ha through urea in two splits i.e. T_8 (75.1 cm), 112 kg/ha through urea in three splits i.e. T_3(74.7 cm), 112 kg/ha through UG all basal i.e. T_5 (74.4 cm), 112 kg/ha through RPCU all basal i.e. T_4 (73.9 cm), 112 kg/ha through urea all basal i.e. T_2 (72.8 cm) and no nitrogen i.e. T_1 (60.8 cm). However, there was no significant difference between T_9 and T_7, T_9 and T_8, T_9 and T_3, T_7 and T_8, T_7 and T_3, T_8 and T_3, T_7 and T_5, T_7 and T_4, T_7 and T_2, T_8 and T_5, T_8 and T_4, T_8 and T_2, T_3 and T_5, T_3 and T_4, T_3 and T_2, T_5 and T_4, T_5 and T_2 and T_4 and T_2.

Plant height varied significantly at harvest due to interaction of genotypes and nitrogen management practices. Highest plant height (88.3 cm) was recorded with V_1 T_6 interaction and was significantly superior to all treatment combinations except V_1T_9 (85.4 cm) and V_1T_7 (84.7 cm). The least plant height (56.3 cm) was recorded with V_2T_1 combination.

4.1.3 Total number of shoots per hill

The data on total number of shoots per hill due to genotypes and nitrogen management practices are presented in Table 7.

Over the nitrogen management practices, total number of shoots per hill varied significantly due to genotypes. Highest number of shoots per hill (15.7) recorded with Jaya (V_2) and was significantly superior to Mangala i.e. V_1 (14.5).

Over the genotypes, there was significant difference in total number of shoots per hill due to nitrogen management practices. Maximum shoots per hill (19.3) was obtained with 112 kg/ha through USG root zone placement (T_6) and was statistically on par with 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. T_7(17.6). T_6 was significantly superior to 112 kg/ha through urea all basal i.e. T_2 (16.1), 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9 (15.7), 112 kg/ha through RPCU all basal

Table 7. Total number of shoots per hill as influenced by genotypes and nitrogen management practices

	Nitrogen management practices	Genotypes: Mangala (V_1)	Genotypes: Jaya (V_2)	Mean
T_1	Control (no nitrogen)	10.5	11.1	10.8
T_2	112 kg/ha as urea all basal	15.5	16.8	16.1
T_3	112 kg/ha as urea in 3 splits	13.2	14.5	13.9
T_4	112 kg/ha as RPCU all basal	14.8	14.3	14.6
T_5	112 kg/ha as UG all basal	14.3	14.5	14.4
T_6	112 kg/ha as USG root zone placement	18.1	20.5	19.3
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	17.4	17.7	17.6
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	12.3	14.9	13.6
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	14.9	16.5	15.7
	Mean	14.5	15.7	

	Genotypes	Nitrogen management	Inter action
'F' test	*	**	NS
S.Em ±	0.383	6.812	0.525
C.D. (at 5%)	1.098	2.329	-

RPCU = Rock phosphate coated urea
UG = Urea gypsum
USG = Urea super granules

i.e. T_4 (14.6), 112 kg/ha through UG all basal i.e. T_5 (14.4), 112 kg/ha through urea in three splits i.e. T_3 (13.8), 56 kg/ha through UG basal + 56 kg/ha through urea in two splits i.e. T_8 (13.6), and no nitrogen i.e. T_1 (10.8). However, there was no significant difference between T_7 and T_2, T_7 and T_9, T_2 and T_9, T_2 and T_4, T_2 and T_5, T_2 and T_3, T_9 and T_4, T_9 and T_5, T_9 and T_3, T_4 and T_5, T_4 and T_3, T_5 and T_3, T_9 and T_8, T_4 and T_8, T_5 and T_8 and T_3 and T_8.

There was no significant difference in total number of shoots per hill due to interaction of genotypes and nitrogen management practices. However, maximum number of shoots per hill (20.5) was obtained with the interaction of V_1 T_6 and the lowest number of shoots per hill (10.5) was obtained with V_2T_1 interaction.

4.1.4 Number of panicles per hill

The data on number of panicles per hill due to genotypes and nitrogen management practices are presented in Table 8.

Over the nitrogen management practices, number of panicles per hill varied significantly due to genotypes. Maximum number of panicles/hill (12.8) were recorded with Jaya (V_2) and was statistically superior over Mangala i.e. V_1 (10 panicles/hill).

Table 8. Number of panicles per hill as influenced by genotypes and nitrogen management practices

Nitrogen management practices		Genotypes: Mangala (V_1)	Genotypes: Jaya (V_2)	Mean
T_1	Control (no nitrogen)	7.0	9.3	8.1
T_2	112 kg/ha as urea all basal	9.6	12.3	11.0
T_3	112 kg/ha as urea in 3 splits	10.5	12.9	11.7
T_4	112 kg/ha as RPCU all basal	10.1	12.4	11.2
T_5	112 kg/ha as UG all basal	9.0	12.2	10.6
T_6	112 kg/ha as USG root zone placement	11.9	16.0	14.0
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	11.5	15.5	13.5
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	9.7	12.2	11.0
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	10.6	12.5	11.5
	Mean	10.0	12.8	

	Genotypes	Nitrogen management	Interaction
'F' test	**	**	NS
S.Em ±	0.249	0.529	0.382
C.D.(at 5%)	0.715	1.516	-

RPCU = Rock phosphate coated urea
UG = Urea gypsum
USG = Urea super granules

Over the genotypes, there was significant difference in number of panicles per hill due to nitrogen management practices. Maximum panicles per hill (14) was obtained with 112 kg/ha through USG root zone placement (T_6) and was statistically on par with 56 kg/ha through RPCU basal+ 56 kg/ha through urea in two splits i.e. T_7 (13.5 panicles/ hill), T_6 and T_7 are significantly superior to 112 kg/ha through urea in three splits i.e. T_3 (11.7 panicles/ha), 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9 (11.5 panicles/hill), 112 kg/ha through RPCU all basal i.e. T_4 (11.2 panicles/hill), 56 kg/ha through UG basal + 56 kg/ha through urea in two splits i.e. T_8 (11.0 panicle/ha), 112 kg/ha through urea all basal, i.e. T_2 (11.0 panicle/hill), 112 kg/ha through UG all basal i.e. T_5 (10.6 panicles/hill) and no nitrogen i.e. T_1 (8.1 panicle/hill). However, there was no significant difference between T_3 and T_9, T_3 and T_4, T_3 and T_8, T_3 and T_2, T_3 and T_5, T_9 and T_4, T_9 and T_8, T_9 and T_2, T_9 and T_5, T_4 and T_8, T_4 and T_2, T_4 and T_5, T_8 and T_2, T_8 and T_5 and T_2 and T_5.

There was no significant difference in number of panicles per hill due to interaction of genotypes and nitrogen management practices. However, maximum number of panicles per hill (16.0 were obtained with V_1T_6 interaction and the lowest number of panicles per hill (7.0) were obtained with V_2T_1 interaction.

4.1.5 Panicle length

The data on the panicle length due to genotypes and nitrogen management practices are presented in Table 9.

Over the nitrogen management practices, there was no significant difference in panicle length due to genotypes. However, slightly higher panicle length (21.3 cm) was obtained with Jaya (V_2) compared to Mangala i.e. V_1 (21.2 cm).

Over the genotypes, panicle length varied significantly due to nitrogen management practices. Maximum panicle length (22 cm) was obtained with 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits (T_9) and was statistically on par with 112 kg/ha through USG root zone placement i.e. T_6(22 cm), 56 kg/ha through UG B basal + 56 kg/ha through urea in two splits i.e. T_8(21.9 cm), 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. T_7(21.9 cm), 112 kg/ha through urea in three splits i.e. T_3 (21.8 cm), T_9, T_6 and T_8 are significantly superior to 112 kg/ha through urea all basal i.e. T_2 (20.8 cm), 112 kg/ha through RPCU all basal i.e. T_4 (20.8 cm), 112 kg/ha through UG all basal i.e. T_5 (20.7 cm) and no nitrogen i.e. T_1 (19.1 cm). However, there was no significant difference between T_7 and T_2, T_7 and T_4, T_3 and T_2, T_3 and T_4, T_3 and T_5, T_2 and T_4, T_2 and T_5 and T_4 and T_5.

Table 9. Panicle length (cm) as influenced by genotypes and nitrogen a management practices

	Nitrogen management practices	Genotypes Mangala (V_1)	Jaya (V_2)	Mean
T_1	Control (no nitrogen)	18.8	19.5	19.1
T_2	112 kg/ha as urea all basal	21.3	20.4	20.8
T_3	112 kg/ha as urea in 3 splits	21.4	22.2	21.8
T_4	112 kg/ha as RPCU all basal	20.8	20.8	20.8
T_5	112 kg/ha as UG all basal	20.6	20.9	20.7
T_6	112 kg/ha as USG root zone placement	21.9	22.0	22.0
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	22.4	21.3	21.9
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	21.7	22.1	21.9
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	21.6	22.4	22.0
	Mean	21.2	21.3	

	Genotypes	Nitrogen management	Inter-action
'F' test	NS	*	NS
S.Em ±	0.176	0.373	0.339
C.D. (at 5%)	-	1.069	-

RPCU = Rock phosphate coated urea
UG = Urea gypsum
USG = Urea super granules

There was no significant difference in panicle length due to interaction of genotypes and nitrogen management practices. However, maximum panicle length (24.4 cm) was obtained with the interaction of V_2T_9 and V_1 T_7. The lowest panicle length (18.8 cm) was obtained with interaction of V_1 T_1.

4.1.6 <u>Number of filled grains per panicle</u>

The data on number of filled grains per panicle due to genotypes and nitrogen management practices are presented in Table 10.

Over the nitrogen management practices, there was significant difference in number of filled grains per panicle due to genotypes. Maximum number of filled grains were recorded with Jaya i.e. V_2 (97.9) and was statistically superior to Mangala i.e. V_1 (82.0).

Over the genotypes, there was significant difference in number of filled grains per panicle due to nitrogen management practices. Maximum number of filled grains were recorded with 112 kg/ha through USG root zone placement i.e. T_6 (95.8) and was statistically on par with all other treatments except no nitrogen i.e. T_1 (74.5).

Table 10. Number of filled grains per panicle as influenced by genotypes and nitrogen management practices

Nitrogen management practices		Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	60.9	88.0	74.5
T_2	112 kg/ha urea all basal	81.6	95.4	88.5
T_3	112 kg/ha as urea in 3 splits	84.0	97.3	90.7
T_4	112 kg/ha as RPCU all basal	84.5	101.9	93.2
T_5	112 kg/ha as UG all basal	78.9	98.1	88.5
T_6	112 kg/ha as USG root zone placement	85.7	105.8	95.8
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	87.7	96.4	92.0
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	86.2	98.1	92.2
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	86.7	99.5	94.1
	Mean	82.0	97.9	

	Genotypes	Nitrogen management	Interaction
'F' test	**	*	NS
S.Em ±	1.943	4.122	2.851
C.D.(at 5%)	5.574	11.823	-

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

There was no significant difference in number of filled grains per panicle due to interaction of genotypes and nitrogen management practices. However, maximum number of filled grains per panicle recorded with the interaction of V_2T_6 (105.8) and lowest number of filled grains (60.9) were recorded with interaction of V_1T_1.

