RESPONSE OF MODERN VARIETIES OF RICE TO NITROGEN IN KOLE LANDS

By

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THESIS

submitted in partial fulfilment of
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DECLARATION

I hereby declare that this thesis entitled "Response of modern varieties of rice to nitrogen in *Kole* lands" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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Certified that this thesis entitled "Response of modern varieties of rice to nitrogen in Kole lands" is a record of research work done by Shri.Premkumar, J., under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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We, the undersigned, members of the Advisory Committee of Shri. Premkumar, J., a candidate for the degree of Master of Science in Agriculture with major in Agronomy, agree that the thesis entitled "Response of modern varieties of rice to nitrogen in Kole lands" may be submitted by Shri.Premkumar, J. in partial fulfilment of the requirement for the degree.

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Introduction

1. INTRODUCTION

In Kerala, rice occupies an area of 7.9 lakh ha producing 12 m tonnes of grains coming to about 50 per cent of our total requirement (Anon, 1987). Although the green revolution had a tremendous impact on food grain production, the spread of the high yielding varieties was much slower in Kerala. Cultivation of high yielding varieties is limited to only 26 per cent of the total cropped area in the state compared to the national average of 53 per cent. This is because these varieties with higher yield potential developed for a particular location and environment often fare badly in another situation because of the specific soil climatic and fertilizer requirements.

For achieving the increased production potential of new varieties, technically feasible and economically viable agrotechniques are to be developed for each specific location taking into consideration its complex interaction with soil and climatic factors.

In increasing the productivity, nitrogen earns its prominence mainly because it is the key factor for the realisation of yield potential of modern varieties of rice.

The response of nitrogen varies significantly with varieties and locations.

The 'Kole lands extending over an area of 11000 ha in Trichur and Malappuram districts is an important rice growing tract of Kerala. It is a flood plain generally lying 0.5 - 2.0 m below sea level, subject to frequent inundation of sea water which keep them under submerged conditions for nearly seven months during the year. The main cropping season in these regions is Kole season (December-January to March-April) for which short duration varieties are grown.

Till now no detailed study has been undertaken with regard to the varietal and manurial requirements, especially nitrogen of this region. The fertilizer recommendations for the varieties generally grown in Kole land are based on the trials conducted at other places and as such no specific recommendation has been evolved for this tract. It is observed that farmers of this area generally grow rice cultivars such as Jyothi, Triveni, Annapurna and many other local varieties. They also apply more than 100 kg N ha^{-1} to get an average yield of about 4 - 4.5 t ha^{-1}. The pre release Culture 10-1-1 developed at Rice Research Station, Mannuthy is gaining wide acceptance in Kole lands.

The present investigation was therefore undertaken with the following objectives.

(1) To study the performance of Culture 10-1-1 in comparison with other prevailing high yielding varieties in Kole lands.

(2) To assess the response of these high yielding varieties and Culture 10-1-1 to nitrogen fertilization.

Review of Literature

2. REVIEW OF LITERATURE

Responsiveness to nitrogen by rice varieties is one of the major factors contributing to variation in grain yield. Realisation of the higher production potential of 'Modern' varieties of rice requires adequate nutrient application, especially nitrogen.

Nitrogen is the limiting element in most of the Indian soils. In addition, rice, because of its unique growth habit and habitat congenial for nitrogen loss, has a very low nitrogen recovery. Nitrogen requirement of rice varies with varieties, locations, soil, climatic and management factors. Hence general fertilizer recommendations are meaningless without a data base for each specific location. No work has been conducted in Kole lands with regard to varietal and manurial requirements of rice, especially nitrogen.

The relevant literature available on the response of rice cultivars to nitrogen and its influence on growth and yield characteristics are briefly reviewed in this chapter.

2.1 Influence of nitrogen on growth characteristics

The influence of nitrogen on various growth characters is an established fact.

2.1.1 Plant height

The response to nitrogen vary widely with varieties. Differential response of plant height to nitrogen in different varieties has been observed by Khan and Vergara (1982) and Ustimenko et al. (1983).

Increase in plant height with nitrogen should be expected as this element is found to enhance vegetative growth especially if applied early. An increase in plant height with increasing nitrogen application has been reported by many workers (Koyama et al. 1973; Iruthayaraj and Morachan, 1980; De Datta, 1981; Yoshida, 1981; Ghobrial, 1983 and Ramasamy, 1985).

However, Enus and Sadique (1974) found plant height to be unaffected by application of nitrogen.

2.1.2 Tiller number

Varietal variation in tiller production is well known. The ability to utilise the additional nitrogen available for tiller production is purely a varietal trait. Stone and Steinmetz (1979); Lal (1981); Latif (1982) and Sheik Dawood (1986) observed variation in number of tiller for the different rice cultivars tested.

Tiller number is found to be increased by nitrogen. Positive correlation of tiller production with incremental levels of nitrogen were reported by Tanaka (1972); Rego (1973), Balasubramanian (1980); Noosa and Vargas (1980); Ramasamy (1982); and Ram et al.(1984).

2.1.3 Leaf area index

Variation in leaf area index with varieties has been reported. Stone and Steinmetz (1979) registered variation in leaf area index among varieties tested which they attributed to the differential tillering capacity and size of leaves. Lal (1981); Pillai and Krishnamurthy (1983) and Krishnakumar (1986) also reported similar results. However, results of the trials conducted at IRRI (IRRI, 1970) did not indicate any optimum leaf area index for varieties tested eventhough yield appeared to increase with leaf area index.

Tanaka et al. (1964) and Das Gupta (1969) reported that nitrogen application resulted in increase in leaf area index. Abdulgalil *et al*. (1979), Meuller *et al*.(1979) Kupkanchanakul and Vergara (1980), Ramasamy (1982), Sadayappan (1982) and Salam (1984) also registered an increase in leaf area index with enhanced nitrogen application in different varieties tested.

2.1.4. Dry matter production

Dry matter production is dependent on factors like plant height, tiller number and leaf area index. Chinnaswamy and Chandrasekharan (1977) found variation in nitrogen response among varieties tested.. IR-8 was found to increase the dry matter production upto 160 kg N ha^{-1} whereas TKM-6 showed increase only upto 120 kg N ha^{-1}. From the trials conducted by Macalinga *et al*. (1977), variation in nitrogen response was noted among IR-28 and IR-38 which was attributed to the differential response of leaf area index and tiller number to nitrogen. Agaisimani *et al*. (1983) also reported variation in response of two varieties Ratna and Sakit in dry matter production.

Osada (1967) opined that factors contributing to dry matter production as well as rate of photosynthesis per unit leaf area were easily influenced by nitrogen. Varma (1972) observed increase in dry matter production in four dwarf rice cultivars upto 160 kg N ha^{-1}. Beye (1977), Haque *et al*. (1977), Balasubramanian (1980), Nagre and Mahajan (1981); Prasad (1981); Upadhyay and Pathak (1981); Sadayappan (1982), Rojas *et al*. (1983) and Salam (1984) also reported increased dry matter production in different rice varieties with additional levels of nitrogen.

It can be concluded from the report of above workers that vegetative growth characters were significantly influenced by varieties and nitrogen levels.

2.2 Yield attributes

2.2.1 Productive tiller per m^2

Production of effective tillers is a varietal character and its response to nitrogen varies. Kurup and Sreedharan (1973) reported difference in number of effective tillers produced in varieties Karuna and Annapurna. Krishnakumari (1983) pointed out that the ratio of effective tillers to total tillers varied with varieties. She also observed that this value was not constant for Jyothi and IR-8. Ustimenko *et al*. (1983) observed variation in effective tiller production with nitrogen in all the varieties tested.

Productive tillers had a positive relationship with nitrogen level in Taichung (Native)1 and IR-8

(Chaudhary et al., 1969). Pande and Singh (1970), Ishizuka (1971) and Koyama et al. (1973) have opined that the increased panicles per m^2 production with incremental nitrogen as the main attribute in deciding the grain yield. Enus and Sadeque (1974), Abraham et al. (1975) and Padmaja (1976) also registered increase in productive tillers with nitrogen. Noosa and Vargas (1980) reported a linear increase with increasing nitrogen level from 50 to 200 kg ha^{-1}. Singh et al. (1981 a), Ghobrial (1983) and Singh et al. (19 4) also observed an increase in productive tillers upto 120 kg N ha^{-1} in different varieties tried.

2.2.2 Length of the panicle

Kurup and Sreedharan (1971) observed variation in length of panicle with added nitrogen in varieties Karuna and Annapurna. Sreedharan (1975) also observed variation in panicle length among the four varieties, viz. Bala, Ratna, Vijaya and Jayanti tested. Differential nitrogen response by varieties tested were also observed by Krishnakumar (1986) and Sheik Dawood (1986).

Chaudhary et al. (1969) established a positive correlation between panicle length and levels of nitrogen. Kurup and Sreedharan (1971), Sreedharan (1975) and Latif (1982) also observed increasing trend in panicle length with increasing nitrogen levels. However Singh et al. (1984) did not observe any increase in panicle length with incremental dose of nitrogen.

2.2.3 Panicle weight

Variation in panicle weight among varieties with incremental levels of nitrogen is also reported (Sreedharan, 1975 and Jaikumaran, 1981).

Beneficial influence of nitrogen in increasing panicle weight was reported by many workers (Padmaja, 1976; Subbiah et al., 1977; Sreedharan and Vamadevan, 1981; and Krishnakumar, 1986).

2.2.4 Number of filled grains per panicle

Variation in the number of filled grains per panicle among varieties were reported by Urs and Mahadevappa (1972). Ustimenko et al. (1983) and Krishnakumar (1986) also observed differences in filled grains per panicle among the varieties tested.

Nitrogen application was found to increase the filling of grains and a positive relationship was established between nitrogen levels and filled grains per panicle by

Chaudhary *et al.* (1969); Pande and Singh (1970); Ishizuka (1971); Koyama *et al.* (1973) and Mani (1979). In Ratna an increase in filled grains with increased nitrogen upto 120 kg N ha^{-1} was reported by Singh *et al.* (1981 b). Subbiah (1983) observed a linear response to nitrogen only upto 90 kg N ha^{-1}. Singh *et al.* (1984) recorded a significant increase in filled grains per panicle for 150 kg N ha^{-1} over 75 kg N ha^{-1}. However, Srivastava *et al.* (1984) could achieve an increase only upto 100 kg N ha^{-1} with the variety Archana.

2.2.5 Filling percentage

Ota and Yamada (1965) did not observe much increase in spikelet sterility in varieties which are highly responsive to nitrogen, by its increased application. But sterility was found to increase upto 100 per cent in less responsive varieties. They opined that sterility was more in the case of *indica* varieties. Murthy and Murthy (1981) evaluated spikelet sterility in 2500 entries from the germplasm collection at CRRI, Cuttack and found that it varied from 1 - 100 per cent. The sterility was higher in early and late maturing varieties. Murthy *et al.* (1983) and Ustimenko *et al.* (1983) also found spikelet sterility varying among the varieties tested.

Tanaka *et al.* (1964) and Matsushima (1970) observed that percentage of filled grains decreased with high nitrogen application. This was attributed to the production of more number of spikelets leading to a lower percentage of ripened grains. Tayebi and Dadaschi (1981) and Rojas *et al.* (1983) reported an increase in dead and shrivelled grains with increased nitrogen application. They observed that spikelet sterility was increased with increase in nitrogen from 0 to 240 kg N ha^{-1}.

2.2.6 1000 grain weight

1000 grain weight varies with varieties as it is a varietal trait. Differences among varieties with additional levels of nitrogen were reported by many workers (Kurup and Sreedharan, 1971; Jana *et al.* 1981; and Krishnakumar, 1986).

Kaliyanikutty *et al.* (1969) and Abraham *et al.* (1975) established a positive correlation between levels of nitrogen and 1000 grain weight. Increase in 1000 grain weight was also observed by Padmaja (1976); Tayebi and Dadaschi (1981) and Habeeburrahman (1983).

However, Koyama *et al.* (1973), Sanchez *et al.* (1973), Enus and Sadeque (1974), Pillai *et al.* (1975), Kupkanchanakul and Vergara (1980) and Singh *et al.* (1984)

failed to register any difference in 1000 grain weight by increased N application.

The varietal response to nitrogen with regards to yield attributes is an established fact. It can be deduced from the works mentioned above that the yield attributes namely panicles per m^2, panicle length, panicle weight, numbers of filled grains per panicle and 1000 grain weight were positively correlated with increasing nitrogen levels. However, filling percentage was negatively correlated with increased nitrogen.

2.3 Yield

2.3.1 Grain yield

Since nitrogen response varies from soil to soil and there is not much work done in Kole lands where the present study was conducted the relevent details in other soils and locations with different varieties are reviewed to get a comparative idea.

Chaudhary et al.(1969) registered a linear response in grain yield with application of nitrogen upto 135 kg N ha^{-1}. Rego (1973), Raju (1978), Sharma and De (1979) and Rao and Rao (1980) also reported increasing grain yield with nitrogen application. Subbiah (1983) found linear yield response only upto 90 kg N ha^{-1}.

Dwarf <u>indicas</u> responded progressively upto 105 kg N ha^{-1} (Chandler, 1966). Padhi and Misra (1968) achieved marked difference in the response with different cultivars to levels of nitrogen. Lanka (1969) observed variation in response of varieties to nitrogen. The response per kg of nitrogen was 21 kg for Taichung (Native)1, 13.1 kg for Ptb 10 and 12.4 kg for Tkm 6. Lanka and Behera (1969) from their trials with Taiwanese varieties reported yield increase upto 120 kg N ha^{-1}, mainly by increasing fertile grains per panicle. Rice cultivar Padma showed yield response upto 150 kg N ha^{-1} whereas rice cultivars IR-5, IR-8, Jaya and Hamsa increased yield upto 240 kg N ha^{-1} (Hilton, 1971). From the trials with eight short duration rice varieties, Subbiah and Morachan (1974) observed variation in yield response to nitrogen. The response was linear for some varieties and quadratic for others. They also recorded yield response upto 160 kg N ha^{-1}. Pandey and Sharma (1975) found that rice cultivars Bala, Padma, Ratna and Sabarmati responded upto 150 kg N ha^{-1}. Supriya and Kalinga-2 also responded only upto 100 kg N ha^{-1} (Singh and Rao, 1977). Long term fertility experiments conducted at IRRI Philippines revealed yield response upto 140 kg N ha^{-1} for rice cultivars IR-8, IR-36 and IR-48 (IRRI, 1979). From another trial that conducted at IRRI

(IRRI, 1980) the early maturity lines evaluated showed yield response upto 100kg N ha^{-1}. Jana et al. (1981) observed that IR-8 and IR-579 increased yield upto 140 kg N ha^{-1} and decreased with 210 kg N ha^{-1}. Prasad et al. (1982) recorded variation in response to nitrogen in four varieties tested whereas Peeran and Anandan (1983) observed variation in nitrogen response in ten rice cultivars tested. Of the ten pre release cultures tested only IET 2490 and IET 2730 showed yield response upto 120 kg N ha^{-1}. Krishnakumar (1986) recorded difference in yield response among the two varieties, IR-50 and Co 37 tried.