4.1.7 Number of unfilled grains per panicle

The data on number of unfilled grains per panicle due to genotypes and nitrogen management practices are presented in Table 11.

Over the nitrogen management practices, there was significant difference in number of unfilled grains per panicle due to genotypes. Maximum number of unfilled grains (22.8) were recorded with Jaya (V_2) and were statistically superior to Mangala i.e. V_1 (11.5).

Over the genotypes, there was significant difference in number of unfilled grains per panicle due to nitrogen management practices. Maximum number of unfilled grains per panicle (22.1) were obtained with 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9 and was statistically on par with 112 kg/ha through USG root zone placement i.e. T_6 (21.6), 112 kg/ha through

Table 11. Number of unfilled grains per panicle as influenced by genotypes and nitrogen management practices

Nitrogen management practices		Genotypes Mangala (V_1)	Jaya (V_2)	Mean
T_1	Control (no nitrogen)	8.6	20.5	14.6
T_2	112 kg/ha as urea all basal	11.2	16.2	13.7
T_3	112 kg/ha as urea in 3 splits	11.3	26.8	19.0
T_4	112 kg/ha as RPCU all basal	12.0	23.7	17.8
T_5	112 kg/ha as UG all basal	19.4	21.3	15.3
T_6	112 kg/ha as USG root zone placement	14.7	28.5	21.6
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	12.7	21.6	17.2
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	7.5	19.1	13.3
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	16.5	27.8	22.1
	Mean	11.5	22.8	

	Genotypes	Nitrogen management	Interaction
'F' test	**	*	NS
S.Em ±	0.774	1.642	1.479
C.D.(at 5%)	2.220	4.709	-

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

urea in three splits i.e. T_3 (19.0) and 112 kg/ha through RPCU all basal i.e. T_4 (17.8). T_9 was significantly superior to 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. T_7 (17.2), 112 kg/ha through UG all basal i.e. T_5 (15.3), no nitrogen i.e. T_1 (14.6), 112 kg/ha through urea all basal i.e. T_2 (13.7) and 56 kg/ha through UG basal + 56 kg/ha through urea in two splits, i.e. T_8(13.3). However, there was no significant difference between T_6 and T_7, T_3 and T_7, T_4 and T_7, T_3 and T_5, $T_3$and T_1, T_4 and T_5, T_4 and T_1, T_7 and T_5, T_7 and T_1, T_5 and T_{11}, T_4 and T_2, T_4 and T_8, T_7 and T_2, T_7 and T_8, T_5 and T_2, T_5 and T_8, T_1 and T_2, T_1 and T_8 and T_2 and T_8.

There was no significant difference due to interaction of genotypes and nitrogen management practices on the number of unfilled grains per panicle. However, maximum number of unfilled grains (28.5) were obtained with the interaction of V_2T_6 and the lowest number of unfilled grains (8.6) were obtained with the interaction of V_1T_1.

4.1.8 Thousand grain weight

The data on 1000 grain weight due to genotypes and nitrogen management practices are presented in Table 12.

Over the nitrogen management practices, there was significant difference in 1000 grain weight due to geno-

Table 12. Thousand grain weight (g) as influenced by genotypes and nitrogen management practices

Nitrogen management practices	Genotypes		Mean
	Mangala (V_1)	Jaya (V_2)	
T_1 Control (no nitrogen)	21.6	27.5	24.5
T_2 112 kg/ha as urea all basal	24.0	28.2	26.1
T_3 112 kg/ha as urea in 3 splits	23.2	28.7	26.0
T_4 112 kg/ha as RPCU all basal	24.9	29.1	27.0
T_5 112 kg/ha as UG all basal	23.7	28.7	26.2
T_6 112 kg/ha as USG root zone placement	23.3	29.1	26.7
T_7 56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	23.7	28.9	26.3
T_8 56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	23.1	28.7	25.9
T_9 56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	23.9	28.4	26.2
Mean	23.6	28.6	

	Genotypes	Nitrogen management	Interaction
'F' test	**	**	NS
S.Em ±	0.164	0.348	0.311
C.D. (at 5%)	0.471	0.999	-

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

types. Maximum thousand grain weight (28.6 g) was recorded with Jaya (V_2) and was significantly superior to Mangala i.e. V_1 (23.6 g).

Over the genotypes, there was significant difference in 1000 grain weight due to nitrogen management practices. Maximum weight (27 g) was obtained with 112 kg/ha through RPCU all basal i.e. T_4 and was statistically on par with 112 kg/ha through USG root zone placement i.e. T_6 (26.7 g), 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. T_7 (26.3 g), 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9 (26.2 g), 112 kg/ha through UG all basal i.e. T_5 (26.2 g), 112 kg/ha through urea all basal i.e. T_2 (26.1 g) and 112 kg/ha through urea in three splits i.e. T_3 (26.1 g). T_4 was significantly superior to 56 kg/ha through UG basal + 56 kg/ha through urea in two splits i.e. T_8 (25.9 g) and no nitrogen i.e. T_1 (23.6 g). However, there was no significant difference between T_6 and T_8, T_7 and T_8, T_9 and T_8, T_5 and T_8, T_2 and T_8 and T_3 and T_8.

There was no significant difference due to interaction of genotypes and nitrogen management practices on 1000 grain weight. However, maximum weight (28.9 g) was obtained with the interaction of V_2T_7 and the lowest grain weight (21.6 g) was obtained with the interaction of V_1T_1.

4.1.9 Grain yield

The data on grain yield as influenced by genotypes and nitrogen management practices are presented in Table 13, and Fig.

Over the nitrogen management practices, the grain yield varied significantly due to genotypes. Maximum grain yield (5040 kg/ha) was obtained with Jaya (V_2) compared to Mangala i.e. V_1(4243 kg/ha).

Over the genotypes, the grain yield varied significantly due to nitrogen management practices. Maximum grain yield (5336 kg/ha) was obtained with 112 kg/ha through USG root zone placement (T_6) and was statistically on par with 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9(5081 kg/ha). T_6 was significantly superior to 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. T_7 (4956 kg/ha), 112 kg/ha through urea in three splits i.e. T_3 (4776 kg/ha), 112 kg/ha through RPCU all basal i.e. T_4 (4736 kg/ha), 56 kg/ha through UG basal 56 kg/ha through urea in two splits i.e. T_8 (4571 kg/ha), 112 kg/ha through UG all basal i.e. T_5 (4477 kg/ha, 112 kg/ha through urea all basal, i.e. T_2 (4471 kg/ha) and no nitrogen i.e. T_1 (3371 kg/ha). However, there was no

Table 13. Grain yield (kg/ha) as influenced by genotypes and nitrogen management practices

	Nitrogen management practices	Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	3311	3430	3371
T_2	112 kg/ha as urea all basal	4143	4800	4471
T_3	112 kg/ha as urea in 3 splits	4413	5139	4776
T_4	112 kg/ha as RPCU all basal	4262	5211	4736
T_5	112 kg/ha as UG all basal	4167	4787	4477
T_6	112 kg/ha as USG root zone placement	4809	5863	5336
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	4348	5563	4956
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	4224	4918	4571
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	4511	5616	5081
	Mean	4243	5040	

	Genotypes	Nitrogen management	Inter-action
'F' test	**	**	*
S.Em ±	50.08	106.23	168.42
C.D. (at 5%)	143.64	304.70	550.21

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

significant difference between T_9 and T_7, T_7 and T_3, T_7 and T_4, T_3 and T_4, T_3 and T_8, T_3 and T_5, T_4 and T_8, T_4 and T_5, T_4 and T_2, T_8 and T_5, T_8 and T_2 and T_5 and T_2.

The grain yield varied significantly due to interaction of genotypes and nitrogen management practices. Maximum grain yield (5863 kg/ha) was obtained with interaction of V_2 T_6 and was statistically on par with V_2 T_9 (5616 kg/ha) and V_2 T_7(5563 kg/ha). The lowest grain yield (3311 kg/ha) was obtained with V_1T_1 combination.

4.1.10 <u>Straw yield</u>

The data on straw yield as influenced by genotypes and nitrogen management practices are presented in Table 14.

Over the nitrogen management practices, the straw yield varied significantly due to genotypes. Maximum straw yield (6656 kg/ha) was recorded with Jaya (V_2) compared to Mangala i.e. V_1 (5847 kg/ha).

Over the genotypes, the straw yield varied significantly due to nitrogen management practices. Maximum straw yield (7475 kg/ha) was obtained with 112 kg/ha through USG root zone placement (T_6) and was significantly

Table 14. Straw yield (kg/ha) as influenced by genotypes and nitrogen management practices

Nitrogen management practices		Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	4374	4442	4408
T_2	112 kg/ha as urea all basal	5575	6194	5884
T_3	112 kg/ha as urea in 3 splits	5805	6964	6385
T_4	112 kg/ha as RPCU all basal	6023	6661	6342
T_5	112 kg/ha as UG allbasal	5743	6434	6088
T_6	112 kg/ha as USG root zone placement	6655	8297	7476
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	6139	6918	6528
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	5924	6447	6186
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	6382	7550	6966
	Mean	5847	6656	

	Genotypes	Nitrogen management	Interaction
'F' test	**	**	**
S.Em ±	52.818	112.215	227.492
C.D.(at 5%)	151.729	321.866	743.181

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

superior to 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9 (6966 kg/ha). T_6 and T_9 are significantly superior to 56 kg/ha through RPCU basal 56 kg/ha through urea in two splits i.e. T_7 (6528 kg/ha), 112 kg/ha through urea in three splits i.e. T_3 (6385 kg/ha), 112 kg/ha through RPCU all basal i.e. T_4 (6342 kg/ha), 56 kg/ha through UG basal + 56 kg/ha through urea in two splits i.e. T_8 (6186 kg/ha), 112 kg/ha through UG all basal i.e. T_5 (6088 kg/ha), 112 kg/ha through urea all basal i.e. T_2 (5884 kg/ha) and no nitrogen i.e. T_1 (4408 kg/ha). However, there was no significant difference between T_7 and T_3, T_7 and T_4, T_3 and T_4, T_3 and T_8, T_3 and T_5, T_4 and T_8, T_4 and T_5, T_8 and T_5, T_8 and T_2 and T_5 and T_2.

The straw yield varied significantly due to interaction of genotypes and nitrogen management practices. Maximum straw yield (8297 kg/ha) was recorded with V_2 T_6 and was significantly superior to other treatment combinations (7550 to 4374 kg/ha). The lowest straw yield (4374 kg/ha) was obtained with V_1T_1 combination.

4.1.11 Total dry matter

The data on total dry matter as influenced by genotypes and nitrogen management practices are presented in Table 15 and Fig.5.

Over the nitrogen management practices, total dry matter varied significantly due to genotypes. Maximum drymatter yield (11696 kg/ha) was recorded with Jaya (V_2) compared to Mangala, i.e. V_1 (10090 kg/ha).