Variation of yield response to nitrogen with soils have been reported by Welis (1972). He found that yield responded upto 159 kg N ha^{-1} in silt loam soils and upto 136 kg N ha^{-1} in heavy clay soil. Khatua et al. (1975) observed differences in nitrogen response of same cultivars with different soils. Jaya showed yield response upto 120 kg N ha^{-1} in alluvial and red soils and upto 60 kg N ha^{-1} in laterite soils. In alluvial soils yield response upto 100 kg N ha^{-1} were registered by Georgiev and Dojadziska (1981). In light textured soils Singh et al. (1981 a) observed yield response upto 120 kg N ha^{-1}. Vishwanath et al. (1983) reported yield response upto 120 kg N ha^{-1} in red sandy loam soil. In clay loam soil Srevastava *et al.* (1984) could obtain yield response only upto 100 kg N ha^{-1} with variety Archana.

From the field trial conducted at IRRI, De Datta *et al.* (1968) reported maximisation of yield for IR-8 in dry seasons to be at 120 kg N ha^{-1} whereas Sreedharan and George (1968) obtained a progressive yield increase in IR-8 during dry season upto 160 kg N ha^{-1}. The trials conducted at CRRI Cuttack (CRRI, 1970) reveal that for varieties optimum level of nitrogen was 150 kg N ha^{-1} in *rabi* season and 80-100 kg N ha^{-1} in *kharif* season. Pandey and Das (1973) found that in dry season yield responded upto 160 kg N ha^{-1} and in wet season upto 120 kg N ha^{-1}. Murthy and Murthy (1978) reported 87.8 per cent increase in nitrogen response during rabi *over kharif*. Rao *et al.* (1980) and Venkateswarlu and Singh (1980) obtained yield response upto 100 and 128 kg N ha^{-1} respectively during *kharif* season. Chatterjee and Maite (1981) observed yield response for dwarf varieties tested between 100-120 kg N ha^{-1} in dry season and 80-100 kg N ha^{-1} during *kharif*. Grain yield increased linearly upto 120 kg N ha^{-1} during dry season whereas it increased only upto 60 kg N ha^{-1} in wet season (Fagi and De Datta, 1981). Sreedharan and Vamadevan (1981) also reported that positive increase in grain yield was noted upto 160 kg N ha^{-1} in dry season and upto 80 kg N ha^{-1} in wet season.

The optimum level of N for Taichung (Native)1 was found to be 150 kg N ha^{-1} (Bathkal and Patel, 1970). Sarkar and Sinha (1973) reported the optimum level of nitrogen for varieties IET 1991 and Ratna to be 178 kg ha^{-1}. Singh and Pal (1973) registered maximisation of yield at 150 kg N ha^{-1} for variety IR-20. Of the eight varieties tested by Mengel and Leonards (1976), five varieties maximised the yield at 136 kg N ha^{-1} while the others at 181 kg N ha^{-1}. Singh et al. (1977) found the economic optimum for seven rice cultivars to be in the range of 114 to 130 kg N ha^{-1}. Singh and Modgal (1977) reported the economic optimum dose of nitrogen (kg N ha^{-1}) for varieties Jaya and IR-20 to be 158 and 116, respectively. Trials conducted at Maligaya Rice Research and Training Centre revealed that maximisation of yield for IR-36 and IR-50 occurred at 120 and 150 kg N ha^{-1} (IRRI, 1981). Ratna produced the highest yield at 120 kg N ha^{-1} (Singh et al. (1981 b).

However, Sadyappan (1972) found no response in IR-20 beyond 100 kg N ha^{-1} whereas Devi et al. (1981) did not observe any significant increase in grain yield in rice cultivars Aswathi and Triveni with increase of nitrogen from 40 to 120 kg ha^{-1}.

It can be inferred from the reports of above workers that nitrogen enhanced the grain yield. Response to nitrogen among varieties varied widely with locations. Brandon et al. (1982) also observed similar results and opined that general recommendation are meaningless without a data base for each soil.

2.3.2 Straw yield

Kurup and Sreedharan (1971) observed difference in straw yield among varieties Karuna and Annapurna with increased nitrogen levels. Chinnaswami and Chandrasekharan (1977), Prasad (1981), Latif (1982) and Krishnakumar (1986) also reported variation in straw yield among varieties.

Lanka (1969) reported that straw yield was increased upto 160 kg N ha^{-1} for variety Taichung (Native)1 and Annapurna. Kurup and Sreedharan (1971) found the straw yield decreasing after 100 kg N ha^{-1}. Rego (1973) and Padmaja (1976) also got increased straw yield with incremental nitrogen level. Patel *et al*. (1978) from their trial conducted in dry season recorded maximisation of straw yield at 160 kg N ha^{-1} for Kalinga-1, Ratna, IR-22, IR-28 and Pusa 33. Georgiev and Bojadziska (1981), Agaisimani (1983), Habeeburrahman (1983) also reported straw yield increase upto a certain level after which it decreased. A linear increase in straw yield with nitrogen application was observed by Salam (1984) and Reddy (1985).

However, Santhi (1985) recorded a decrease in straw yield beyond an application of 75 kg N ha^{-1}.

2.3.3 Harvest index

Sreedharan (1975) observed that variation in harvest index existed between varieties tested. Macalinga *et al*. (1977) also brought out variation in harvest indices among rice cultivars IR-36 and IR-28. Prasad (1981) reported difference in harvest indices among the cultivars, Sabarmati and Pusa 33. Son *et al*. (1983) also reported similar results in varieties tested.

The beneficial influence of nitrogen in increasing harvest index was reported by Sreedharan (1975). Prasad (1981) obtained an increase in harvest index upto 100 kg N ha^{-1}

after which it decreased. Latif (1982) and Habeeburahman (1983) also reported similar increase in harvest index with nitrogen.

However, Kupkanchanakul and Vergara (1980), Venkateswarlu and Prasad (1982) and Son et al. (1983) did not notice any variation in harvest index due to nitrogen application.

2.4 Chemical studies

2.4.1 Protein content of the grain

Varietal differences in protein content was reported by Kido and Yanatori (1968). They opined that small grain varieties in general had high protein than bold grain type. Padma, a small grain type, recorded higher grain protein content than IR-8, IR-262 and IR-5 (AICRIP, 1968). Kurup and Sreedharan (1971) observed that variety Karuna had higher protein content than Annapurna. Kadrekar and Mehta (1975) observed a linear increase in protein content with increased nitrogen level in rice cultivar IR-8. However a negative response was obtained with higher nitrogen levels in cultivar Patni-6. Sreedharan (1975) and Latif (1982) also observed variation among varieties with regard to grain protein content.

An increase in nitrogen rates resulted in a linear increase in protein content of the varieties tested (Rao, 1969; Ahmmed, 1970 and Ramanujam and Rao, 1970). De Datta *et al*. (1972) found that protein content was enhanced from 9.5 to 10.2 per cent by increased nitrogen application from 30 to 150 kg N ha^{-1}. Meerasahib (1972) and Rego (1973) also reported progressive increase of protein content with enhanced nitrogen application. Abraham *et al*. (1974) obtained maximisation of grain protein content at 120 kg N ha^{-1} in Triveni. Pisharody *et al*. (1976); Rabindra *et al*. (1977); Sadayappan and Kolandaswamy (1978) and Habeeburrahman (1983) also recorded increase in protein content with addition of nitrogen.

However, Muthuswamy and Raj (1973) could not get any increase in protein content with different levels of nitrogen ranging from 0 to 160 kg N ha^{-1} in four varieties tried. Georgiev and Bojadziska (1981) and Tak *et al*. (1982) also reported similar results.

2.4.2 Nutrient uptake

Differential response of nitrogen uptake among varieties to increasing nitrogen rates was reported by Kurup and Sreedharan (1971). Gostenko *et al*. (1976) found the differences in response to nitrogen being smaller during early growth stages and marked from booting stage onwards. Khan and Vergara (1982) also observed difference in response for N uptake to applied nitrogen in ten different varieties tried. Latif (1982) also reported similar results.

Russel (1961) pointed out that the nitrogen uptake increased with stages of development and the uptake values were at peak at harvest. Sadanandan _et al._ (1969) found the nitrogen uptake rapid to start with and the increase was marked during the flowering stage. They also observed significant correlation between the uptake of P and K, N and P and N and K. Kurup and Sreedharan (1971) and Varma (1972) remarked that uptake of nitrogen was increased by nitrogen application and percentage of nitrogen translocated to grain decreased with increased nitrogen levels. Sarkar and Sinha (1973) also got similar result with uptake at 150 kg N ha^{-1}. Abraham _et al._ (1976) found the nitrogen uptake by straw increased upto 120 kg N ha^{-1} and that by grain upto 80 kg N ha^{-1} and the total nitrogen uptake only upto 80 kg N ha^{-1} after which it decreased. Khan and Pathak (1976) also reported similar results. Increase of nitrogen uptake with incremental nitrogen levels was reported by many workers (Pillai and De, 1980 b; Habeeburrahman, 1983; Salam, 1984 and Reddy, 1985).

However, Bredero (1965) concluded from his studies that nitrogen was absorbed independent of the rate of nitrogen applied, provided sufficient soil nitrogen was available for uptake. Loganathan and Raj (1972) also found nitrogen uptake unaffected by variation in dosage of nitrogen applied even upto 160 kg N ha^{-1}.

Hanway (1962) found that higher uptake of nitrogen resulted in greater absorption of phosphorus. Shinde and Dutt (1964), Bredero (1965) and Ramanujam (1967), Kalyanikutty (1970), reported that nitrogen uptake determined the phosphorus and potassium uptake. Sadanandan _et al_. (1969) and Alaxander _et al_. (1974) observed significant correlation among nitrogen and phosphorus uptake. K uptake was also increased by nitrogen uptake (Gopalaswamy and Raj, 1977). Singh and Modgal (1978) registered an increase in P and K uptake due to increased nitrogen. They also observed variation in K uptake due to increased nitrogen application among varieties though P uptake was not effected by varietal variations. Balasubramanian (1978), Pillai and De (1980 b), Latif (1982) and Salam (1984) also recorded increase in P and K uptake with increased nitrogen application.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation to study the response of Modern rice varieties to nitrogen in Kole lands was laid out in a cultivators field in the Kole lands of Trichur district during the main (Kole) season i.e. December-January to March-April, 1985. The materials used and methods adopted for the study are given below.

3.1 Kole lands of Kerala

The Kole lands of Kerala comprises the Chowghat and Mukundapuram taluks of Trichur district and Ponnani taluk of Malappuram district and extends to an area of 11000 ha. The tract is bordered by hilly tract on the east, Kanoly canal on the west, Mariyad Kayal in the south and Muthur kayal in the north. It is drained by two rivers viz., Karuvannur and Kechari. They lie between 0.5 - 2.0 m below mean sea level and are waterlogged and submerged for major part of the year.

The soils of this tract are very unique and are generally classified into low lands and uplands. The low lying Kole fields represent the piedomont type of deposit silted up in the flood plains by alluvium brought down by the rivers, the thickness of which varies from 10-15 meters. This is of sedimentary in origin and when dug up at places withered tree trunks and lime shell deposits are seen.

In low land one crop of rice (Punja) in summer is generally taken and in some places an additional crop is also taken. During June-July to November-December the entire area will be under water. Uplands soils are laterite with lesser amount of silt and clay. A coconut based cropping pattern is followed in this region.

Soil characteristics

Hameed (1975) conducted a fertility investigation in the Kole soils of Kerala. The surface horizon was heavy in texture with large proportion of clay and organic matter in the range between 1.97 to 5.58 per cent. Very high content of organic matter (30 to 70 per cent) in the lower horizon indicated the existence of peat there.

In general the Kole lands are highly acidic with average pH being 4.1 and EC varying between 0.1 to 15 m.mhos/cm at 25°C. Lime requirement of surface soil ranged from 4 to 15 t $CaCO_3$/ha. The average N, P_2O_5, K_2O, CaO and MgO content of surface soil were 0.34 per cent, 0.13 per cent

Table 1. Meteorological data for the cropping period 1984-'85

Standard week	Period		Rainfall (mm)	Max. temp. (°C)	Minimum temp. (°C)	Relative humidity (%)	Pan evoporation (mm)	Sunshine hours
1	January	1-7	14.7	32.1	21.9	73.0	36.4	9.8
2		8-14	-	32.5	23.7	67.0	47.9	9.5
3		15-21	-	33.1	21.6	52.0	62.1	10.4
4		22-28	-	34.7	22.7	56.0	71.2	10.3
5	February	29-4	-	33.5	21.6	64.0	56.8	6.2
6		5-11	-	34.7	23.1	68.0	42.5	9.1
7		12-18	-	35.4	23.5	46.0	39.3	10.1
8		19-25	-	36.1	22.8	61.0	44.1	10.0
9	March	26-4	-	36.8	23.6	56.0	48.5	9.7
10		5-11	-	37.0	24.7	54.0	58.2	8.6
11		12-18	-	35.5	25.5	70.0	66.5	8.3
12		19-25	-	35.7	25.2	70.0	49.0	7.4
13	April	26-1	2.0	35.8	23.8	69.0	47.5	8.6
14		2-8	17.3	35.3	25.7	66.0	46.4	6.6
15		9-15	-	35.4	25.4	65.0	41.0	9.2
16		16-22	-	35.3	25.2	67.0	49.8	8.8
17		23-29	3.0	35.9	26.2	65.0	47.7	9.4
18	May	30-6	-	35.9	26.5	66.0	48.1	8.8

0.18 per cent, 0.32 per cent and 0.21 per cent respectively. High cation exchange capacity (27 to 48 me/100 gm of soil) indicate the presence of 2:1 type of clay minerals. Average Al_2O_3 : Fe_2O_3 ratio was found to be 2.4 per cent which indicated accumulation of iron in these soils.

3.2 Site of the experiment

The experiment was laid out in the Arumury Kole near Eravu in the Trichur district of Kerala. The land remain submerged after the cropping period and is 0.90 m below the mean sea level. It is situated at 12° 32' North latitude and 74° 20' East longitude.

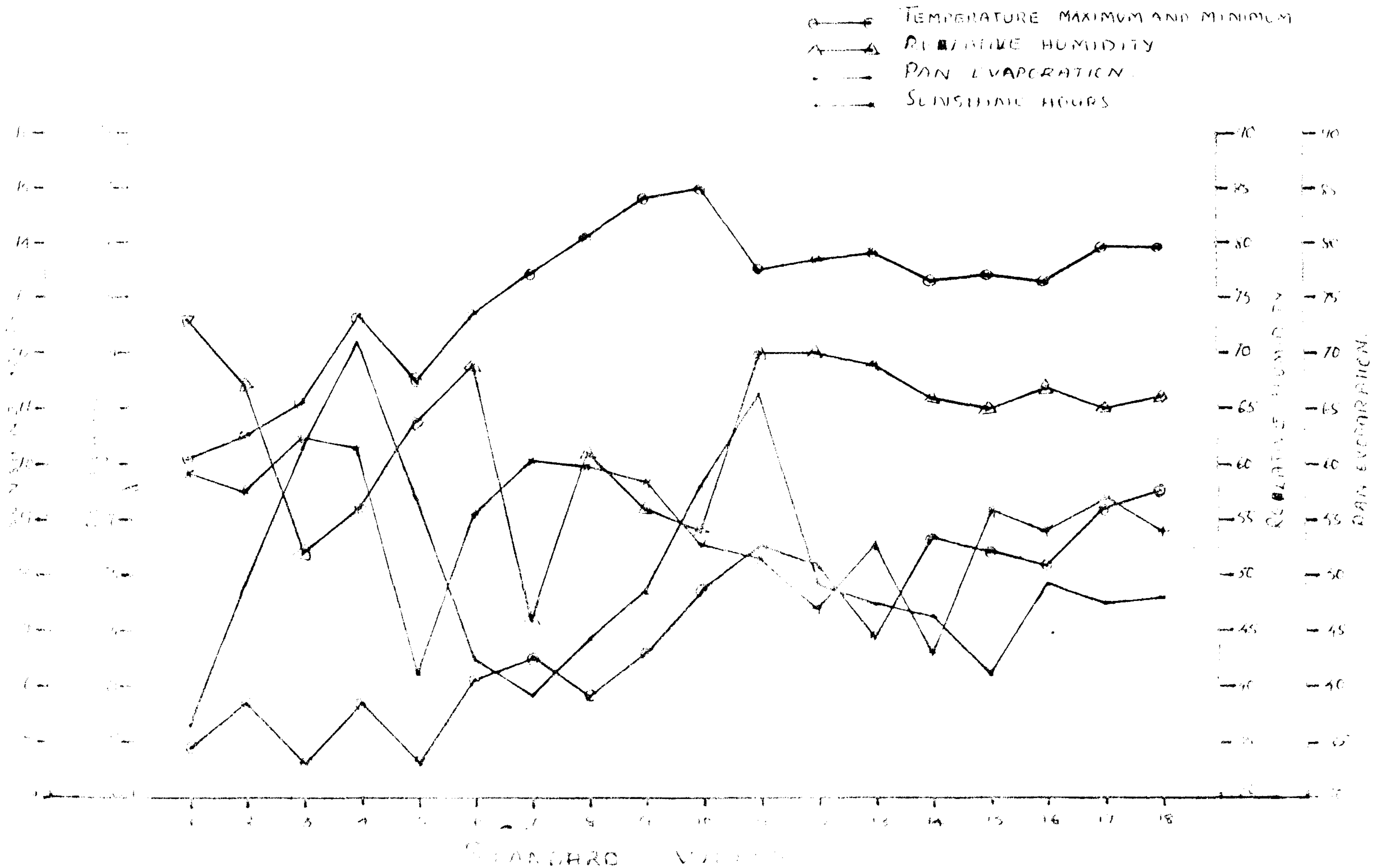
3.2.1 Soil

The soil was clayey in texture comprising of 6.23 per cent sand, 13.86 per cent fine sand, 21.66 per cent silt and 56.25 per cent clay. Chemical analysis reveal that the soil had 0.19 per cent total nitrogen, 4.9 ppm available P_2O_5 and 62 ppm exchangeable K and had a pH of 5.1 in 1: 2.5 soil water extract.

3.3 Climate

The area receives rainfall mainly from the South West monsoon and to a certain extent from North East Monsoon.

Fig. 1. WEATHER PARAMETERS DURING THE CROPPING PERIOD



During the cropping period the area receives a few summer showers. Data pertaining to mean maximum and minimum temperature, mean relative humidity, mean pan evaporation and sunshine hours recorded during the cropping season at the Agro Meterological Observatory in Mannuthy are given in Table 1 and Figure 1. The table also gives weekly rainfall which shows that weather condition received is normal.

3.4 Season

The experiment was conducted during the main Kole season i.e. from December-January to March-April of 1985. The crop was irrigated by canal system of irrigation.

3.5 Cropping history

The experiment field was single cropped Kole land where rice was continuously grown year after year. The land remained submerged during the rest of the year.

3.6 Materials

3.6.1 Cultivars

The cultivars used for the investigation were Jyothi, Culture 10-1-1 and Triveni.

Jyothi is 110-125 day photo insensitive variety with red long bold grains with a potential yield of 6 t ha^{-1} (Anon, Parentage

Peta x Dee Gee Woo Gen
↓
IR-8 x Ptb 10
↓
Jyothi

Culture 10-1-1 was developed at Agricultural Research Station, Mannuthy, Trichur. It is red kerneled semi tall short duration type having high utility for <u>Kole</u> lands of Kerala. Though the Culture 10-1-1 is not released a very large area of the main <u>Kole</u> crop is grown with this pre release Culture 10-1-1 in Trichur district.

Parentage

Tsai Yuan Chung x Dee Gee Woo Gen
↓
Ptb 10 x T (N) 1
↓
Culture 10-1-1

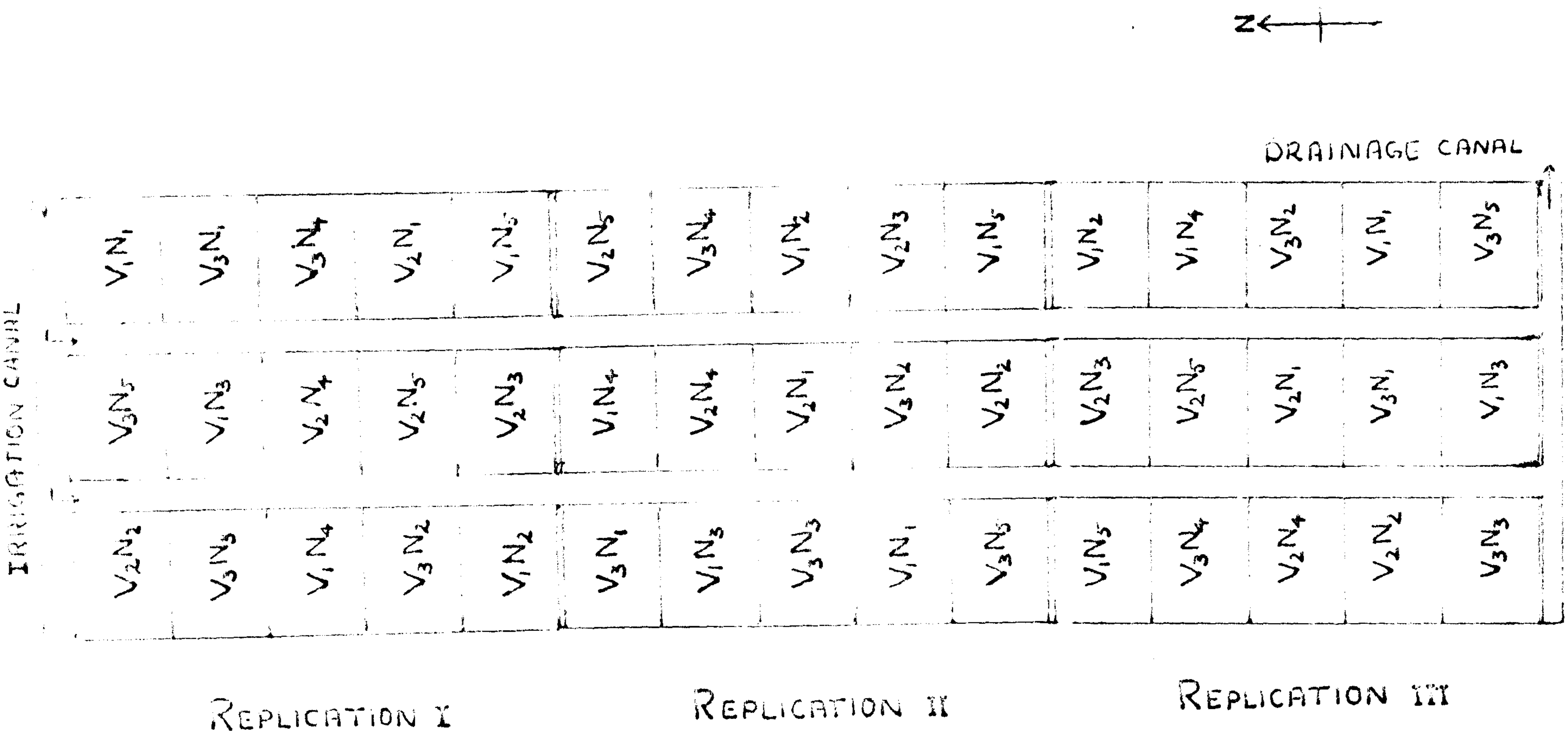
Triveni is a short duration photoinsensitive variety with white long bold grains. The duration of the variety ranges between 95-105 days and its yield potential is 6 T ha^{-1} (Anon, 1987)

Parentage

Tsai Yuan Chung x Dee Gee Woo Gen
↓
T (N) 1 x Ptb 10
↓
Annapurna x Ptb 15
↓
Triveni

Ptb 10 and Ptb 15 are selections released from Rice Research Station, Pattambi.

FIGURE 2 LAY OUT PLAN OF THE EXPERIMENT IN FACTORIAL RBD



V_1	JYOTHI		N_1	50 Kg ha^{-1}
V_2	CULTURE 10-1-1		N_2	70 " "
V_3	TRIVENI		N_3	90 " "
			N_4	110 " "
			N_5	130 " "

3.6.2 Fertilizers and lime

Urea (46 per cent N), Superphosphate (16 per cent P_2O_5) and Muriate of Potash (60 per cent K_2O) were used for the experiment. Calcium hydroxide was used as the liming material. Uniform dose of 45 kg P, 45 kg K, 600 kg lime ha^{-1} and nitrogen at the specified levels were applied compared to the general recommendation of 70: 35: 35 kg NPK ha^{-1} adopted in Kole land for the high yielding short duration varieties.

3.7 Methods

3.7.1 Treatments

The treatment consisted of factorial combination of Culture 10-1-1 and two cultivars of rice and five levels of nitrogen.

Cultivars

V_1 - Jyothi

V_2 - Culture 10-1-1

V_3 - Triveni

N levels

N_1 - 50 kg N ha^{-1}

N_2 - 70 kg N ha^{-1}

N_3 - 90 kg N ha^{-1}

N_4 - 110 kg N ha^{-1}

N_5 - 130 kg N ha^{-1}

3.7.2 Design and layout

The investigation was laid out as 3 x 5 factorial Randomised Block Design with three replications. The treatments were randomly allotted to plots. The layout plan and allocation of treatments for the experiment are given in Fig.2.

3.7.3 Spacing and plot size

a. Spacing 15 x 10 cm^2

b. Plot size

Gross 6 x 5 m^2

Net 4.65 x 4.2 m^2

c. Border rows. Three rows of plants were left as border rows all round each plot. One additional row was left length wise (6 m side) to facilitate periodical sampling of plant material and the next row was also left to avoid possible effect on the net plot.

3.7.4 Details of field cultivation

All operations were done in accordance with the Package of Practices of Kerala Agricultural University (KAU, 1986).

The main field was ploughed, puddled and levelled. Lime was incorporated with the last ploughing and washed. Plots of 6 x 5 m^2 dimension were demarcated by bunds of 30 cm width and height. Twentyone day old seedling of uniform growth were transplanted on 1st February 1985 at the rate of 2 - 3 seedlings/hill. Gap filling was done on seventh day after planting. The crop was given two hand weedings at 22nd and 40th day after transplanting. The plots were kept under 5 cm continuous submergence from the date of planting to 10 days before harvest.

3.7.4.1 Application of fertilizers

Basal dose of 45 kg P was incorporated at the time of levelling in the demarcated plots. Half the dose of nitrogen as per the treatment schedule and half of potassium recommended were applied 10 days after transplanting. The balance fertilizers were applied 21 days after the first application.

3.7.4.2 Crop protection

Adequate plant protection measures were taken whenever it was found necessary.

3.7.4.3 Harvesting

Jyothi was harvested 91 days after planting on 3.5.1985. Culture 10-1-1 was harvested 77 days after planting on 18.4.85. Triveni was harvested 79 days after planting on 20.4.1985. Border plants on all the sides of the plots were harvested first and the net plots were then harvested and threshed.

3.8 Observations recorded

3.8.1 Biometric observation

For periodical observations, thre sampling units of two x two hills (Total 12 hills) were randomly selected in each plot as suggested by Gomes (1972) and the following observations were recorded.

3.8.1.1 Height

Height was recorded from the base of the plant to the tip of the topmost leaf at active tillering. At flowering and harvest stages the height from the base to the tip of the tallest panicle was taken and the mean height worked out.

3.8.1.2 Number of tillers per m^2

Total number of tillers of all the 12 hills at active tillering and flowering stages were recorded and expressed as number of tillers per m^2.

3.8.1.3 Leaf area index (LAI)

Leaf area index was calculated by adopting the method suggested by Gomes (1972) at active tillering, flowering and harvest stages.

3.8.1.4 Dry matter production

Dry matter production at active tillering and flowering stages were found out from the samples drawn out for measuring leaf area. The grain yield and straw yield were added together to get the dry matter production at harvest.

3.8.1.5 Yield attributes

3.8.1.5.a Number of panicles per m^2

The total number of panicles from the 12 randomly selected hills were counted and expressed as number of panicles per m^2.