Over the genotypes, the total dry matter varied significantly due to nitrogen management practices. Maximum dry matter yield (12693 kg/ha) was obtained with 112 kg/ha through USG root zone placement (T_6) and was significantly superior to 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9 (12047 kg/ha). T_6 and T_9 are significantly superior to 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. T_7 (11483 kg/ha), 112 kg/ha through urea in three splits i.e. T_3 (11161 kg/ha), 112 kg/ha through RPCU all basal i.e. T_4 (11078 kg/ha), 56 kg/ha through UG basal + 56 kg/ha through urea in two splits i.e. T_8 (10757 kg/ha), 112 kg/ha through UG all basal, i.e. T_5 (10565 kg/ha), 112 kg/ha through urea all basal

Table 15. Total dry matter (kg/ha) as influenced by genotypes and nitrogen management practices

	Nitrogen management practices	Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	7685	7873	7779
T_2	112 kg/ha as urea all basal	9718	10994	10356
T_3	112 kg/ha as urea in 3 splits	10218	12103	11161
T_4	112 kg/ha as RPCU all basal	10285	11871	11078
T_5	112 kg/ha as UG all basal	9910	11220	10565
T_6	112 kg/ha as USG root zone placement	11463	13923	12693
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	10487	12481	11483
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	10148	11365	10757
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	10893	13202	12047
	Mean	10090	11696	

	Genotypes	Nitrogen management	Interaction
'F' test	**	**	**
S.Em ±	77.023	163.397	231.08
C.D. (at 5%)	184.005	390.338	553.021

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

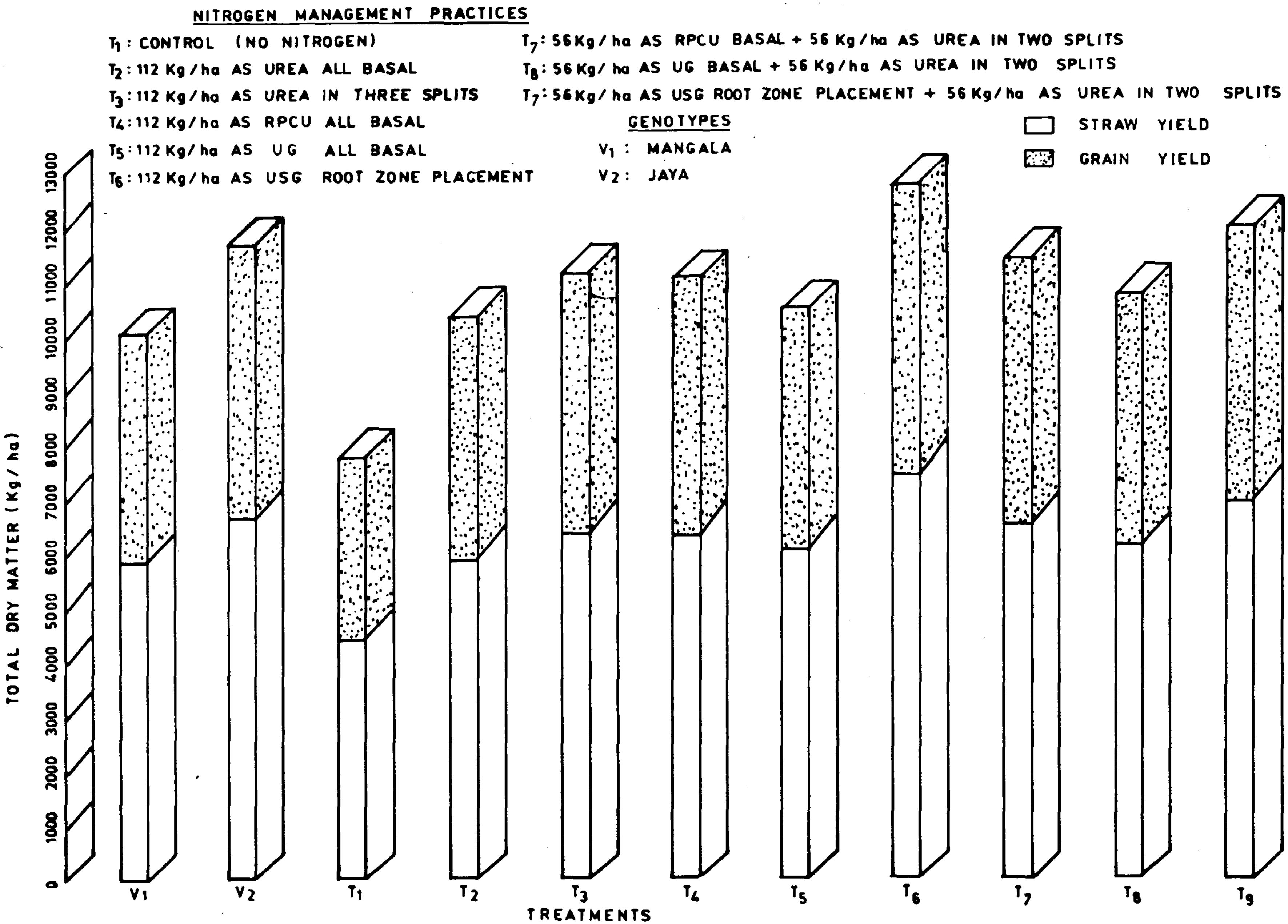


FIG. 5. TOTAL DRY MATTER (Kg/ha) AS INFLUENCED BY GENOTYPES AND NITROGEN MANAGEMENT PRACTICES

i.e. T_2 (10356 kg/ha) and no nitrogen i.e. T_1 (7779 kg/ha). However, there was no significant difference between T_7 and T_3, T_3 and T_4, T_4 and T_8, T_8 and T_5 and T_5 and T_2.

The total dry matter varied significantly due to interaction of genotypes and nitrogen management practices. Maximum dry matter yield (13923 kg/ha) was recorded with V_2 T_6 and was significantly superior to other combinations (13202 to 7685 kg/ha). The lowest dry matter yield (7685 kg/ha) was obtained with V_1T_1combination.

4.1.12 Grain to straw ratio

The data on grain to straw ratio was influenced by gemotypes and nitrogen management practices are presented in ɫ Table 16.

Over the nitrogen management practices, grain to straw ratio not varied significantly due to genotypes. However, maximum grain to straw ratio (0.76) was recorded with Jaya (V_2) compared to Mangala i.e. V_1 (0.73).

Over the genotypes, grain to straw ratio not vaiied significantly due to nitrogen management practices. However, maximum ratio (0.76) was obtained with no nitrogen (T_1) and the least ratio (0.70) was obtained with 112 kg/ha through USG root zone placement (T_6).

Table 16. Grain to straw ratio as influenced by genotypes and nitrogen management practices

Nitrogen management practices		Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	0.76	0.77	0.76
T_2	112 kg/ha as urea all basal	0.74	0.78	0.76
T_3	112 kg/ha as urea in 3 splits	0.76	0.74	0.75
T_4	112 kg/ha as RPCU all basal	0.71	0.78	0.75
T_5	112 kg/ha as UG all basal	0.73	0.74	0.74
T_6	112 kg/ha as USG root zone placement	0.72	0.68	0.70
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	0.71	0.81	0.76
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	0.72	0.76	0.74
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	0.71	0.75	0.73
	Mean	0.73	0.76	

	Genotypes	Nitrogen management	Interaction
'F' test	NS	NS	NS
S.Em ±	0.011	0.022	0.023
C.D.(at 5%)	-	-	-

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

Grain to straw ratio not varied significantly due to interaction of genotypes and nitrogen management practices. However, maximum grain to straw ratio (0.81) with $V_2 T_7$ interaction and the least (0.68) was obtained with $V_2 T_6$ interaction.

4.1.13 Harvest Index (%)

The data on Harvest Index as influenced by genotypes and nitrogen management practices are presented in Table 17.

Over the nitrogen management practices, there was significant difference in harvest index due to genotypes. Jaya (V_2) recorded maximum (43.0%) harvest index and was significantly superior to Mangala i.e. V_1 (41.9%).

Over the genotypes, harvest index not varied significantly due to nitrogen management practices. However, maximum harvest index (43.3%) was recorded with no nitrogen (T_1) and lowest harvest index (40.1%) was obtained with 112 kg/ha through USG root zone placement(T_6).

There was no significant difference in harvest index due to interaction of genotypes and nitrogen management practices. However, maximum (44.6%) was recorded with V_2T_7 interaction and the least (39.8%) was recorded with V_1T_6 interaction.

Table 17. Harvest index (%) as influenced by genotypes and nitrogen management practices

Nitrogen management practices		Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	43.1	43.5	43.3
T_2	112 kg/ha as urea all basal	42.6	43.7	43.2
T_3	112 kg/ha as urea in 3 splits	43.2	42.5	42.8
T_4	112 kg/ha as RPCU all basal	41.4	43.9	42.7
T_5	112 kg/ha as UG all basal	42.1	42.7	42.4
T_6	112 kg/ha as USG root zone placement	39.8	40.4	40.1
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	41.4	44.6	43.0
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	41.7	43.2	42.5
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	41.4	42.8	42.1
	Mean	41.9	43.0	

	Genotypes	Nitrogen management	Inter - action
'F' test	*	NS	NS
S.Em ±	0.373	0.792	0.576
C.D. (at 5%)	1.071	-	-

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

4.1.14 Light absorption percentage

The data on light absorption per cent in rice as influenced by genotypes and nitrogen management practices are presented in Table 18 and Fig.6.

Over the nitrogen management practices, high absorpbtion percentage varied significantly due to genotypes. Maximum light absorption per cent (54.0) was recorded with Jaya (V_2) compared to Mangala i.e. V_1(49.7).

Over the genotypes, light absorption percentage varied significantly due to nitrogen management practices. Maximum light absorption (61.8%) was obtained with 112 kg/ha through USG root zone placement (T_6) and was significantly superior to 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9 (57.7%), 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. T_7(56.1%) 112 kg/ha through RPCU all basal i.e. T_4 (53.3%), 112 kg/ha through urea in three splits i.e. T_3 (52.1%), 56 kg/ha through UG basal + 56 kg/ha through urea in two splits i.e. T_8 (50.4%), 112 kg/ha through UG all basal i.e. T_5 (50.0%), 112 kg/ha through urea all basal i.e. T_2 (47.6%) and no nitrogen i.e. T_1(37.6%). However, there was no significant difference between T_9 and T_7, T_4 and T_3, T_3 and T_8, T_3 and T_5, T_8 and T_5 and T_5 and T_2.