3.8.1.5.b Panicle length

Length of randomly selected 20 panicles were measured and mean of it was calculated to get the panicle length.

3.8.1.5.c. Panicle weight

All the 20 panicles of the sample taken were weighed and weight per panicle was calculated.

3.8.1.5.d Number of filled grains per panicle and filling percentage

The panicle from the sample selected were threshed and the number of filled and unfilled grains were counted. From this the filling percentage was calculated.

$$\text{Filling percentage} = \frac{\text{Number of filled grains per panicle}}{\text{Total number of grains per panicle}} \times 100$$

3.8.1.5.e 1000 grain weight

Two sets of filled grains, 500 each were counted, weighed separately and added to get 1000 grain weight.

3.8.1.6 Grain yield

The net plot grain yield was taken after drying in the sun for 3-4 days, winnowed, cleaned and expressed as yield kg ha^{-1} at 14 per cent moisture.

3.8.1.7 Straw yield

The straw harvested from the net plot was uniformly dried in sunlight, weighed and expressed as straw yield kg ha^{-1}.

3.8.1.8 Harvest index

Harvest index was worked out by dividing the economic yield (grain yield ha^{-1}) with biological yield (Dry matter production i.e. grain + straw yield at harvest).

3.8.2 Economics

Gross and net income ha^{-1} and benefit cost ratio calculated based on the cost of cultivation detailed below.

a. Cost of cultivation ac^{-1} (excluding N)	Rs.	3900.00
b. Cost of 1 kg urea	Rs.	2.40
c. Price of 1 kg paddy	Rs.	2.00
d. Price of 1 kg straw	Rs.	1.00

Physical and economic optimum of nitrogen were worked out as suggested by Nigam and Gupta (1979).

3.8.3 Chemical analysis

3.8.3.1 Plant analysis

3.8.3.1.a Nitrogen content

Nitrogen content of the plant samples at active tillering and flowering stages and that of grain and straw at harvest was determined by adopting the microKjeldahl digestion method as suggested by Jackson (1958).

3.8.3.1.b Phosphorus content

Phosphorus content of plant samples at active tillering and flowering stages and that of grain and straw at harvest were determined through diacid extraction (1: 1 HNO_3 : $HC1O_4$) and thereafter calorimetrically estimated using spectrophotometer (Spectronic 20) by developing Vanadomolybdophosphoric acid yellow colour as suggested by Jackson (1958).

3.8.1.c Potassium content

Potassium content of plants at active tillering and flowering stages and of that grain and straw at harvest were assessed through diacid extraction and thereafter read using EEL Flame photometer.

3.8.1.d Protein content of grain

The protein content of grain was computed by multiplying the nitrogen content of grain by a factor 6.25 (Simpson *et al*., 1965).

3.8.3.1.e Uptake of N, P and K

N, P and K contents of plant samples at active tillering and flowering stages were multiplied with dry matter yield and uptake of these nutrients at these stages were computed. The N, P and K content of grain and straw were multiplied with their respective yields and values thus obtained were added together to get uptake of N, P and K at harvest.

3.8.3.2 Soil analysis

Soil samples were drawn from the field prior to planting and immediately after harvest. It was dried in shade and processed for analysing total nitrogen, available P and exchangeable K content.

3.8.3.2.a Total nitrogen

Soil samples drawn were analysed by micro Kjeldhal method (Jackson, 1958).

3.8.3.2.b Available P

Available P was estimated by extraction with Bray No.1 solution and thereafter blue colour was developed by chloromolybdic acid and read in spectronic 20 (Jackson, 1958).

3.8.3.2.c Exchangeable K

Exchangeable K was extracted by leaching with neutral normal amonium acetate solution and thereafter read using EEL flame photometer (Jackson, 1958).

3.8.4 Statistical analysis

Statistical analysis was done by employing the techniques of analysis as described by Panse and Sukhatme (1978).

Results

RESULTS

The observations of the present study were statistically analysed. The results obtained are furnished below.

1. Growth characters

1.1 Height of plant

Data on height of plant at active tillering, flowering and at harvest are presented in Tables 2 to 4.

The result showed that the effects of nitrogen, cultivars and their interactions had significant influence at all stages.

Plant height was increased from active tillering to harvest. V_2 recorded maximum height and was significantly superior to V_1 and V_3 at all stages. V_3 was significantly superior to V_1 at active tillering and flowering but were on par at harvest.

Increase in nitrogen level significantly increased plant height upto N_4 at all stages.

Table 2. Height (cm) at active tillering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	40.60	45.32	47.00	48.60	49.40	46.18
V_2 (Culture 10-1-1)	49.30	53.40	53.90	60.30	56.30	54.64
V_3 (Triveni)	49.90	51.07	53.60	56.10	55.53	53.24
Mean	46.60	49.92	51.50	55.00	53.74	

C.D. (0.05) V = 0.75 N = 0.97 V x N = 1.68

Table 3. Height (cm) at flowering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	53.00	56.53	58.30	58.97	59.10	57.18
V_2 (Culture 10-1-1)	68.50	72.50	72.90	77.90	71.30	72.62
V_3 (Triveni)	68.50	67.70	67.80	68.50	66.20	67.20
Mean	62.43	65.58	66.33	68.46	65.53	

C.D. (0.05) V = 0.98 N = 1.27 V x N = 2.19

Table 4. Height (cm) at harvest

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	75.60	80.00	80.80	81.30	82.86	80.11
V_2 (Culture 10-1-1)	77.50	83.60	85.40	89.20	85.10	84.16
V_3 (Triveni)	76.40	80.70	81.60	82.20	81.20	80.42
Mean	76.50	81.43	82.60	84.23	83.06	

C.D. (0.05) V = 0.70 N = 0.90 V x N = 1.56

Table 5. Number of tillers per m^2 at active tillering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	576.80	627.00	655.40	656.60	630.30	629.50
V_2 (Culture 10-1-1)	556.67	674.50	693.00	681.80	597.63	640.72
V_3 (Triveni)	586.13	581.37	623.67	582.80	601.70	595.13
Mean	573.87	627.62	657.36	640.20	609.88	

C.D. (0.05) V = 13.61 N = 17.57 VxN = 30.44

Interaction effect was significant at all stages. Plant height increased upto N_5 in V_1 whereas the increase was only upto N_4 in V_2 and V_3 at all stages. Maximum plant height was registered by V_2N_4 and lowest by V_1N_1 at harvest.

1.2 Number of tiller per m^2

Data on number of tillers per m^2 at active tillering, flowering and at harvest are presented in Tables 5 to 7.

Number of tiller per m^2 was increased from active tillering to flowering and reduced at harvest.

The effect of cultivars was significant at all stages. V_2 produced significantly the higest tiller number at flowering and harvest stages, followed by V_1 and V_3. At active tillering V_1 and V_2 were on par. V_1 was significantly superior to V_3 at all stages also.

Tiller number was increased significantly upto N_3 at all stages, thereafter reduction in tiller number was noticed. N_4 was on par with N_3 at active tillering and at harvest stages. N_5 significantly reduced tiller number compared to N_3 and N_4 at all stages.

Interactions of cultivars and nitrogen were significant at all stages. At active tillering N_4 recorded the highest

Table 6. Number of tiller per m^2 flowering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	667.30	710.80	772.93	685.10	693.00	705.83
V_2 (Culture 10-1-1)	648.80	755.00	792.00	765.60	674.50	727.18
V_3 (Triveni)	597.30	693.00	707.50	747.80	696.30	688.38
Mean	637.80	719.60	757.48	732.83	687.93	

C.D. (0.05) V = 10.18 N = 13.14 N x V = 22.76

Table 7. Number of tillers per m^2 at harvest

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	528.00	545.80	582.13	572.20	571.60	559.55
V_2 (Culture 10-1-1)	534.63	597.30	630.20	605.37	598.80	593.26
V_3 (Triveni)	481.80	545.80	582.47	586.10	535.30	546.29
Mean	514.81	562.97	598.27	587.22	568.57	

C.D. (0.05) V = 10.13 N = 13.08 N x V = 22.65

Table 8. Leaf area index at active tillering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	4.31	4.57	4.60	4.68	4.90	4.61
V_2 (Culture 10-1-1)	4.72	5.47	5.80	5.79	5.88	5.53
V_3 (Triveni)	3.43	4.12	4.74	4.83	5.07	4.44
Mean	4.15	4.72	5.05	5.10	5.20	

C.D. ([illegible]) V = 0.02 N = 0.03 V x N = 0.04

Table 9. Leaf area index at flowering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	4.38	4.73	4.87	5.13	5.93	5.01
V_2 (Culture 10-1-1)	4.97	5.68	6.06	6.29	5.57	5.71
V_3 (Triveni)	4.18	4.64	4.69	4.70	5.09	4.66
Mean	4.50	5.02	5.21	5.37	5.53	

C.D. ([illegible]) V = 0.23 N = 0.30 V x N = 0.52

value for V_1 and N_3 for V_2 and V_3. At flowering V_1 and V_2 registered maximum tiller number at N_3 where in V_3 the highest value was observed at N_4. At harvest all the varieties increased tiller number upto N_3. V_2N_3 recorded maximum tiller number.

1.3 Leaf area index

Values of Leaf Area Index at different stages of growth are presented in Tables 8 to 10.

Leaf Area Index was increased from active tillering to flowering and thereafter there was a drastic decrease at harvest.

Among cultivars V_2 recorded significantly higher leaf area index values over V_1 and V_3 at active tillering and flowering stages. However at harvest V_2 registered significantly lower values than V_1 and V_3. V_1 was significantly superior to V_3 at active tillering and flowering but were on par at harvest.

The effect of nitrogen levels on leaf area index was significant at all stages. There was an increase in leaf area index with increasing N at active tillering. At flowering an increasing trend was noted upto N_5. However

Table 10. Leaf area index at harvest

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	0.34	0.39	0.41	0.40	0.40	0.39
V_2 (Culture 10-1-1)	0.28	0.31	0.33	0.38	0.38	0.33
V_3 (Triveni)	0.37	0.38	0.41	0.44	0.40	0.40
Mean	0.33	0.36	0.38	0.41	0.39	

C.D. (0.05) V = 0.01 N = 0.02 V x N = 0.03

Table 11. Dry matter production (kg ha^{-1}) at active tillering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	2688.0	2918.0	2984.0	2865.0	2838.0	2858.0
V_2 (Culture 10-1-1)	2750.7	3176.0	3369.0	3142.3	2984.0	3084.4
V_3 (Triveni)	1993.7	2420.3	2651.7	2557.0	2530.0	2430.3
Mean	2477.4	2838.1	3001.6	2854.8	2784.0	

C.D. (0.05) V = 46.1 N = 69.9 V x N = 103.1

at harvest the increase was only upto N_4. Leaf area index decreased at N_5 but it was on par with N_4.

N x V interactions were significant at all stages. At active tillering stage V_2N_5 recorded maximum value and the minimum by V_3 N_1. At flowering, leaf area index increased in V_1 and V_3 upto N_5 whereas it increased only upto N_4 for V_2. Maximum value of 6.27 was recorded by V_2N_4 and the lowest by V_3N_1. At harvest the highest value was observed at V_3N_4 and the lowest at V_2N_1.

1.4 Dry matter production

Data on dry matter production at active tillering, flowering and at harvest are presented in Tables 11 to 13.

Cultivars had significant influence on dry matter production at all stages. V_2 recorded significantly higher dry matter production followed by V_1 which was significantly superior to V_3 at all stages.

With regard to nitrogen level the dry matter production was increased significantly upto N_3 at active tillering and upto N_4 at flowering and at harvest. Thereafter there was a significant reduction.

Table 12. Dry matter production (kg ha^{-1}) at flowering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	4593.0	4758.0	4840.0	5253.0	4855.3	4859.9
V_2 (Culture 10-1-1)	4593.0	4784.0	4964.0	5266.0	4909.0	4093.3
V_3 (Triveni)	4609.0	4793.0	4909.0	4785.0	4785.0	4776.2
Mean	4598.5	4778.3	4904.3	5101.3	4849.8	

C.D.(0.05) V = 39.03 N = 50.8 V x N = 87.9

Table 13. Dry matter production (kg ha^{-1}) at harvest

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	7458.7	8548.7	9382.0	10374.3	9803.7	9113.5
V_2 (Culture 10-1-1)	8209.7	9596.0	10494.00	10759.7	11028.7	9859.4
V_3 (Triveni)	7284.7	8325.7	9272.0	9213.7	9028.7	8624.9
Mean	7651.0	8823.5	9716.0	10115.9	9690.1	

C.D.(0.05) V = 211.1 N = 272.6 V x N = 472.1

The interactions of nitrogen and cultivars were significant at all stages. At active tillering stage the highest value was recorded by V_2N_3 and the lowest by V_3N_1. At flowering V_1 and V_2 showed significant increase upto N_4 whereas in V_3 significant increase was seen only upto N_3. V_1N_4 was on par with V_2N_4 but significantly superior to V_3N_3. At harvest V_1 registered significant increase in dry matter upto N_4. Though there was an increase in dry matter upto N_4 for V_2 also, N_3 and N_4 were on par. Significant increase in dry matter was observed in V_3 upto N_3 with reduction in the dry matter production with further increase in nitrogen levels.

2. Yield attributes

2.1 Number of panicles per m^2

Data on the number of panicles are furnished in Table 14.

The effect of cultivars was significant. V_2 was significantly superior to V_1 and V_3 which in turn were on par.

Increase in panicle number was noticed with N levels upto N_3. N_3 and N_4 were on par. N_5 recorded panicle number which was significantly lower than N_2.

Table 14. Number of panicles per m^2

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	333.03	357.20	383.30	400.50	356.70	366.15
V_2 (Culture 10-1-1)	343.87	406.77	432.40	435.23	393.17	402.29
V_3 (Triveni)	343.20	367.50	388.57	378.13	352.90	366.06
Mean	340.03	377.16	401.42	404.62	367.59	

C.D.(0.05) V = 5.62 N = 7.26 V x N = 12.57

Table 15. Panicle length (cm)

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	18.03	18.50	18.91	19.27	19.37	18.82
V_2 (Culture 10-1-1)	17.57	18.13	18.59	18.81	19.00	18.42
V_3 (Triveni)	17.95	18.56	18.98	19.29	19.46	18.85
Mean	17.85	18.39	18.83	19.12	19.28	

C.D.(0.05) V = 0.03 N = 0.04 V x N = 0.07

V x N interactions were significant. V_2N_4 recorded the maximum panicle number and V_1N_1 had the lowest panicle number. V_1 registered a significant increase upto N_4 where as V_2 and V_3 recorded significant increase only upto N_3.

2.2 Panicle length

Data on values of panicle length are furnished in Table 15.

Among cultivars significantly higher values were registered by V_3 and V_1 over V_2. V_3 and V_1 were comparable.

Effect of nitrogen level on panicle length was significant. Length of the panicle was increased upto N_5 with enhancement of N application.

The interaction effects of varieties and nitrogen were significant. V_3N_5 recorded the maximum value. The other two cultivars also recorded the highest value at N_5.

2.3 Weight per panicle

Data on the weight per panicle are given in Table 16.

From the results it could be seen that panicle weight was significantly influenced by levels of nitrogen and cultivars but not by their interaction.

Table 16. Panicle weight (g)

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	1.39	1.50	1.58	1.60	1.60	1.53
V_2 (Culture 10-1-1)	1.42	1.54	1.60	1.62	1.61	1.56
V_3 (Triveni)	1.43	1.56	1.62	1.65	1.64	1.58
Mean	1.41	1.54	1.60	1.62		

C.D.(0.05) V = 0.01 N = 0.01 V x N = N.S.

Table 17. Number of filled grains per panicle

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	47.60	52.14	54.03	57.23	55.87	53.57
V_2 (Culture 10-1-1)	47.38	48.51	52.05	52.64	52.59	50.65
V_3 (Triveni)	49.79	55.86	60.56	60.45	60.26	57.38
Mean	48.26	52.17	55.55	56.77	56.24	

C.D (0.05) V = 2.54 N = 3.28 V x N = N.S.

Among cultivars V_3 was significantly superior to V_1 and V_2. V_2 was significantly superior to V_1.

As to nitrogen levels panicle weight was increased upto N_4. N_4 and N_5 were on par.

2.4 Number of filled grains per panicle

The values of filled grains per panicle are furnished in Table 17.

Significant influence was exerted only by levels of nitrogen and cultivars. The interaction (V x N) effects failed to exert any influence.

With regards to cultivars V_3 recorded significantly higher values over V_1 and V_2. V_1 was significantly superior to V_2.

Increase in nitrogen levels resulted in more number of filled grains per panicle. However, the latter three levels were on par but significantly superior to N_2 and N_1 which were similar in their effect.

2.5 Percentage of filled grains

The percentage of filled grains corresponding to various treatments are presented in Table 18.

Table 18. Percentage of filled grains (%)

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	73.98	72.97	71.39	70.67	69.74	71.75
V_2 (Culture 10-1-1)	70.90	69.56	68.90	68.00	66.92	68.86
V_3 (Triveni)	72.00	70.70	70.20	69.40	68.93	70.25
Mean	72.29	71.08	70.16	69.36	68.53	

C.D.(0.05) V = 0.47 N = 0.60 V x N = N.S.

Table 19. 1000 grain weight (g)

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	24.81	25.00	25.08	24.76	24.66	24.86
V_2 (Culture 10-1-1)	26.30	26.92	26.97	26.50	26.40	26.62
V_3 (Triveni)	24.25	24.43	24.48	24.60	24.75	24.50
Mean	25.12	25.45	25.51	25.29	25.27	

C.D. (0.05) V = 0.11 N = 0.14 V x N = 0.25

Percentage of filled grains were influenced by the levels of nitrogen and cultivars. The interactions of nitrogen and cultivars did not have any influence.

Among cultivars V_1 was significantly superior to V_3 and V_2. V_3 was significantly superior to V_2.

Successive increase in nitrogen levels significantly reduced the percentage of filled grains. Maximum value was recorded by N_1 which was significantly superior to all levels of nitrogen.

2.6 1000 grain weight

Data on the mean 1000 grain weight are given in Table 19.

The effect of cultivars was significant with V_2 recording significantly higher values over V_1 and V_3. V_1 was significantly superior to V_3.

With regard to nitrogen level the thousand grain weight was increased upto N_2. The highest two levels as well as N_2 and N_3 were on par.

Interaction effect were significant. In V_1, N_3 was significantly superior to N_1 while in V_3, N_4 was significant over N_1. In V_2, N_2 has given significantly higher 1000 grain weight over N_1.

Table 20. Grain yield (kg ha^{-1})

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	3705.7	4327.7	4777.3	5112.0	4541.0	4492.7
V_2 (Culture 10-1-1)	3732.3	4411.7	5060.0	4897.7	4357.3	4491.8
V_3 (Triveni)	3713.7	4353.3	4988.0	4724.7	4522.3	4460.4
Mean	3717.2	4364.2	4941.8	4911.4	4473.6	

C.D. (0.05) V = N.S.   N = 117.5   V x N = 203.5

Table 21. Straw yield (kg ha^{-1})

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	3843.0	4221.0	4604.7	5172.3	5262.7	4620.7
V_2 (Culture 10-1-1)	4477.3	5184.3	5437.3	5862.0	5880.7	5368.3
V_3 (Triveni)	3571.0	3972.3	4284.0	4489.0	4506.3	4164.5
Mean	3963.8	4459.2	4775.3	5174.0	5216.6	

C.D. (0.05) V = 199.2   N = 154.3   V x N = N.S.

3. Grain yield

Data on the mean grain yield are presented in Table 20.

As evident from the table the grain yield was significantly influenced by the levels of nitrogen and interactions of cultivars and nitrogen. There was no significant difference among cultivars in grain yield.

Grain yield increased significantly upto N_3 after which a decrease was seen. N_5 recorded significantly lower values than N_3 and N_4 which were on par.

V_1 showed significant yield increase upto N_4 whereas V_2 and V_3 registered significant yield increase upto N_3 only. Maximum grain yield was obtained by V_1N_4 which was comparable with V_2N_3 and V_3N_3.

4. Straw yield

The mean straw yield data are furnished in Table 21.

It was seen that the levels of nitrogen and cultivars had significant influence on straw yield. The interactions of factors nitrogen and variety failed to exert any significant influence on straw yield.

Table 22. Harvest index

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	0.50	0.51	0.51	0.49	0.46	0.49
V_2 (Culture 10-1-1)	0.45	0.46	0.48	0.46	0.48	0.46
V_3 (Triveni)	0.51	0.52	0.54	0.51	0.50	0.52
Mean	0.48	0.49	0.51	0.49	0.46	

C.D.(0.05) V = 0.01 N = 0.01 V x N = N.S.

Table 23. Protein content of grains (%)

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	7.93	9.48	9.62	11.89	11.91	10.17
V_2 (Culture 10-1-1)	7.64	9.48	9.70	11.91	11.78	10.10
V_3 (Triveni)	9.49	11.58	12.32	12.59	11.46	11.49
Mean	8.35	10.18	10.55	12.13	11.72	

C.D.(0.05) V = 0.34 N = 0.44 V x N = 0.76

Among cultivars, V_2 recorded the highest value which was significantly superior to V_1 and V_3. V_1 was significantly superior to V_3.

The straw yield was significantly increased upto N_4 which was on par with N_5 and significantly superior to other nitrogen levels.

2.6 Harvest index

Data on the harvest indices are furnished in Table 22.

As evident from the table, nitrogen and cultivars exerted significant influence in harvest index. V x N interaction did not influence harvest index significantly.

Among cultivars V_3 had significantly higher value over V_1 and V_2. V_1 recorded significantly higher value than V_2.

Harvest index value was increased upto N_3 and decreased thereafter. N_1 and N_2 were on par. N_5 registered significantly lower value than other levels.

Table 24. Nitrogen uptake (kg ha^{-1}) at active tillering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	63.42	67.64	79.25	81.68	88.02	76.00
V_2 (Culture 10-1-1)	68.70	83.79	89.94	88.89	71.92	80.65
V_3 (Triveni)	51.59	60.80	71.14	78.75	74.69	67.39
Mean	61.24	70.74	80.11	83.10	78.20	

C.D.(0.05) V = 3.29 N = 4.25 V x N = 7.36

Table 25. Nitrogen uptake (kg ha^{-1}) at flowering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	85.58	96.03	97.76	120.74	104.91	101.00
V_2 (Culture 10-1-1)	94.28	103.39	106.47	115.41	110.66	106.44
V_3 (Triveni)	83.03	87.82	102.25	120.57	108.40	100.41
Mean	87.63	95.75	102.16	118.91	107.99	

C.D.(0.05) V = N.S. N = 8.64 V x N = N.S.

3. Chemical studies

3.1 Protein content of the grain

The mean protein content values of grain are furnished in Table 23.

The effect of cultivars was significant. V_3 recorded significantly higher protein content over V_1 and V_2 which were on par.

As to nitrogen levels the protein content was increased upto N_4 and a decrease was noted at N_5. N_4 and N_5 were on par and significantly superior to other levels of nitrogen. N_3 and N_2 were also on par.

In protein content, an increasing trend was seen in V_1 upto N_5 and in V_2 and V_3 upto N_4. Highest protein content of 12.59 per cent was recorded for V_3N_4 which was on par with V_3N_3, V_2N_4 and V_1N_5.

3.2 Nitrogen uptake

Data on the uptake of nitrogen at active tillering, flowering and harvest stages are furnished in Tables 24 to 26.

Cultivars exerted its influence significantly at active tillering where V_2 recorded higher value over V_1 and V_3, V_1 was superior to V_3. However at flowering and at harvest there was no significant variation among cultivars.

Table 26. N uptake (kg ha^{-1}) at harvest

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	95.54	114.46	147.54	189.71	153.36	140.12
V_2 (Culture 10-1-1)	100.12	131.97	146.75	169.85	156.00	140.94
V_3 (Triveni)	95.14	135.06	167.15	171.61	143.39	142.47
Mean	96.94	127.16	153.81	177.06	150.92	

C.D.(0.05) V = N.S. N = 7.03 V x N = 12.18

Table 27. P uptake (kg ha^{-1}) at active tillering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	7.70	8.48	8.97	8.87	8.59	8.52
V_2 (Culture 10-1-1)	8.73	9.28	10.68	9.99	9.52	9.64
V_3 (Triveni)	6.15	7.58	8.19	7.92	7.67	7.50
Mean	7.53	8.45	9.28	8.93	8.59	

C.D.(0.05) V = 0.15 N = 0.20 V x N = 0.34

The nitrogen levels influenced the uptake at active tillering, flowering and at harvest stages. The uptake was increased upto N_4 followed by a significant reduction at N_5 level at all the stages. N_3 was on par with N_4 at active tillering but there was significant difference at flowering and harvest. N_3 was significantly superior to N_2 at active tillering and harvest. However N_3 was on par with N_2 at flowering.

Interaction effects were significant at active tillering and at harvest stages. At active tillering the highest nitrogen uptake was recorded by V_2N_4 and the minimum by V_3 N_1 which was on par with V_2N_1 and V_1N_1. At harvest nitrogen uptake was increased upto N_4 in V_1 and V_2 where as in V_3 the uptake was enhanced only upto N_3.

3.3 P uptake

Data on phosphorus uptake by plants at various stages of crop growth are furnished in Tables 27 to 29.

The effects of cultivars was significant at active tillering and harvest stages. The highest P uptake was observed for V_2 at both the stages. V_1 recorded significantly superior values over V_3 at both the stages.

Table 28. P uptake (kg ha^{-1}) at flowering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	12.19	12.71	13.27	13.36	13.56	13.01
V_2 (Culture 10-1-1)	12.42	13.07	13.64	13.90	14.13	13.43
V_3 (Triveni)	12.58	13.01	13.39	13.97	14.04	13.40
Mean	12.40	12.93	13.44	13.74	13.89	

C.D. (0.05) V = N.S. N = 0.50 V x N = N.S.

Table 29. P uptake at harvest (kg ha^{-1})

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	15.49	17.51	19.55	21.67	19.55	18.75
V_2 (Culture 10-1-1)	17.20	20.21	20.89	21.80	19.43	19.91
V_3 (Triveni)	14.21	17.20	19.68	19.60	19.24	17.99
Mean	15.63	18.31	20.04	21.02	19.41	

C.D. (0.05) V = 0.29 N = 0.37 V x N = 0.64

Table 30. K Uptake (kg ha^{-1}) at active tillering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	52.72	59.31	63.52	57.18	54.83	57.51
V_2 (Culture 10-1-1)	52.11	63.36	67.87	59.55	58.49	60.28
V_3 (Triveni)	39.05	52.97	56.37	54.43	55.49	51.66
Mean	47.96	58.55	62.58	57.05	56.27	

C.D. (0.05) V = 2.47 N = 3.19 V x N = 5.5

Table 31. K Uptake (kg ha^{-1}) at flowering

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	71.83	85.97	94.26	85.94	84.96	84.59
V_2 (Culture 10-1-1)	85.98	90.94	96.46	102.06	98.85	94.86
V_3 (Triveni)	76.53	80.81	80.54	87.53	76.03	80.29
Mean	78.11	85.92	90.42	91.84	86.61	

C.D. (0.05) V = 3.76 N = 4.85 V x N = 8.4

Influence of nitrogen on P uptake was significant at all the stages. At active tillering stage P uptake was significantly increased upto N_3, with N_4 and N_5 showing a significant decrease. At flowering, significant increase was seen upto N_3 which was on par with N_4 and N_5. At harvest significant increase was noted only upto N_4.

V x N interactions were significant at active tillering and harvest. At active tillering stage maximum value was recorded by V_2N_3 which was significantly superior to V_1N_3 and V_3N_3. At harvest the highest value was registered by V_2N_4. V_1 and V_2 increased P uptake upto N_4 whereas in V_3 the increase was only upto N_3.

3.4 K uptake

Data on the uptake of K at all stages of growth are presented in Tables 30 to 32.

Effect of cultivars was significant at all the stages. V_2 recorded significantly superior values over V_1 and V_3 at active tillering and flowering. However at harvest V_1 and V_2 were on par. V_3 registered the lowest K uptake at all stages.

Table 32. K Uptake (kg ha^{-1}) at harvest

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	112.16	127.52	140.09	154.29	149.79	136.77
V_2 (Culture 10-1-1)	113.64	143.34	149.94	152.23	136.05	139.04
V_3 (Triveni)	91.83	104.72	116.24	117.35	114.33	108.89
Mean	105.88	125.20	135.42	141.29	133.39	

C.D. (0.05) V = 5.92 N = 7.64 V x N = N.S.