Table 18. Light Absorption (%) as influenced by genotypes and nitrogen management practices

	Nitrogen management practices	Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	34.6	40.6	37.6
T_2	112 kg/ha as urea all basal	45.4	49.8	47.6
T_3	112 kg/ha as urea in 3 splits	49.7	54.4	52.1
T_4	112 kg/ha as RPCU all basal	51.6	55.0	53.3
T_5	112 kg/ha as UG all basal	49.1	51.1	50.1
T_6	112 kg/ha as USG root zone placement	59.5	64.2	61.8
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	53.0	59.1	56.1
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	48.9	51.9	50.4
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	55.5	60.0	57.7
	Mean	49.7	54.0	

	Genotypes	Nitrogen management	Interaction
'F' test	**	**	NS
S.Em ±	0.532	1.128	1.595
C.D. (at 5%)	1.270	2.694	-

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

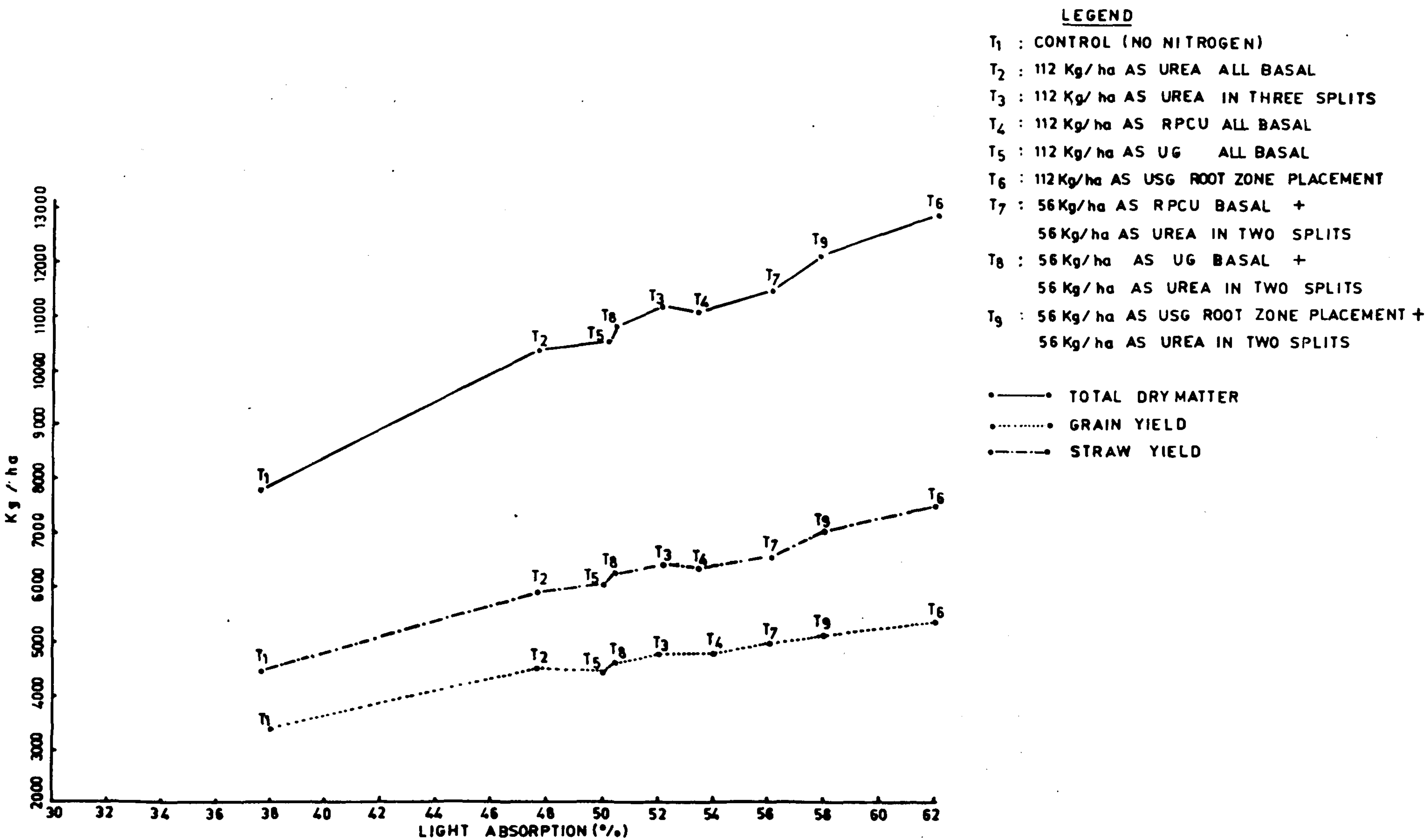


FIG.6. TOTAL DRYMATTER, GRAIN YIELD, STRAW YIELD AND LIGHT ABSORPTION AS INFLUENCED BY GENOTYPES AND NITROGEN MANAGEMENT PRACTICES

The light absorption per cent not varied significantly due to interaction of genotypes and nitrogen management practices. However, maximum light absorption (64.2%) was recorded with V_2T_6 interaction and the lowest (34.6%) was obtained with V_1T_1 interaction.

4.1.15. <u>Nitrogen concentration</u>

<u>Grain</u>

The data on the nitrogen concentration in grain as influenced by genotypes and nitrogen management practices are presented in Table 19.

Over the nitrogen management practices, the nitrogen concentration in grain not varied significantly due to genotypes. Both the genotypes Mangala (V_1) and Jaya (V_2) recorded same nitrogen concentration (1.40%).

Over the genotypes, the nitrogen concentration in grain varied significantly due to nitrogen management practices. Maximum nitrogen concentration (1.45%) was recorded with 112 kg/ha through urea in three splits (T_3). T_3 was statistically on par with all other treatments except no nitrogen i.e. T_1 (1.17%).

There was no significant difference in grain nitrogen concentration due to interaction of genotypes and nitrogen

Table 19. Nitrogen concentration (%) in grain as influenced by genotypes and nitrogen management practices

Nitrogen management practices		Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	1.13	1.21	1.17
T_2	112 kg/ha as urea all basal	1.43	1.41	1.42
T_3	112 kg/ha as urea in 3 splits	1.46	1.44	1.45
T_4	112 kg/ha as RPCU all basal	1.43	1.41	1.42
T_5	112 kg/ha as UG all basal	1.39	1.40	1.39
T_6	112 kg/ha as USG root zone placement	1.46	1.44	1.45
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	1.43	1.41	1.42
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	1.44	1.44	1.44
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	1.45	1.45	1.45
	Mean	1.40	1.40	

	Genotypes	Nitrogen management	Inter-action
'F' test	NS	**	NS
S.Em ±	0.11	0.025	0.016
C.D.(at 5%)	-	0.071	-

RPCU = Rock phosphate coated urea
UG = Urea gypsum
USG = Urea super granules

management practices. However, maximum (1.46%) with V_1T_5 and V_1T_6 interaction and the lowest (1.13%) was recorded with V_1T_1 interaction.

Straw

The data on the nitrogen concentration in straw as influenced by genotypes and nitrogen management practices are presented in Table 20.

Over the nitrogen management practices, the nitrogen concentration in straw varied significantly due to genotypes. Maximum nitrogen concentration (0.81%) was observed with Jaya (V_2) and was significantly superior to Mangala, i.e. V_1 (0.75%).

Over the genotypes, the nitrogen concentration in straw varied significantly due to nitrogen management practices. Maximum nitrogen concentration (0.81%) was observed with 56 kg/ha through UG basal + 56 kg/ha through urea in two splits (T_8) and was statistically on par with 112 kg/ha through RPCU all basal i.e. T_4 (0.81%), 112 kg/ha through UG all basal i.e. T_5 (0.80%), T_8 was significantly superior to 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. T_7(0.79%), 112 kg/ha through urea all basal i.e. T_2(0.77%), 56 kg/ha through USG root zone placement +

Table 20. Nitrogen concentration (%) in straw at harvest as influenced by genotypes and nitrogen management practices

Nitrogen management practices	Genotypes		Mean
	Mangala (V_1)	Jaya (V_2)	
T_1 Control (no nitrogen)	0.71	0.78	0.74
T_2 112 kg/ha as urea all basal	0.74	0.80	0.77
T_3 112 kg/ha as urea in 3 splits	0.73	0.81	0.77
T_4 112 kg/ha as RPCU all basal	0.78	0.84	0.81
T_5 112 kg/ha as UG all basal	0.80	0.80	0.80
T_6 112 kg/ha as USG root zone placement	0.73	0.79	0.76
T_7 56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	0.76	0.82	0.79
T_8 56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	0.80	0.83	0.81
T_9 56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	0.74	0.80	0.77
Mean	0.75	0.81	

	Genotypes	Nitrogen management	Interaction
'F' test	**	**	*
S.Em ±	0.004	0.009	0.014
C.D. (at 5%)	0.012	0.026	0.045

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

56 kg/ha through urea in two splits i.e. T_9 (0.77%), 112 kg/ha through urea in three splits i.e. T_3 (0.77%), 112 kg/ha through USG root zone placement i.e. T_6 (0.76%) and no nitrogen i.e. T_1 (0.74%). However, there was no significant difference between T_4 and T_5, T_4 and T_7, T_5 and T_7, T_7 and T_2, T_7 and T_9, T_9 and T_3, T_2 and T_9, T_2 and T_3, T_9 and T_3, T_2 and T_6, T_9 and T_6, T_3 and T_6, T_9 and T_1, T_3 and T_1 and T_6 and T_1.

Nitrogen concentration in straw varied significantly due to interaction of genotypes and nitrogen management practices. Maximum nitrogen concentration (0.84%) was obtained with V_2T_4 interaction and the least (0.71%) was obtained with V_1T_1 combination.

4.1.16 Nitrogen uptake

The data on the total nitrogen uptake was influenced by genotypes and nitrogen management practices are presented in Table 21 and Fig.7.

Over the nitrogen management practices, the total nitrogen uptake varied significantly due to genotypes. Maximum nitrogen uptake (124.2 kg/ha) was recorded with Jaya (V_2) and was statistically superior to Mangala i.e. V_1 (103.9 kg/ha).

Table 21. Total nitrogen uptake (kg/ha) as influenced by genotypes and nitrogen management practices

Nitrogen management practices		Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	69.4	76.5	72.9
T_2	112 kg/ha as urea all basal	100.8	117.3	109.1
T_3	112 kg/ha as urea in 3 splits	106.8	130.5	118.6
T_4	112 kg/ha as RPCU all basal	107.6	129.6	118.6
T_5	112 kg/ha as UG all basal	104.0	118.2	111.1
T_6	112 kg/ha as USG root zone placement	117.0	145.6	131.3
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	108.7	135.1	121.9
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	108.2	123.5	115.9
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	112.1	141.4	126.8
	Mean	103.9	124.2	

	Genotypes	Nitrogen management	Interaction
'F' test	**	**	*
S.Em ±	1.193	2.531	2.531
C.D.(at 5%)	3.422	7.259	12.303

RPCU = Rock phosphate coated urea

UG = Urea gypsum

SUG = Urea super granules

GENOTYPES

V_1 : MANGALA

V_2 : JAYA

NITROGEN MANAGEMENT PRACTICES

T_1 : CONTROL (NO NITROGEN)