Table 33. Total N (%) after cropping

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	0.19	0.20	0.21	0.22	0.22	0.21
V_2 (Culture 10-1-1)	0.19	0.20	0.20	0.22	0.22	0.21
V_3 (Triveni)	0.19	0.21	0.21	0.22	0.22	0.21
Mean	0.19	0.20	0.21	0.22	0.22	

C.D. (0.05) V = N.S. N = 0.01 V x N = N.S.

Nitrogen levels influenced the K uptake at all the stages. There was an increase in the uptake upto N_3 at active tillering and harvest stages. At flowering the increase was seen upto N_4. However, N_2 and N_3 were on par. A significant reduction was observed at N_5.

Interaction effects were significant at active tillering and flowering stages. At active tillering maximum value was recorded by V_2N_3 and the minimum by V_3N_1. At flowering the highest value was recorded by V_2N_4 and lowest by V_1N_1.

3.5 Soil analysis

3.5.1 Total nitrogen

Data on the nitrogen of soil after harvesting is presented in Table 33.

The effect of cultivars and their interaction with nitrogen levels were not significant. With regard to nitrogen levels N_3, N_4 and N_5 were on par and significantly superior to N_1. N_4 and N_5 were significantly superior to N_2 and N_1.

Table 34. Available P (ppm) at harvest

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	4.65	4.63	4.60	4.48	4.33	4.54
V_2 (Culture 10-1-1)	4.50	4.48	4.39	4.31	4.35	4.40
V_3 (Triveni)	4.81	4.67	4.65	4.61	4.59	4.67
Mean	4.65	4.59	4.55	4.46	4.42	

C.D.(0.05) V = 0.05 N = 0.07 V x N = 4.42

Table 35. Exchangeable K (ppm) at harvest

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	52.00	53.50	56.00	56.50	57.00	54.80
V_2 (Culture 10-1-1)	52.50	53.97	54.00	54.00	58.00	54.49
V_3 (Triveni)	57.50	58.00	60.56	64.50	60.83	60.27
Mean	54.67	65.16	56.50	58.33	58.61	

C.D.(0.05)V = 0.93 N = 1.20 V x N = 2.07

3.5.2 AVailable P

Data on the available P content of the soil after cropping is presented in Table 34.

The effect of cultivars was significant. V_3 recorded the highest value which was significantly superior to V_1 and V_2. V_2 had significantly lower values than V_1.

As to nitrogen levels, there was a progressive decrease in P content of soil with increase in nitrogen. N_1 recorded the highest value which was significantly superior to N_3, N_4 and N_5. N_3 was on par with N_4 but significantly superior to N_5.

The interaction of cultivars and nitrogen were significant. V_2N_3 recorded the highest and V_3N_1 the lowest value.

3.5.3 Exchangeable K

The exchangeable K content of soil after harvest of crop is presented in Table 35.

The effect of cultivars was significant. V_3 recorded the highest value which was significantly superior to V_2 and V_1 which in turn were on par.

With regard to nitrogen, the exchangeable K content significantly increased in soil upto N_5. N_4 and N_5 were on par and significantly superior to N_1 and N_2 which were on par.

V x N interactions were significant. Maximum value was registered by V_3N_4 which was significantly superior to V_2N_5 and V_1N_5.

Discussion

5. DISCUSSION

5.1 Growth characteristics

5.1.1 Plant height (Tables 2 to 4)

From the Fig.3 it can be seen that Culture 10-1-1 has given the tallest plant. The other two varieties were recording smaller height which were similar. Varietal variations to nitrogen levels might be an inherent character of varieties (Iruthyaraj, 1975).

A progressive increase in plant height with age of the crop was noticed. An increase was also noticed due to incremental nitrogen levels at all the stages. One of the well known role of nitrogen is increasing plant height (Rojas et al., 1983; Reddy, 1985). This response to nitrogen might be due to the faster growth resulting from the enhanced N uptake and efficient photosynthesis.

The interaction showed that Jyothi had responded upto 130 kg N ha^{-1} whereas Culture 10-1-1 and Triveni responded only upto 110 kg N ha^{-1} (Fig.4). Culture 10-1-1 recorded comparatively taller plants right from the early stages which could be attributed to its varietal trait. Jyothi was the shortest at initial stages. It may be due to

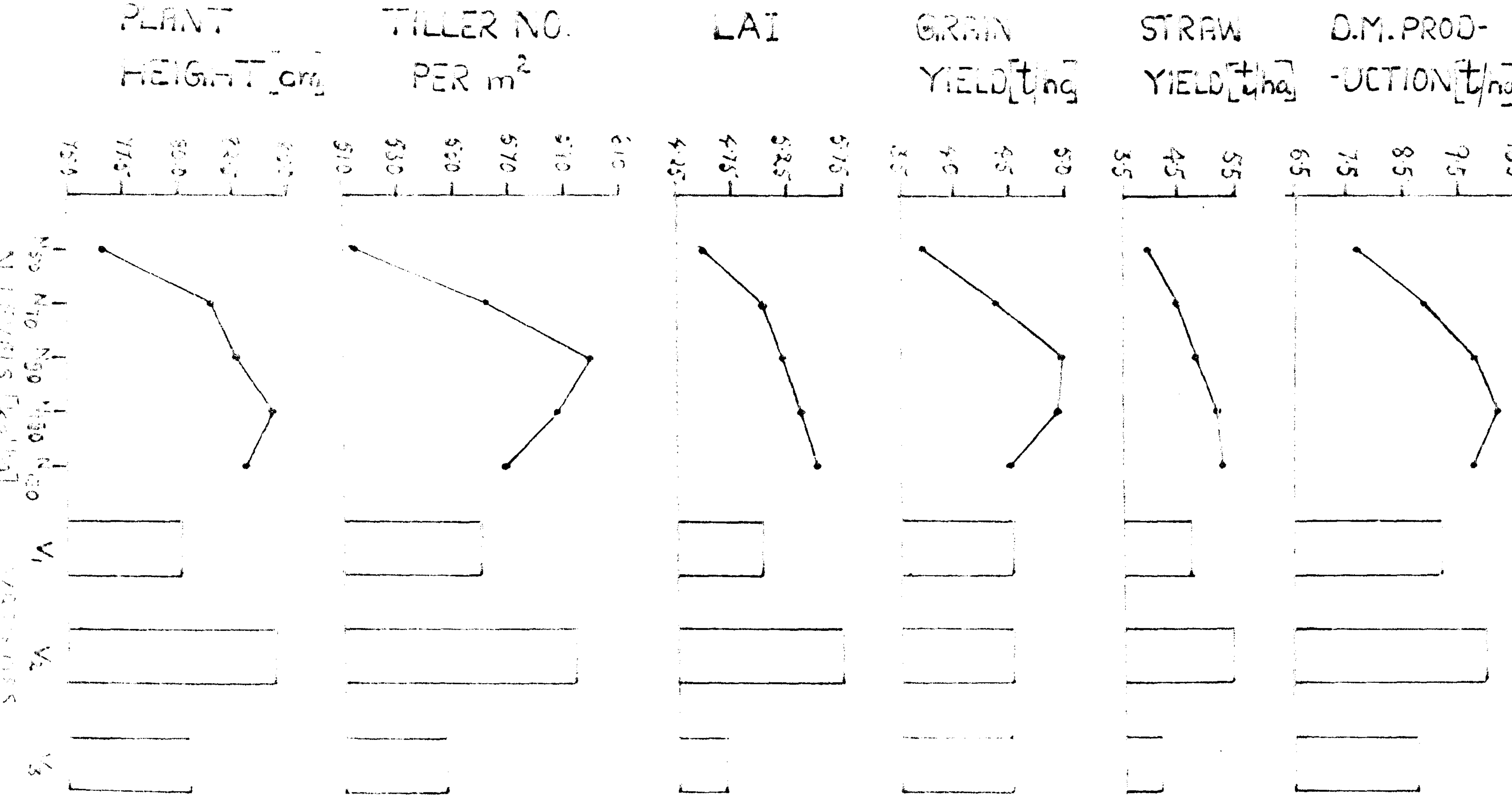


Fig 3 GROWTH ATTRIBUTES, GRAIN YIELD, STRAW YIELD AND DRY MATTER [illegible]
AS INFLUENCED BY LEVELS OF NITROGEN [illegible]

V_1 JYOTHI
V_2 CULTURE 10-[illegible]
V_3 TRIVENI

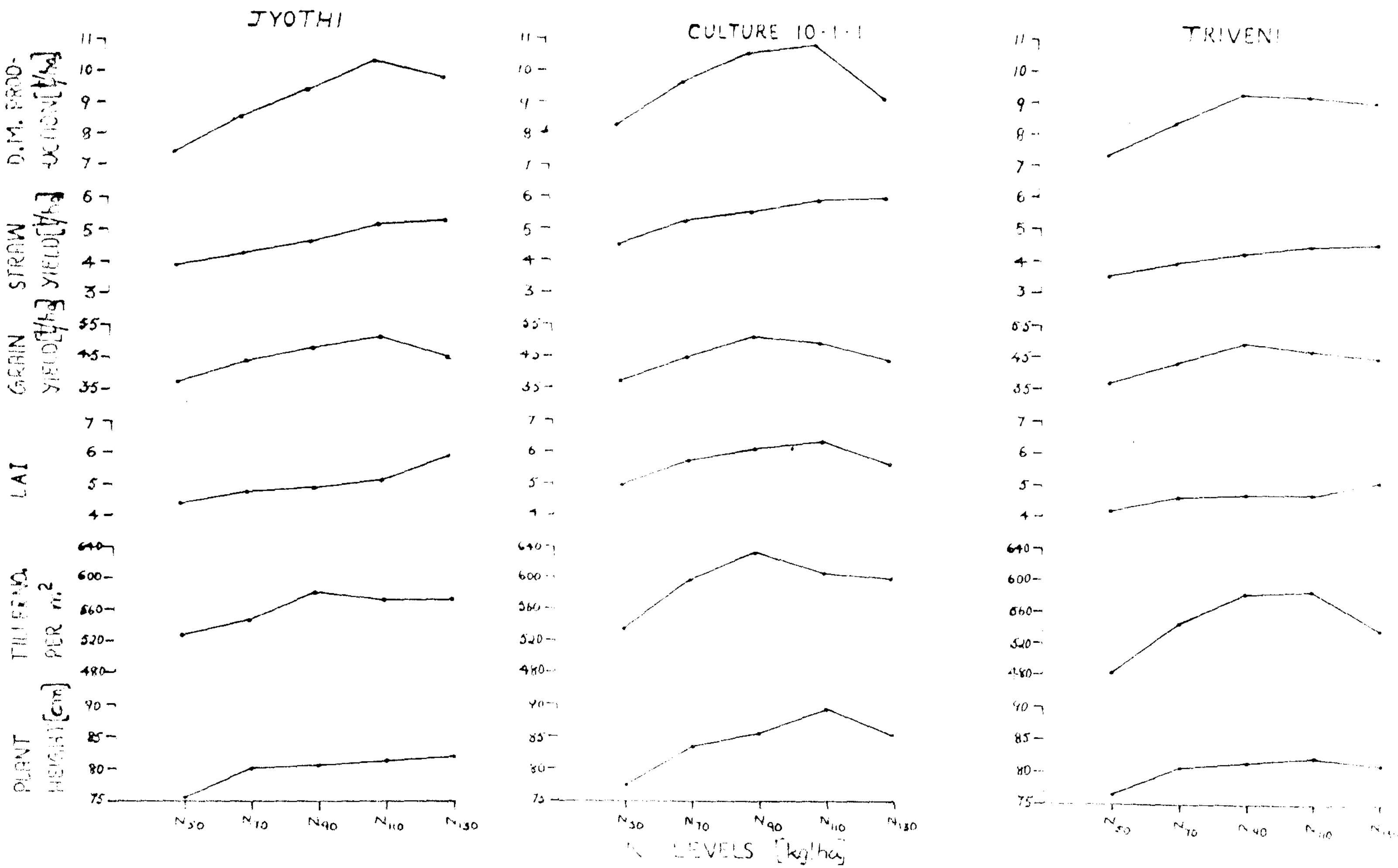
the better utilisation of the absorbed nitrogen in initial stages for tiller production rather than increasing plant height. This is in accordance with the observation made by Nair (1968).

5.1.2 Number of tiller m^{-2} (Tables 5 to 7)

Fig. 3 shows that the highest tiller number was produced by Culture 10-1-1 followed by Jyothi and Triveni. Tillering is a varietal trait and this differential performance might be due to the difference in the ability of individual varieties to utilise the absorbed nitrogen for vegetative or reproductive purpose. Kurup and Sreedharan (1971) and Lal (1981) reported similar varietal differences.

As in the case of plant height, Fig.3 shows that an increase in nitrogen application has enhanced production of tillers. Nair (1968) and Ramasamy (1982) also reported similar results. A decrease noted at higher nitrogen levels might be due to imbalanced nutrition resulting from the increased supply of nitrogen in the absence of corresponding increase in P and K level. This is evident from Table 29 on P uptake and Table 32 on K uptake wherein a decrease in P and K uptake was noticed beyond a certain level of nitrogen.

Fig.4. INFLUENCE OF LEVELS OF NITROGEN ON GROWTH ATTRIBUTES, GRAIN YIELD, STRAW YIELD AND DRY MATTER PRODUCTION OF VARIETIES



Another probable reason may be due to the mutual shading consequent to the higher level of nitrogen. It is known that tillering is closely related to the amount of nitrogen available in soil to maintain the plant nitrogen content above a certain level, which explains the initial increase in tiller numbers (Varma and Srivastava, 1972).

It can be seen from the Figure 4 that all the varieties responded upto 90 kg N ha^{-1} though the response was comparatively higher for Culture 10-1-1 over other varieties. The rate of decline in tiller number at harvest was higher for Jyothi followed by Triveni which might be due to overcrowding of plants and mutual shading (Fig.5). It can also be seen that the Culture 10-1-1 has more effectively utilized the nitrogen available in the initial stages for vegetative purpose namely plant height and tiller number than the other two varieties which can be attributed as to its varietal trait.