T_2 : 112 Kg/ha AS UREA ALL BASAL

T_3 : 112 Kg/ha AS UREA IN THREE SPLITS

T_4 : 112 Kg/ha AS RPCU ALL BASAL

T_5 : 112 Kg/ha AS UG ALL BASAL

T_6 : 112 Kg/ha AS USG ROOT ZONE PLACEMENT

T_7 : 56 Kg/ha AS RPCU BASAL + 56 Kg/ha AS UREA IN TWO SPLITS

T_8 : 56 Kg/ha AS UG BASAL + 56 Kg/ha AS UREA IN TWO SPLITS

T_9 : 56 Kg/ha AS USG ROOT ZONE PLACEMENT + 56 Kg/ha AS UREA IN TWO SPLITS

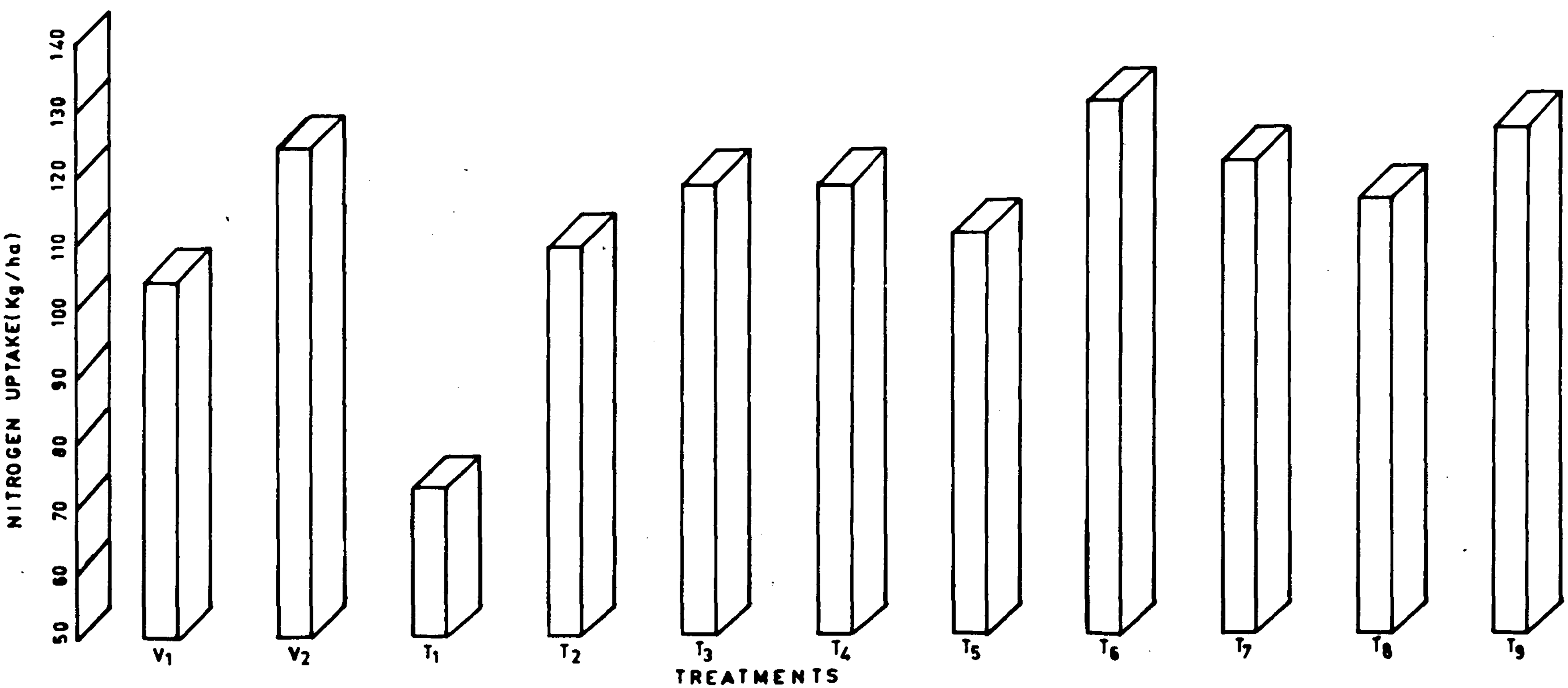


FIG.7 NITROGEN UPTAKE (Kg/ha) AS INFLUENCED BY GENOTYPES AND NITROGEN MANAGEMENT PRACTICES.

Over the genotypes, the total nitrogen uptake varied significantly due to nitrogen management practices. Maximum uptake (131.3 kg/ha), was recorded with 112 kg/ha through USG root zone placement (T_6) and was statistically on par with 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits i.e. T_9 (126.8 kg/ha). T_6 was statistically superior compared to 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. * T_7 (121.9 kg/ha), 112 kg/ha through urea in three splits i.e. T_3 (118.6 kg/ha), 112 kg/ha through RPCU all basal i.e. T_4 (118.6 kg/ha), 56 kg/ha through UG basal + 56 kg/ha through urea in two splits i.e. T_8 (115.9 kg/ha), 112 kg/ha through UG all basal i.e. T_5 (111.1 kg/ha), 112 kg/ha through urea all basal i.e. T_2 (109.1 kg/ha) and no nitrogen i.e. T_1 (72.9 kg/ha). However, there was no significant difference between T_9 and T_7, T_7 and T_3, T_7 and T_4, T_7 and T_8, T_3 and T_4, T_3 and T_8, T_4 and T_8, T_8 and T_5, T_8 and T_2 and T_5 and T_2.

Total nitrogen uptake varied significantly due to interaction of genotypes and nitrogen management practices. Maximum uptake (145.6 kg/ha) was recorded with V_2T_6 interaction and was statistically on par with V_2T_9 and V_2T_7 interactions. The lowest uptake (69.4 kg/ha) was recorded with V_1T_1 interaction.

4.1.17 Apparent recovery of nitrogen

The data on apparent recovery of nitrogen as influenced by genotypes and nitrogen management practices are presented in Table 22.

Over the nitrogen management practices, apparent recovery of nitrogen varied significantly due to genotypes. Maximum apparent recovery (48.3%) was observed in Jaya (V_2) and was significantly superior to Mangala i.e. V_1 (34.7%).

Over the genotypes, apparent recovery of nitrogen varied significantly due to nitrogen management practices. Maximum apparent recovery (52.1%) was observed with 112 kg/ha through USG root zone placement (T_6) and was statistically on par with 56 kg/ha through USG root zone placement i.e. T_9 (48.1%), T_6 was significantly superior compared to 56 kg/ha through RFCU basal + 56 kg/ha through urea in two splits i.e. T_7(43.7%), 112 kg/ha through urea in three splits i.e. T_3 (40.9%), 112 kg/ha through RFCU all basal i.e. T_4 (40.8%), 56 kg/ha through UG basal + 56 kg/ha through urea in two splits i.e. T_8 (38.4%), 112 kg/ha through UG all basal i.e. T_5 (34.2%) and 112 kg/ha through urea all basal i.e. T_2 (33.6%). However, there was no significant difference between T_9 and T_7, T_7 and T_3, T_7 and T_4, T_7 and T_8, T_3 and T_4, T_3 and T_8, T_4 and T_8, T_3 and T_5, T_4 and T_5, T_8 and T_5 , T_8 and T_2 and T_5 and T_2.

Table 22. Apparent recovery (%) as influenced by genotypes and nitrogen management practices

Nitrogen management practices		Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	-	-	-
T_2	112 kg/ha as urea all basal	28.1	38.1	33.6
T_3	112 kg/ha as urea in 3 splits	33.5	48.2	40.9
T_4	112 kg/ha as RPCU all basal	34.2	47.5	40.8
T_5	112 kg/ha as UG all basal	31.1	37.3	34.2
T_6	112 kg/ha as USG root zone placement	42.5	61.7	52.1
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	35.1	52.4	43.7
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	34.7	42.0	38.4
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	38.2	58.0	48.1
	Mean	34.7	48.3	

	Genotypes	Nitrogen management	Interaction
'F' Test	**	**	NS
S.Em ±	1.177	2.353	2.574
C.D.(at 5%)	3.389	6.779	-

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

Apparent recovery of nitrogen not varied significantly due to interaction of genotypes and nitrogen management practices. However, maximum apparent recovery (61.7%) was recorded with $V_2 T_6$ interaction and the lowest (28.1) was recorded with $V_1 T_2$ interaction.

4.2. Succeeding fodder cowpea

4.2.1 Plant height

The data on the residual effect of rice genotypes and nitrogen management practices on the plant height of fodder cowpea are presented in Table 23.

Over the residual nitrogen management practices after rice, plant height of succeeding fodder cowpea not varied significantly due to residual effect of rice genotypes. Maximum plant height (25.1 cm) was recorded with the plot where Mangala (V_1) was grown, compared to Jaya i.e. V_2 (24.6 cm).

Over the residual effect of rice genotypes, plant height of succeeding fodder cowpea not varied significantly due to residual nitrogen management practices after rice. However, maximum plant height (29.0 cm) was recorded with residual effect of 112 kg/ha through USG root zone placement (T_6) and the least plant height (20.4 cm) was recorded with no nitrogen (T_1).

Table 23. Residual effect of rice genotypes and nitrogen management practices on plant height (cm) of cowpea

	Nitrogen management practices	Genotypes Mangala (V_1)	Jaya (V_2)	Mean
T_1	Control (no nitrogen)	20.0	20.9	20.4
T_2	112 kg/ha as urea all basal	24.4	22.8	23.6
T_3	112 kg/ha as urea in 3 splits	27.7	23.5	25.6
T_4	112 kg/ha as RPCU all basal	25.8	22.1	24.0
T_5	112 kg/ha as UG all basal	26.6	22.8	24.7
T_6	112 kg/ha as USG root zone placement	28.1	30.0	29.0
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	23.1	24.0	23.6
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	24.3	26.1	25.2
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	25.7	29.5	27.6
	Mean	25.1	24.6	

	Genotypes	Nitrogen management	Interaction
'F' test	NS	NS	NS
S.Em ±	1.111	2.357	1.486
C.D. (at 5%)			

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

Plant height of succeeding fodder cowpea not varied significantly due to interaction of residual effect of rice genotypes and residual nitrogen management practices after rice. Maximum plant height (29.9 cm) was observed with $V_2 T_6$ interaction and the lowest (20.0 cm) was observed with V_1T_1 interaction.

4.2.2 <u>Number of branches per plant</u>

The data on the residual effect of rice genotypes and nitrogen management practices on the number of branches per plant of succeeding fodder cowpea are presented in Table 24.

Over the residual nitrogen management practices after rice, number of branches per plant of succeeding fodder cowpea not varied significantly due to residual effect of rice genotypes. More number of branches (3.2) was recorded with plot where Mangala (V_1) was grown compared to Jaya, i.e. V_2 (3.1).

Over the residual effect of rice genotypes, number of branches per plant of succeeding fodder cowpea not varied significantly due to residual nitrogen management practices after rice. However, more branches (3.5) was recorded with 56 kg/ha through USG basal + 56 kg/ha

Table 24. Residual effect of rice genotypes and nitrogen management practices on number of branches in cowpea

Nitrogen management practices		Genotypes: Mangala (V_1)	Genotypes: Jaya (V_2)	Mean
T_1	Control (no nitrogen)	2.5	2.3	2.4
T_2	112 kg/ha as urea all basal	3.3	3.2	3.2
T_3	112 kg/ha as urea in 3 splits	3.3	3.3	3.3
T_4	112 kg/ha as RPCU all basal	3.3	3.1	3.2
T_5	112 kg/ha as UG all basal	3.1	3.1	3.1
T_6	112 kg/ha as USG root zone placement	3.5	3.4	3.4
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	3.3	3.3	3.3
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	3.3	3.3	3.3
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	3.6	3.4	3.5
	Mean	3.2	3.2	

	Genotypes	Nitrogen management	Interaction
'F' test	NS	*	NS
S.Em ±	0.091	0.194	0.045
C.D.(at 5%)	-	0.556	-

RPCU = Rock phosphate coated urea

UG = Urea gypsum

USG = Urea super granules

through urea in two splits (T_9) and the least (2.4) was recorded with no nitrogen (T_1).

Number of branches per plant of succeeding fodder cowpea not varied significantly to interaction of residual effect of rice genotypes and residual nitrogen management practices after rice. However, more branches (3.6) was recorded with V_1 T_9 interactions and the least (2.3) was recorded with V_2 T_1 interaction.

4.2.3 Fodder yield

The data on the residual effect of rice genotypes and nitrogen management practices on the fodder yield of the succeeding fodder cowpea are presented in Table 25 and Fig.8.