5.1.3 Leaf area index (Tables 8 to 10)

The leaf area index increased with stages upto flowering followed by a drastic decrease at harvest. From Fig. 3 it can be seen that Culture 10-1-1 gave the highest

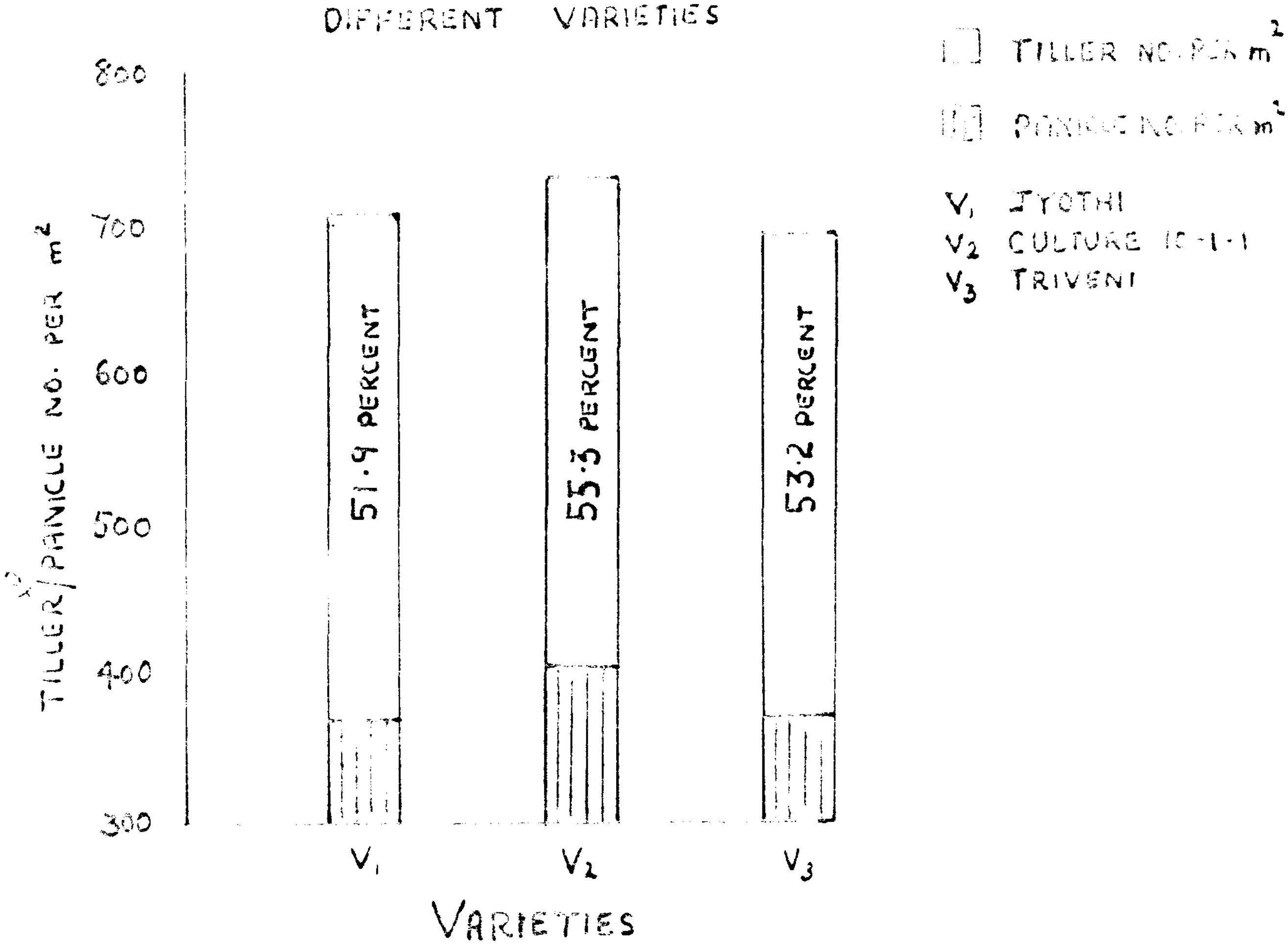


Fig. 5. Total tiller number, panicle number and percentage of productive tillers in different varieties

leaf area index followed by Jyothi and Triveni upto flowering. At harvest Jyothi and Triveni had similar values and Culture 10-1-1 the lowest. Leaf area index is function of size of leaf and tiller production. Figure 3 and the data on plant height and tiller production (Table 2 to 7) shows that Culture 10-1-1 secured the highest values at active tillering and flowering stage. Nitrogen has a positive role in delaying senescence of leaves by which it increases the leaf area duration. Difference in leaf area duration due to different levels of nitrogen and varieties was reported by Stone and Steinmetz (1979). Culture 10-1-1 had comparatively earlier senescence than other two varieties which might be attributed as to the reason for getting lowest leaf area index for this variety at harvest.

Figure 3 also shows that leaf area index increased with nitrogen levels. As nitrogen level increased leaf N also might have increased (Salam, 1984) probably leading to a linear increase in leaf photosynthetic rate (Yoshida, 1981). Thus increased N resulted in higher vegetative growth which was marked by higher tiller production and size of leaves resulting in increased leaf area index. Similar results were also reported by Murata and Matsushima (1978).

The optimum leaf area index for maximum yield was found to be around six (Sreedharan, 1975). This value was attained at flowering by Culture 10-1-1 at 90 kg N ha^{-1} and by Jyothi at 110 kg N ha^{-1}. Triveni did not attain the value even at 130 kg N ha^{-1} (Fig.4). At harvest there was no comparable difference among nitrogen levels for all the varieties.

5.1.4 Dry matter production (Tables 11 to 13)

Dry matter production increased with stages of growth. Fig. 3 shows that Culture 10-1-1 recorded significantly higher values at all stages over the other two varieties. Perusal of the data on plant height, tiller number and leaf area index and Fig.4 showed an increased value of these vegetative factors for Culture 10-1-1 which resulted in higher dry matter production.

Dry matter production was enhanced with increased levels of nitrogen. It can also be noticed from Fig.3 that an almost similar trend was there with the vegetative attributes. According to Krishnakumar (1986) the number of leaves per tiller in rice being more or less fixed, it should be mainly through an increase in tiller production that dry matter production could be increased and the reported trend was in line with this conclusion.

Higher dry matter production even at initial nitrogen levels (9.67 at 50 kg N ha^{-1}) obtained in this study can be attributed to high initial nitrogen content of soil coupled with the higher solar energy receipt (Fig.1) enjoyed by the crop. It may be stated that the cropping season is from December-January to March-April as indicated in Materials and Methods. However, the dry matter production was found to increase further with the enhanced nitrogen. Kang and Hue (1976) reported that bright sunshine especially from transplanting to panicle initiation is desirable for increased dry matter production.

The variety Culture 10-1-1 gave the highest dry matter production at 110 kg N ha^{-1} at flowering and harvest stages. Dry matter production is a factor which mainly decides the yield and the response of varieties to levels of nitrogen is almost following the same model as that of yield which will be discussed later. The differential performance of varieties with reference to nitrogen levels is attributed to varietal characteristics.

5.2 Yield attributes

5.2.1 Number of panicles per m^2 (Table 14)

It is evident from the Fig.6 that Culture 10-1-1 recorded the highest value for panicle numbers. This may be

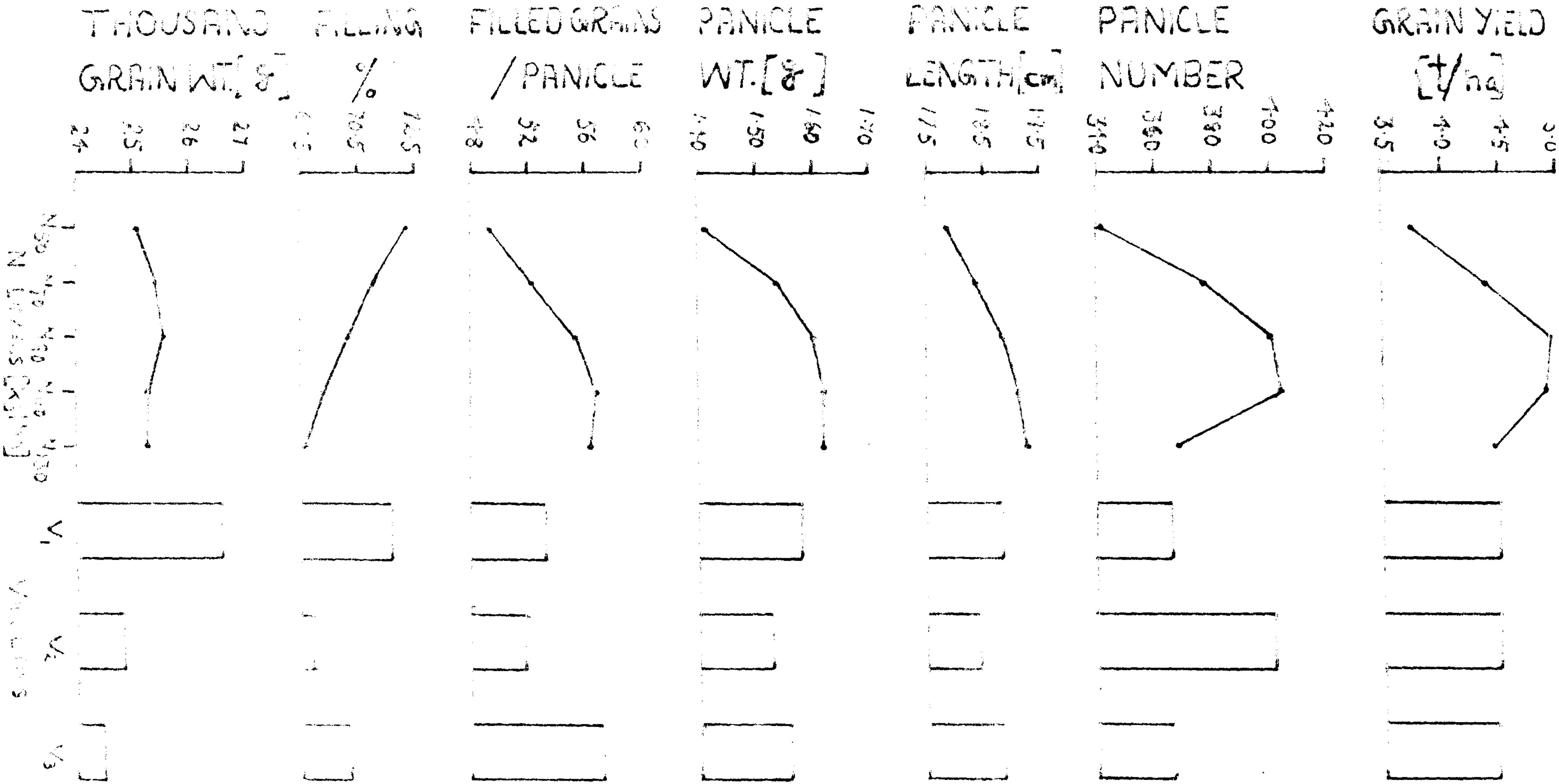


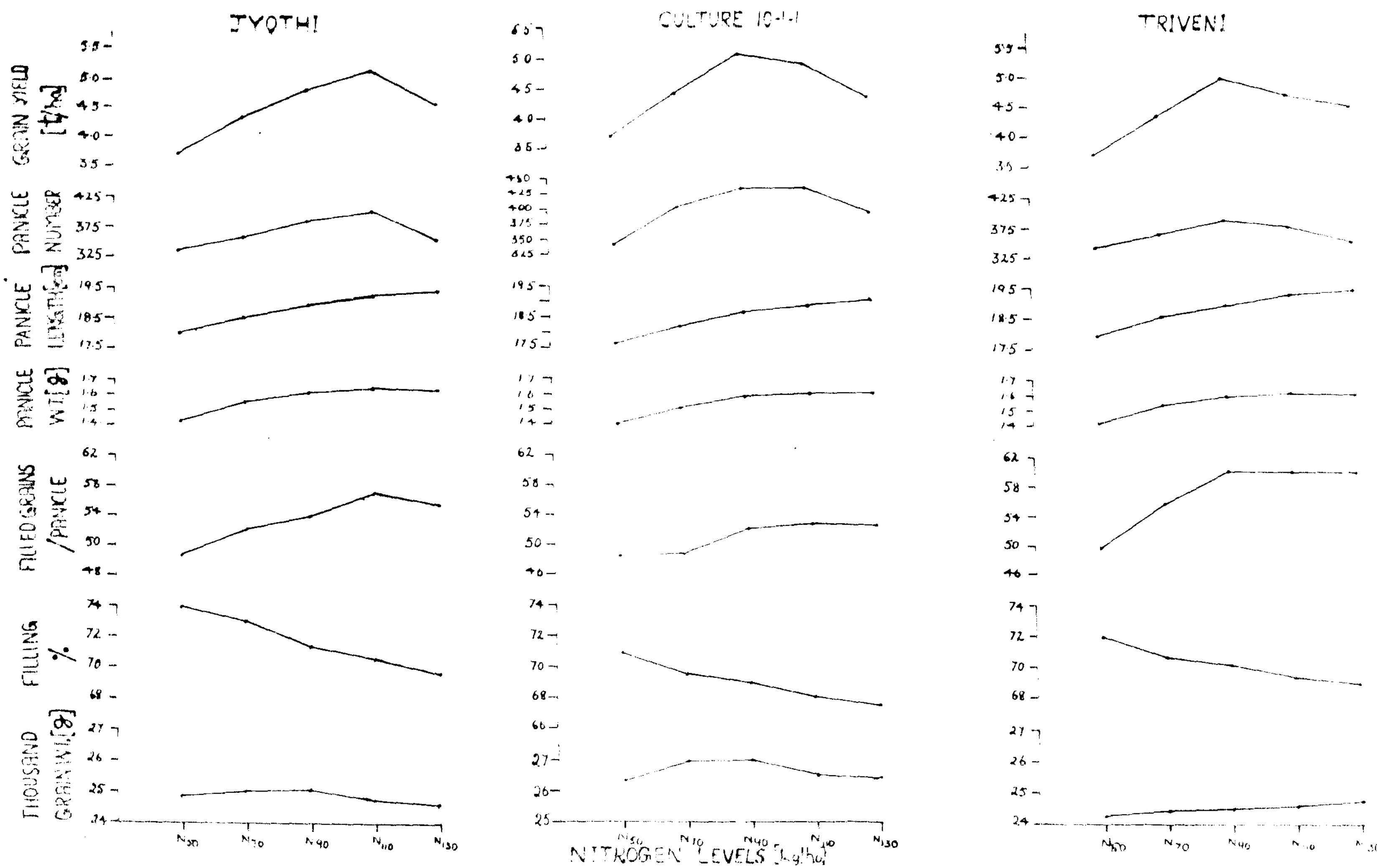
Fig. 6 Yield attributes and grain yield as influenced by levels of nitrogen and varieties.