Over the residual nitrogen management practices after rice, there was significant difference in the fodder yield of succeeding fodder cowpea due to residual effect of rice genotypes. Maximum fodder yield (9931 kg/ha) was obtained with the plot where Mangala (V_1) was grown and was significantly superior to Jaya i.e. V_2 (9219 kg/ha).

Over the residual effect of rice genotypes, fodder yield of succeeding cowpea varied significantly due to residual nitrogen management practices. Maximum fodder

Table 25. Residual effect of rice genotypes and nitrogen management practices on fodder yield (kg/ha) of cowpea

	Nitrogen management practices	Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	8717	7620	8168
T_2	112 kg/ha as urea all basal	10562	8660	9611
T_3	112 kg/ha as urea in 3 splits	10292	9443	9863
T_4	112 kg/ha as RPCU all basal	8753	8159	8456
T_5	112 kg/ha as UG all basal	9801	8876	9339
T_6	112 kg/ha as USG root zone placement	10888	10339	10564
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	8594	8414	8504
T_8	56 kg/ha as UG Basal + 56 kg/ha as urea in 2 splits	9432	9778	9605
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	12442	11691	12067
	Mean	9931	9219	

	Genotypes	Nitrogen management	Inter-action
'F' test	*	**	NS
S.Em ±	200.98	426.35	312.29
C.D. (at 5%)	576.48	1222.91	-

RPCU = Rock phosphate coated urea
UG = Urea gypsum
USG = Urea super granules

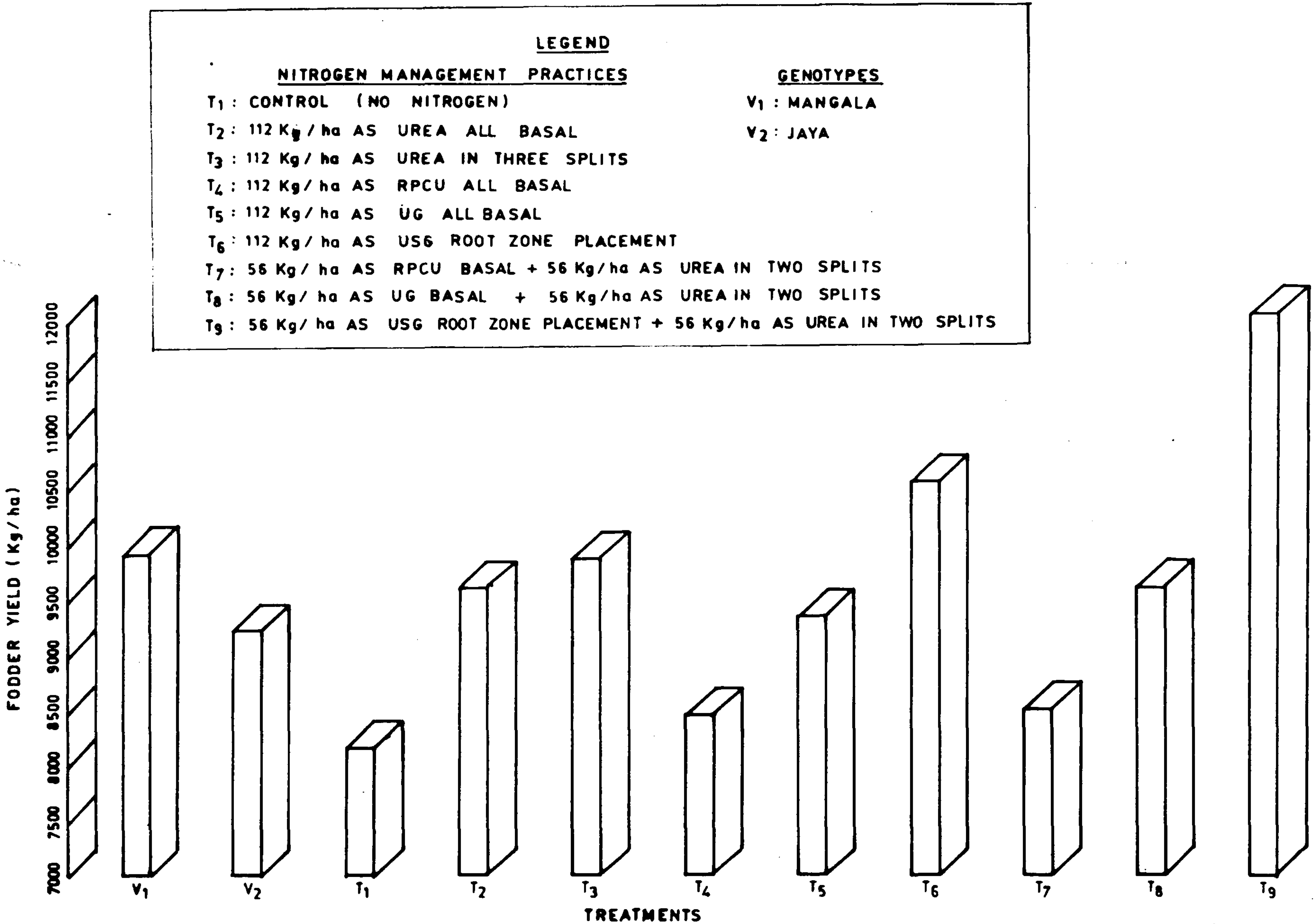


FIG.8. EFFECT OF RICE GENOTYPES AND NITROGEN MANAGEMENT PRACTICES ON THE SUCCEEDING COWPEA FODDER YIELD (Kg / ha).

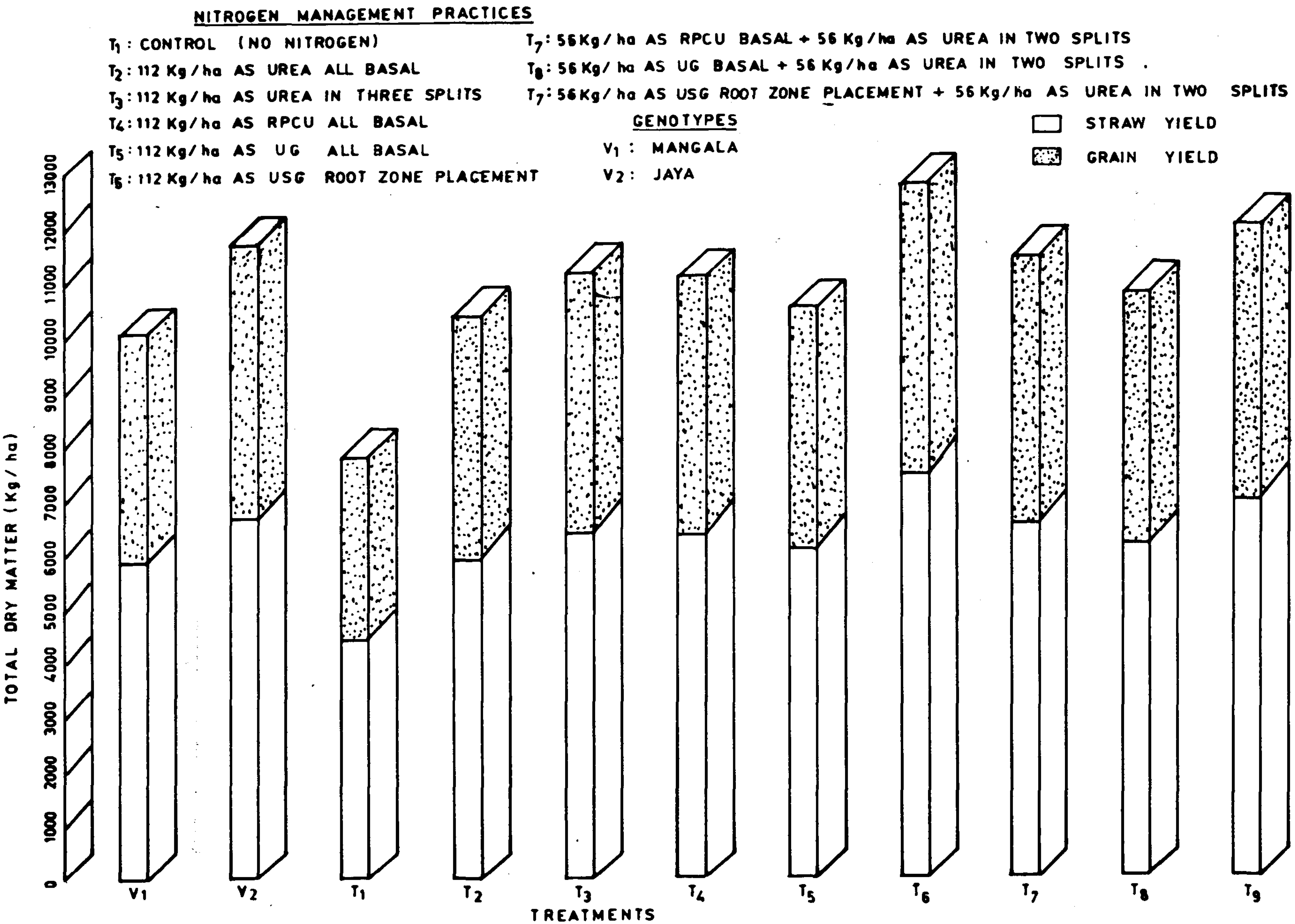


FIG. 5. TOTAL DRY MATTER (Kg/ha) AS INFLUENCED BY GENOTYPES AND NITROGEN MANAGEMENT PRACTICES

yield (12067 kg/ha) was obtained with 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits (T_9) and was statistically superior compared to 112 kg/ha through USG root zone placement i.e. T_6 (10564 kg/ha). 112 kg/ha through urea in three splits i.e. T_3 (9863 kg/ha), 112 kg/ha through urea all basal i.e. T_2 (9611 kg/ha), 56 kg/ha through UG basal + 56 kg/ha through urea in two splits i.e. T_8 (9605 kg/ha), 112 kg/ha through UG all basal i.e. T_5 (9339 kg/ha), 56 kg/ha through RPCU basal + 56 kg/ha through urea in two splits i.e. T_7 (8504 kg/ha), 112 kg/ha through RPCU all basal i.e. T_4 (8456 kg/ha) and no nitrogen i.e. T_1 (8168 kg/ha). However, there was no significant difference between T_6 and T_3, T_6 and T_2, T_6 and T_8, T_3 and T_2, T_3 and T_8, T_2 and T_8, T_3 and T_5, T_2 and T_5, T_8 and T_5, T_2 and T_7, T_2 and T_4, T_5 and T_7, T_5 and T_4, T_5 and T_1, T_7 and T_4, T_7 and T_1 and T_4 and T_1.

There was no significant difference in fodder yield of succeeding cowpea due to interaction residual effect of rice genotypes and residual nitrogen management practices. However, maximum fodder yield (12442 kg/ha) was obtained with $V_1 T_9$ interaction and the least (7620 kg/ha) was obtained with V_2T_1 interaction.

4.2.4 Nitrogen concentration (per cent) in fodder

The data on the residual effect of rice genotypes and nitrogen management practices on the nitrogen concentration in succeeding fodder cowpea are presented in Table 26.

Over the residual nitrogen management practices after rice, there was no significant difference in the nitrogen concentration of the succeeding fodder cowpea due to residual effect of rice genotypes. Maximum nitrogen concentration (3.48%) was observed with the plot where Mangala (V_1) was grown compared to Jaya i.e. V_2 (3.31%).

Over the residual effect of rice genotypes, there was no significant difference in the nitrogen concentration of cowpea due to residual nitrogen management practices. However, maximum nitrogen concentration (3.81%) was observed with 112 kg/ha through USG root zone placement (T_6) and the least (3.15%) was recorded with 112 kg/ha as UG all basal i.e. T_5.

Nitrogen concentration in succeeding fodder cowpea not varied significantly due to the interaction of residual

Table 26. Residual effect of rice genotypes and nitrogen management practices on nitrogen concentration in fodder cowpea

	Nitrogen management practices	Genotypes		Mean
		Mangala (V_1)	Jaya (V_2)	
T_1	Control (no nitrogen)	3.24	3.14	3.19
T_2	112 kg/ha as urea all basal	3.59	3.13	3.36
T_3	112 kg/ha as urea in 3 splits	3.53	3.19	3.36
T_4	112 kg/ha as RPCU all basal	3.58	3.37	3.47
T_5	112 kg/ha as UG all basal	3.02	3.27	3.15
T_6	112 kg/ha as USG root zone placement	3.75	3.87	3.81
T_7	56 kg/ha as RPCU basal + 56 kg/ha as urea in 2 splits	3.33	3.41	3.37
T_8	56 kg/ha as UG basal + 56 kg/ha as urea in 2 splits	3.43	3.10	3.26
T_9	56 kg/ha as USG root zone placement + 56 kg/ha as urea in 2 splits	3.89	3.33	3.61
	Mean	3.48	3.31	

	Genotypes	Nitrogen management	Interaction
'F' Test	NS	NS	NS
S.Em ±	0.092	0.195	0.139
C.D.(at 5%)	-	-	-

RPCU = Rock phosphate coatedm urea

UG = Urea gypsum

USG = Urea super granules

effect of rice genotypes and residual nitrogen management practices. Maximum (3.87%) was recorded with V_2T_6 interaction and the least (3.02) was recorded with V_1T_5 interaction.

DISCUSSION

V. DISCUSSION

A field experiment was conducted during 1983-84 at the Wet land block, Main Research Station, University of Agricultural Sciences, Bangalore to study the response of rice genotypes of early and long duration to different sources, time and method of nitrogen application, to evaluate the relative efficiency of modified urea materials in influencing the growth, grain yield as well as nitrogen use efficiency. Besides, to assess the residual effect, if any, of different sources, time and method of nitrogen application in kharif rice on the growth of succeeding fodder legume.

In general, the crop growth was normal without any incidence of pests and diseases. Weather conditions were normal with little deviations. An examination of the mean grain yield levels also revealed that the weather had apparently no adverse effect on the experimental crop. Rainfall during the rice crop growth period was 651.1 mm.

Seed to seed duration of the genotypes under test were 121 (Mangala) and 156 (Jaya) days. They occupied the main field from 29th June to 2nd November (Mangala) and 29th June to 5th December (Jaya). Cowpea genotype C-152 which was sown on 11th January 1985 occupied the field for 50 days.

Relative performance of rice genotypes

Rice genotypes exhibit significant differences in dry matter accumulation. Averaged over the nitrogen management practices, there was increase in dry matter accumulation from panicle emergence to harvest. Patnaik and Nanda (1969) and Thimmegowda (1985) found that there was a rapid increase in the dry matter production from panicle initiation to flowering stage. Mikkelsen (1970) observed that three fourth of the total dry matter was produced in rice from the beginning to 10 per cent flowering. On an average, maximum dry matter accumulation of 17.7 g/hill and 22.4 g/hill was obtained during panicle emergence and at harvest, respectively. Whereas, Jaya produced maximum dry matter (18.2 and 24.1 g/hill during panicle emergence and at harvest, respectively) compared to Mangala (17.2 and 20.6 g/hill during panicle emergence and at harvest, respectively). The reason for higher dry matter accumulation with Jaya may be possibly due to higher total dry matter production through more number of shoots (15.7 per hill) and also higher canopy as there was higher light absorption (54.0 per cent). Prathap Reddy (1982) observed similar differences and attributed the difference to the duration of the genotype and resulted in better utilisation of added and inherent nutrients from the soil. Higher dry matter accumulation through increased plant height, more number of shoots and physiologically active green leaves retained for a longer period were provided room for increased photosynthetic activity was also explained by Black (1965) and Thimmegowda (1985).

Assessment of total dry matter production during the growth period due to different genotypes indicated that higher total dry matter of 11696 kg/ha was obtained with Jaya, whereas lowest (10090 kg/ha) was recorded with Mangala. The low dry matter with Mangala may be due to reduced size of the photosynthesising surface (through less number of tillers and low level of light absorption) which might have cause reduction in crop growth. These consequently reduced the total straw yield production and in turn grain yield. This is in confirmation with the work of Subbaiah (1983).

Maximum grain yield of 5040 kg/ha was obtained with Jaya and it was 4243 kg/ha with Mangala. Jaya also recorded higher harvest index (43.0%) compared to Mangala (41.9%). This indicates the efficiency of Jaya in converting part of dry matter towards economic yield. The lower harvest index in Mangala may be due to tall stature, protracted tillering and production of non productive tillers. Similar results were reported by Prathap Reddy

(1982) that tall short duration genotypes recorded lower harvest index.

In general, the potential of a long duration genotype like Jaya is higher. Yogeshwar Rao _et al_.(1974), Harihara Reddy (1977), Mangal Prasad and Rejendra Prasad (1980) and Sreerama Murthy (1984) reported that higher yield with a medium duration genotypes compared to short duration genotypes. The main feature which seems important in a high yielding rice like Jaya was that it had more number of panicles (12.8 per hill) at maturity. Such a higher panicle per hill was possible due to better utilisation of available nutrients because of longer duration which might have helped in determining the relatively more panicles. In addition, it favoured the formation of bigger sized grains (28 g/1000 grain) which ultimately lead to heavier mean grain weight/hill. In addition, it favoured the ear length (21.3 cm). This study agrees with that of Thimmegowda (1985) who found that absolute panicles to be determinent factor of yield difference in rice crop. The two rice genotypes studied also differed in their duration (Mangala 121 days and Jaya 156 days) and several workers reported that longer the duration higher the grain yield (Krishnamurthy _et al_.,1972; Panchaksheriah _et al_., 1972; Gangadharaiah, 1983 and Siddagangaiah, 1985).

Nitrogen management practices on growth and yield of rice

Plant growth is dependent on the rate of accumulation of dry matter. An adequate supply of plant nutrients is necessary for enhanced metabolic activity which in turn would influence plant growth. The dry matter accumulation in rice varied due to different nitrogen management practices. Based on the average value obtained from all the treatments, higher dry matter accumulation as influenced by nitrogen management practices was obtained at harvest (23.4 g/hill) compared to panicle emergence stage (17.7 g/hill). Maximum dry matter accumulation of 28.5 g/hill at harvest was obtained with root zone placement of urea supergranules at 112 kg/ha (T_6). This was followed by 56 kg/ha as urea supergranules root zone placement + 56 kg/ha as urea in two splits i.e. T_9 (26.0 g/hill). T_6 gave significantly higher dry matter accumulation compared to 56 kg/ha as RPCU basal + 56 kg/ha as urea in two splits i.e. T_7(23.9 g/hill). 112 kg/ha as RPCU all basal i.e. T_4 (23.6 g/hill), 112 kg/ha as urea in three splits i.e. T_3 (22.4 g/hill), 112 kg/ha as urea all basal i.e. T_2 (20.3 g/hill), 56 kg/ha as UG basal + 56 kg/ha as urea in two splits i.e. T_8(20.2 g/hill). The lowest dry matter accumulation of 15 g/hill was obtained with no nitrogen (T_1). The reason for higher dry matter accumulation with root zone placement of USG at 112 kg/ha may possibly due to higher total dry matter production through increased plant height (79.9 cm), more number of shoots (19.3 per hill) and higher light absorption (61.8%) and in turn might have provided room for increased photosynthetic activity (Black, 1965). Singh and Modgal (1978) noticed a steady increase in dry weight of rice plants as the amount of nitrogen increased. This is also in confirmity with the work of Thimmegowda (1985). Continuous and efficient supply of nutrients during the period of crop growth by deep placement of urea supergranules may possibly due to the reduced nitrogen losses by leaching, denitrification and volatilization through nitrogen losses through various mechanisms depend on physico chemical properties of soil. Similar increase in dry matter production due to deep placement of urea was reported by several earlier workers (Simsiman et al.,1967; Reddy and Freeman, 1973; Rambabu, 1980; Prathap Reddy, 1982 and Sreerama Murthy, 1984).

Assessment of total dry matter production during the growth period under different nitrogen management practices indicate that higher total dry matter of 12693 kg/ha was obtained with T_6 and was followed by T_9 (12047 kg/ha), T_7 (11483 kg/ha), T_3 (11161 kg/ha), T_4(11078 kg/ha), T_8(10757 kg/ha), T_5 (10565 kg/ha), T_2 (10356 kg/ha). The lower total dry matter (7779 kg/ha) was obtained with T_1. In the present study, plants with no nitrogen recorded low plant growth rate and resulted in early senescence and quick drying of leaves and in turn reduced the size of the photosynthetic surface which caused reduction in crop growth. These consequently reduced the total straw yield production and in turn grain yield. This is in confirmity with the work of Ries et al. (1976), Subbaiah and Schidev (1983) and Thimmegowda (1985).

The product of number of shoots and plant height can be taken as an indication of the dry matter production of the plant during the vegetative stages (Matsushima, 1980). These growth components can be considered for substantiating the straw yield variations. The maximum number of shoots per hill (19.3) was obtained with T_6. Whereas maximum plant height of 79.9 cm and 77.8 cm was recorded with T_6 and T_9, respectively.

There was significant difference in straw yield due to nitrogen management practices. Deep placement of urea supergranules at 112 kg/ha (7476 kg/ha) recorded higher straw yield compared to other nitrogen management practices (5884 to 6966 kg/ha). The lower straw yield (4408 kg/ha) was obtained with no nitrogen. Increase in straw yield due to root zone placement of urea supergranules in the present investigation finds support in the work of Rambabu (1980), Prathap Reddy (1982) and Sreerama Murthy (1984) who also reported similar results.

Maximum grain yield of 5336 kg/ha was obtained with T_6 and was followed by T_9 (5081 kg/ha) although both were on par with each other. The lowest grain yield of 3371 kg/ha was obtained with T_1. The higher grain yield obtained with T_6 and T_9 might have been due to adequate supply of nutrients throughout the growth period, because of continuous availability of ammonia through slow mineralisation particularly in treatments receiving urea supergranules. These are quite in confirmity with the earlier findings, where root zone placement has given better results, especially in urea where split application of nitrogen is neither desirable nor possible because of too much of standing water in the field acting as a physical barrier for top dressing nitrogen at critical stages of plant growth (Pillai, 1981). In soils where volatilization and denitrification are the major nitrogen loss mechanisms, deep placement of nitrogen particularly has been found quite beneficial (Makkelsen <u>et al</u>., 1978; Craswell and Vlex, 1979; Mikkelsen and De Datta, 1979; Rambabu, 1980; Bansal and Omanwar, 1981 and Pillai and Krishnamurthy, 1983). Although in soils with high internal drainage and serious leaching loss of added nitrogen, it may not give the desired response.

The current energy crisis and higher price of fertilizers warrants more efficient use of available nitrogenous fertilizers particularly for wet land rice. The role of slow nitrogen releasing modified urea materials are also increasingly being felt now in terms of increased nutrient availability throughout the active growth of the crop. Rambabu (1980) and Pillai and Krishnamurthy (1983) reported the favourable effect of incorporating urea supergranules so that ammonia is released slowsly and utilized more efficiently.

The apparent recovery of nitrogen and the uptake of nitrogen were significantly imporved with the nutrients supplied through modified urea materials. Deep placement of nitrogen as urea super-granules resulted in higher apparent recovery followed by surface application of nitrogen as rock phosphate coated urea (Table 22). Here is evident that nitrogen applied to the reduced zone is less subject to rapid mineralization and volatilization compared to surface application (Mac Rae and Ancajas, 1970; Nommik, 1978 and Pillai and Vamadevan, 1978). This would explain the higher uptake and recovery of nitrogen from urea applied to the reduced zone by deep placement. Deep placement of 50 per cent nitrogen as urea super-granules of 1 g followed by top dressing of the remaining nitrogen as urea in two splits lead to significant increase in apparent recovery of nitrogen over best split urea.

The nitrogen uptake with T_6 (131.3 kg/ha) was high and this in turn might have had a beneficial effect on yield contributing factors. Increase in availability of nitrogen in soil throughout the crop growth period with urea supergranules has been reported by several workers (Prathap Reddy, 1982; and Sreerama Murthy, 1984). Comparison of total nitrogen uptake and apparent nitrogen recovery (Table 21 and 22) indicated higher nitrogen uptake and recovery of nitrogen from root zone placement of urea supergranules than from conventional urea. This probably indicates that root zone placement of urea supergranules minimises nitrogen loss due to denitrification thereby resulting in increase in nitrogen recovery as opined by

(Simsiman *et al.*, 1967; Mangal Prasad and Rajendra Prasad, 1980 and Savant *et al.*, 1982) and resulted in increased grain yield as observed by Singlachar *et al.* (1979), Rambabu (1980), Rajendra Prasad *et al*, (1982) and Vijayachandran and Premadevi (1982).

The treatment with no nitrogen (T_1) recorded low rate of dry matter accumulation and consequently the grain yield than other treatments. The low nitrogen status at T_1 might have caused early senescence and this limited the photosynthesis in the panicle as well as in the leaves might have resulted in lower grain yield. Besides, a number of plant processes associated with the development of inflorescence are likely to be sensitive to low nutrient status. The number of panicles (8.1 per hill) and number of filled grains (74.5 per panicle) were low and consequently this affected the grain yield. Such effects have also been reported by Matsushima (1957, 1965); Koyama and Niamsrichard (1973); Krishnamurthy *et al.* (1976); Shivananjegowda *et al.* (1976); Pillai (1981); Subbaiah *et al.* (1983) and Thimmegowda (1985).

The number of panicles were high (14.0 per hill) with T_6 and was followed by T_7 (13.5 per hill). The lowest number (8.1 per hill) was obtained with T_1 treatment.

Similar increase in panicles per unit area (Sanchez, 1972; Tanaka et al., 1979; Vijayakumar, 1979; and Vinaya Rai and Murthy, 1979), panicle length (Lenka et al., 1976; and Vijayakumar, 1979) due to application of nitrogen were reported earlier. Increase in panicle density due to root zone placement of urea supergranules (Singlachar, 1979; Rambabu, 1980 and Rajendra Prasad et al., 1982) was reported and the data obtained on the present investigation are in agreement with them. The treatments with T_6 and T_9 were able to retain more panicles to give a high desnity of population, without any appreciable reduction in mean grains per panicle and as such it could add to an overall increase in grain yield. Similarly, the number of grains per panicle were ranged from 88.5 to 95.8 in different nitrogen management practices whereas, the lowest number of grains (74.5 per panicle) were recorded with T_1 treatment. Increase in grain number per panicle due to nitrogen was reported by several workers (Pande and Mittra, 1970; Venkatesan and Thiagarajan, 1974 and Singlachar et al., 1979).

Nitrogen supplied to T_6 provided an adequate nirogen for the development of panicle and probably helped to have larger number of spikelets per panicle through higher panicle length (22.0 cm) due to better nutrition, increased photosynthesis and enhanced g translocation of photosynthates to panicles from the plant parts which might have helped in an increased yield. This observation is in confirmity with the results of Black (1965).

Matsushima *et al*. (1968) working on rice found that by making the plant to absorb nitrogen even after heading, the percentage of ripened grains, thousand grain weight and the yield could be increased. Tanaka (1967) and Murata (1968) concluded that the question of increasing dry matter production after flowering is the pre-requisite for boosting up the yield of rice.

The higher grain yield with T_6 and T_9 compared to other treatments was due to more number of panicles per unit area, as a consequence higher panicle number and panicle length because of increase in the number of grains per panicle. Increase in number of panicles owing to increase in nitrogen levels was reported by Tanaka *et al*. (1958), Abraham *et al*. (1969), Pillai (1978, 1981), De Datta (1981) and Subbaiah *et al*., (1983).

The nitrogen content in grain (1.45%) was high with T_6 followed by T_9 (1.45%), T_3 (1.45%), T_8 (1.44%), T_7 (1.42%), T_4 (1.42%), T_2(1.42%) and T_5 (1.39%). The lowest nitrogen content (1.17%) was obtained with T_1 treatment, whereas in straw it was ranged from 0.74 to 0.81 per cent with nitrogen management treatments. The treatment with no nitrogen recorded the lower nitrogen content (0.74%). This indicate that higher nitrogen content of plant may increase the metabolic activity of the plant leading to greater accumulation of dry matter and consequently increased the yield. The influence of nitrogen was seen in increasing the protein content of grain and was reported by Fellers (1918), Norman (1944) and Gopalaswamy and Raj (1977).

Residual effect of preceding rice genotypes and residual nitrogen management practices on fodder cowpea

Green fodder yield due to residual effect of preceding rice genotypes indicate that significantly higher green fodder (9931 kg/ha) was obtained with preceding Mangala was grown and it yielded lower grain yield (4243 kg/ha) and nitrogen uptake (103.9 kg/ha), compared to Jaya (grain yield:5040 kg/ha) and nitrogen uptake (124.2 kg/ha). The higher green fodder yield with the treatment where Mangala was grown may be due to the fact that the uptake of nitrogen was less than the treatment where Jaya was grown and the residue left over after preceding Mangala able to influence plant height (25.1 cm) and number of branches per plant (3.24) and add to an overall increase in green fodder yield. Russel and Russel (1961) and Thimmegowda (1985) opined that crops can influence their successors through nutrients they leave behind in the soil and through their residues.

The green fodder yield of cowpea differed significantly due to residual effect of nitrogen management practices. Higher green fodder (12067 kg/ha) was obtained with the residual effect of 56 kg/ha through USG root zone placement + 56 kg/ha through urea in two splits applied to kharif rice crop. The lower green fodder yield (8168 kg/ha) was obtained with no nitrogen was due to lower plant height (27.6 cm) and number of branches per plant (3.5), Jansson (1963), Broadbent and Nahashima (1968), Westerman and Kurtz (1972), Reddy and Rajendra Prasad (1977), Singh and Sharma (1979) and Mangal Prasad and Rajendra Prasad (1980) recorded significant residual effect of nitrogen applied through different sources on the succeeding wheat crop.

SUMMARY

VI. SUMMARY

A field experiment was conducted during 1983-84 to study the response of rice genotypes of early and long duration to different sources, time and methods of nitrogen application to identify the suitable source, time and method for different genotypes to maximise the rice yield. The major findings of the above investigation are summarised below.

The dry matter accumulation was higher with Jaya genotype (panicle emergence: 18.2 g/hill; at harvest: 24.1 g/hill) compared to Mangala (panicle emergence: 17.2 g/hill; at harvest: 20.6 g/hill).

Jaya recorded higher number of shoots per hill (15.7), panicles per hill (12.8), filled grains per panicle (97.9) and thousand grain weight (28.6 g) compared to Mangala (number of shoots: 14.5; Panicles:10.0; Filled grains:82.0; thousand grain weight: 28.6 g).

Maximum light absorption (54.0 per cent) was obtained with Jaya compared to Mangala (49.7 per cent).

Grain yield of 5040 kg/ha was obtained with Jaya and it was 4243 kg/ha with Mangala. Straw yield was higher with Jaya (6656 kg/ha) compared to Mangala (5847 kg/ha).

Nitrogen uptake was higher with Jaya (124.2 kg/ha) compared to Mangala (103.9 kg/ha).

Nitrogen management practices significantly influenced grain yield. Root zone placement of urea supergranules at 112 kg/ha during planting recorded higher grain yield (5336 kg/ha) and it was on par with root zone placement of urea supergranules at 56 kg/ha + 56 kg/ha as urea in two splits at tillering and panicle initiation (5081 kg/ha). The lowest grain yield of 3371 kg/ha was obtained with no nitrogen.

Maximum straw yield of 7476 kg/ha was obtained with root zone placement of urea supergranules at 112 kg/ha during planting followed by 56 kg/ha urea supergranules root zone placement + 56 kg/ha as urea in the two splits at tillering and panicle initiation (6966 kg/ha).

Total number of shoots per hill (19.3), plant height (79.9 cm) and dry matter accumulation per hill at harvest (28.5 g) were high with root zone placement of urea supergranules at 112 kg/ha.

Yield components like number of panicles per hill (14.0), number of filled grains per panicle (95.8) and thousand grain weight (26.7 g) were higher with root zone placement of urea super granules at 112 kg/ha.

Nitrogen uptake (131.3 kg/ha) was higher with root zone placement of urea super-granules at 112 kg/ha and it was on par with root zone placement of urea super-granules at 56 kg/ha + 56 kg/ha as urea in two splits at tillering and panicle initiation (126.8 kg/ha). The lowest nitrogen uptake (72.9 kg/ha) was obtained with no nitrogen.

Apparent nitrogen recovery of 52.1 per cent was recorded with root zone placement of urea supergranules at 112 kg/ha compared to 33.6 per cent with basal application of 112 kg/ha urea.

Higher green fodder (9931 kg/ha) of cowpea was obtained with preceding short duration Mangala was grown compared to long duration Jaya (9219 kg/ha).

Residual effect of nitrogen management practices also influenced the green fodder yield. Residual effect of root zone placement of urea supergranules at 56 kg/ha + 56 kg/ha urea in two splits at tillering and at panicle initiation recorded higher green fodder yield of 12067 kg/ha.

The lowest green fodder yield of 8168 kg/ha was obtained with residual effect of no nitrogen to *kharif* rice.

From the present investigation it can be concluded that for wet land rice, supply of nitrogen through root x zone placement of urea supergranules results in efficient utilization of nitrogen and increase in rice yields compared to rock phosphate coated urea, urea gypsum and urea. Split application of urea proved better rather than complete basal application. Application of 56 kg/ha rock phosphate coated urea as basal + 56 kg/ha as urea in two splits at tillering and panicle initiation proved better rather than basal application of 112 kg/ha rock phosphate coated urea.

Successful crop of fodder cowpea can be grown with residual moisture and nutrients only in quick succession after *kharif* rice and this rice-fodder cowpea system can be adopted in th tankfed areas where water is scarce after *kharif* rice.

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VII. REFERENCES

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