V_1 - JYOTHI
V_2 - CULTURE 10-1-1
V_3 - TRIVENI

due to the fact that the higher sink capacity resulting from the increased level of nitrogen fertilization was reflected by the production of more number of effective tillers by this variety. It may also be noted from Fig.5 that tiller mortality is lowest in Culture 10-1-1 resulting in higher panicle number. Ustimenko et al. (1983) reported similar variation in panicle number among varieties tested with regard to nitrogen response.

Figure 6 also shows that the number of panicles increased upto 110 kg N ha^{-1} though significantly only upto 90 kg ha^{-1}. Increase in panicle production in accordance with enhanced levels of nitrogen is well established (Pillai and De, 1980a and Tayebi and Dadaschi, 1981). Nitrogen upto a certain level has beneficial effect in not only enhancing tiller production but also in preventing tiller mortality. However, at 130 kg N ha^{-1} the higher nitrogen available might have probably lead to the decline in panicle number by the increased portioning of assimilated nitrogen for vegetative growth leading to mutual shading and lesser effective tillers. The result obtained in this study is in conformity with the findings of Varma and Srivastava (1972) and Subbiah et al.(1977).

Fig. 7. INFLUENCE OF LEVELS OF NITROGEN ON YIELD ATTRIBUTES AND GRAIN YIELD OF VARIETIES



It can be seen from Fig.7 that Jyothi registered its highest value at 110 kg N ha^{-1} whereas Triveni and Culture 10-1-1 produced higher panicle number at 90 kg N ha^{-1}. Perusal of the data on tiller production at active tillering (Table 5) shows that it was the highest for Jyothi at 110 kg N ha^{-1} and for Triveni and Culture 10-1-1 at 90 kg N ha^{-1}. It is probable that most of the early formed tillers have been transformed into effective ones and as such the number of panicle per m^2 has followed the same trend as that of tiller production at active tillering stage.

5.2.2 Length of the panicle(Table 15)

The results reveal that Jyothi and Triveni recorded similar values, higher than that of Culture 10-1-1 (Fig.6). It can also be seen from the same Figure that panicle length was increased significantly with the enhancement of nitrogen levels in each variety. This might be, due to the increased rate of photosynthesis and assimilates formed and translocated to reproductive parts. Increased panicle length due to additional nitrogen application was reported by Kalyanikutty _et al_. (1969) and Latif (1982).

The interaction effects were not significant.

5.2.3 Weight per panicle (Table 16)

Fig.6 shows that Triveni recorded the highest and Jyothi the lowest value for weight per panicle. It can also be seen from the figure that Triveni had the highest number of filled grains per panicle which might have been the probable reason for recording highest panicle weight. Though Culture 10-1-1 had the lowest number of filled grains per panicle it registered the highest value for thousand grain weight resulting in higher panicle weight than Jyothi.

Figure 6 also shows that panicle weight was increased by nitrogen application. This higher nitrogen must have had a positive influence in synthate assimilation in the grains thus increasing the panicle weight. This is in conformity with the observations of Place et al. (1970).

The interaction effects were not significant.

5.2.4 Number of filled grains per panicle (Table 17)

From Fig.6 it can be seen that Triveni recorded the highest value followed by Jyothi and Culture 10-1-1 which registered the lowest. There was no varietal difference in the number of filled grains as influenced by nitrogen fertilization. It may be mentioned in this connection that the yield data given in the Table 20 and Fig.6 does not show any significant effect of varieties on yield. With the same sink, the varieties had partioned the assimilates differently among the different yield attributes. It may also be noted that Triveni had the lowest and Culture 10-1-1 the highest value for panicle number. This might be the probable reason for Triveni to get the highest value for filled grains per panicle. Tanaka (1972) opined that with heavy nitrogen application, eventhough more number of tillers and panicle primordia per unit land area were produced, the number of spikelets per panicle would be less since there are too many sinks when compared to the capacity of source. This might be attributed as the reason for Culture 10-1-1 to register lowest filled grains per panicle.

Fig.6 also showed that the number of filled grains per panicle increased upto 110 kg N ha^{-1} though significantly only upto 90 kg N ha^{-1}. It is well established that number of filled grains increased with nitrogen (Latif, 1982 and Singh et al., 1984). Krishnakumar (1986) opined that differentiation of spikelets was strongly supported by nitrogen supply and their degeneration was effectively prevented by carbohydrate supply through increased photosynthesis that was favourably influenced by N leading to increased filled grains per panicle.

It may be further seen from Fig.9 and Table 32 that the K uptake followed a similar trend as that of filled grains per panicle. This increase in the uptake of K with incremental nitrogen would have contributed to more grain filling asthe role of K in grain filling is well known (Agarwala and Sharma, 1976).

5.2.5 Percentage of filled grains (Table 18).

Fig.6 shows that Jyothi recorded the highest value and Culture 10-1-1 the lowest value for the percentage of filled grains. It can also be seen from the same figure that Jyothi recorded the lowest number of spikelets per panicle and the highest by Triveni. The higher the spikelet number the higher will be the sterility. Matsushima (1970) also observed similar results. Culture 10-1-1 recorded the lowest value of percentage of filled grains presumably because of the higher panicle number produced.

Guo (1982) and Murthy and Murthy (1982) opined that spikelet sterility was positively associated with number of panicles per m^2. The results obtained in this study are in conformity with the above findings.

Enhanced application of nitrogen resulted in an increase in spikelet sterility (Fig.6). A reference to the Tables 15 and 17 and Fig.6 reveal that panicle length was increased upto 130 kg N ha^{-1} and filled grains upto 90 kg N ha^{-1}. From the above tables it can be surmised that by increasing the level of nitrogen the number of spikelets was increased. At the same time those spikelets beyond a certain number was converted to chaff. Another probable reason for higher sterility at higher nitrogen levels is due to imbalance of NPK nutrition. The usual recommendation is to follow a ratio of 2: 1: 1 (KAU, 1986). However, in this experiment there was no provision to give more than 45 kg N ha^{-1}. Lack of sufficient P and K at higher nitrogen levels might have resulted in increased spikelet sterility. This is in accordance with the reports of Murthy and Murthy (1982).

5.2.6 Thousand grain weight (Table 19).

Culture 10-1-1 recorded the highest value followed by Jyothi. Triveni registered the lowest value (Fig.6).

With the sink being similar the assimilates available would have been distributed among the spikelets available equally. Culture 10-1-1 had lesser number of filled grains per panicle which might have been the probable reason for recording the highest value. Triveni had the highest number of filled grains per panicle resulting in lowest thousand grain weight.

It is evident from Fig.8 that thousand grain weight was increased by increasing nitrogen levels as accumulation of carbohydrates in the spikelets were favoured to a great extent by increasing nitrogen levels (Abraham et al., 1975). With higher levels of nitrogen application, more of the nutrient might have been available during the later growth stages leading to increased grain filling. It may also be pointed out here that uptake of nutrients especially K increased with added nitrogen and the role of K in enhancing grain filling is well known (Agarwala and Sharma, 1976).

As already explained Triveni had the highest number of filled grains (Fig.8). So the assimilate available were distributed to all the grains with the result that there is no marked increase in thousand grain weight with nitrogen. Jyothi gave a significant increase upto

70 kg N ha^{-1}, Culture 10-1-1 upto 90 kg N ha^{-1} and Triveni upto 110 kg N ha^{-1}. Thousand grain weight is a character mainly a varietal attribute influenced by fertilization to a certain extent only.

5.2.7 Grain yield (Table 20)

From Fig.6 it can be seen that varieties did not have any influence on grain yield. Even though Jyothi registered the highest grain yield and had higher crop growth period it can be said that there was no appreciable difference in the production potential of the varieties tested under Kole land conditions.

The grain yield was influenced by nitrogen. The role of N in increasing grain yield is well known (Varma and Srevastava,1972; Rangesh, 1973; Abruna, 1984 and Srevastava et al., 1984). Fig.6 showed that yield was increased upto the application of 90 kg N ha^{-1} and a decrease was seen at 130 kg N ha^{-1}, the highest nitrogen level applied.

Murata (1969) listed the beneficial effects of nitrogen as (1) expansion of leaf area, (2) increase in nitrogen content of leaves, and (3) increased sink capacity, to accommodate greater amounts of photosynthates or yield contents. At lower nitrogen level, nitrogen supply may have been the limiting factor in determining the yield and this factor appear to have been operative upto 90 kg N ha^{-1}.

It may be noted from Fig.3 that growth characters namely height, leaf area index, tiller production and dry matter production increased with nitrogen. Early formed tillers (Table 5) which is **decisive** in the determination of panicles and yield also showed similar trend. Main yield contributing factors are number of panicles per m^2, number of filled grains per panicle and thousand grain weight (Matsushima, 1976). Perusal of the data on yield attributes and Fig.6 show a similar increasing trend with nitrogen. The cumulative effect of growth and yield components with applied nitrogen has reflected in increased grain yield. However, heavy application of nitrogen beyond an optimum level was found to have a negative response (Jana et al., 1981). In the present study yield increased upto 90 kg N ha^{-1} which was on par with 110 kg N ha^{-1}. A reduction in 9.5 per cent yield was noticed at 130 kg N ha^{-1} over 110 kg N ha^{-1}. At higher nitrogen application expansion of leaf area may occur(Fig.3) and the excessive vegetative growth and leaf area development might result in mutual shading, leading to increased respiration, reduction in assimilation product and finally yield (Agaisimani et al., 1983). Chinnaswamy and Chandrasekharan (1977) have observed a reduction on photosynthesis respiration ratio with enhanced nitrogen levels. It can also be seen from Tables 17 and 18 that higher nitrogen level produced more spikelets. The sterility was also more at these levels. Hence it is inferred that sufficient assimilates are not available to fill all the spikelets resulting in decreased grain yield (Sreedharan, 1975).

The interaction shows significant difference in yield. Variation in nitrogen response among varieties is well known (Pandey and Sharma, 1975 and Hartley and Milthrope, 1982). Jyothi recorded the maximum yield at 110 kg N ha^{-1} (5112 kg ha^{-1}) whereas Culture 10-1-1 and Triveni at 90 kg N ha^{-1} (4492 and 4460 kg ha^{-1}, respectively). This was reflected mainly by the various yield components. From Figure 7 it can be seen that Culture 10-1-1 recorded substantially higher number of panicles per m^2 and thousand grain weight at 90 kg N ha^{-1} over the other two varieties. Jyothi registered medium values for yield attributes which led to higher grain yield production. Triveni registered the highest number of filled grains per panicle which was the main reason for it getting the similar yield as that of other two cultivars.

The resultspoint out the high potentially of Jyothi for effectively utilising the increased levels of nitrogen. It had higher crop growth period (112 days) probably leading to better utilisation of increased level of nitrogen for assimilate production resulting in higher grain yield. The distinguishing trait of Triveni was that it had the highest number of filled grains per panicle. Culture 10-1-1 distinguished itself by the higher panicle production, thousand grain weight and lesser crop growth period (98 days). It may be noted that Culture 10-1-1 took 14 days and Triveni 12 days lesser than Jyothi to register the same yield. The per day production of Jyothi was 45.64 kg at 110 kg N ha^{-1} and that of Culture 10-1-1 and Triveni at 90 kg N ha^{-1} were 51.63 and 49.88 kg, respectively. At 90 kg N ha^{-1} the per day production of Jyothi was still lower (42.65 kg). The increase in yield per kg of nitrogen from the base level 50 kg N ha^{-1} were 26.79 and 23.44 for Jyothi at 90 and 110 kg N ha^{-1} respectively. It was 33.13 and 31.77 kg for Culture 10-1-1 and Triveni, respectively at 90 kg N ha^{-1}. These factors indicate that Culture 10-1-1 was most promising compared to other varieties.

The above distinguishing traits of each cultivar will serve as a tool for the geneticist to adopt suitable breeding techniques for the further improvement of these cultivars. The agronomists can also manipulate other production parameters by suitable agrotechniques.

5.2.8 Straw yield (Table 21)

Fig.3 shows that Culture 10-1-1 recorded the highest value for straw yield whereas Triveni had the lowest. It can be seen from Table 2 to 10 and Fig.4 that Culture 10-1-1 recorded the highest value for plant height tiller number and leaf area index which led to the highest straw production. Triveni had the lowest values for the above growth characters resulting in the lowest straw production (Fig.4). The straw yield variations with nitrogen among varieties were also brought out by Kurup and Sreedharan (1971) which were attributed to the difference in the ability of varieties to utilise the absorbed nitrogen for vegetative growth.

It can be seen from Fig.3 that the response to nitrogen was seen upto 110 kg N ha^{-1}. The straw yield at

110 and 130 kg N ha^{-1} were similar. Perusal of the data on plant height, tiller production and leaf area index reveal that these characters showed an increasing trend with increasing nitrogen. Probably a combined effect of these attributes might have contributed to the increase in straw yield observed here. It can also be said that at higher levels, nitrogen was more made use for straw production or to put in another way the assimilates formed at higher nitrogen levels were utilised more for vegetative purpose rather than the reproductive purpose. Increase in straw yield with enhanced nitrogen application is a common observation in rice (Patel *et al.*, 1978; and Pillai and De, 1980a).

The interaction effect of nitrogen and variety was not significant.

5.2.9 Harvest index (Table 22)

The result shows that Triveni registered the highest value for harvest index. It can be observed from the Tables 5 to 10 and 21 that this variety recorded the lowest values for leaf area index, number of tillers per m^2 and straw yield compared to other varieties (Fig.3). So it can be said that higher proportion of the total assimilates were used for grain production as the grain production was same and the biological yield was lowest in Triveni compared to other cultivars. It can be seen from Fig.4 that Culture 10-1-1 and Jyothi had higher values for growth attributes leading to high production of straw and biological yield. But as the yield produced were similar the harvest indices were reduced. This explains the lowest harvest index observed in Culture 10-1-1 as it had the highest biological yield. The variation in harvest indices with varieties were also brought out by Son *et al.* (1983).

The harvest index was enhanced with nitrogen upto 90 kg N ha^{-1}. Perusal of the data on grain and straw yield (Table 20, 21 and Fig.3) reveal that the yield of grain was increased upto 90 kg N ha^{-1} and yield of straw upto 130 kg N ha^{-1}. Nitrogen application in the initial levels may have increased the proportion of total synthates translocated for grain production resulting an increase in harvest index. This is in accordance with the observation made by Latif (1982) indicating greater apportioning of the assimilates for reproductive purpose than for vegetative purpose at lower levels of nitrogen. However, at higher nitrogen levels harvest index was found decreasing. It might be noted that the straw yield kept on increasing with nitrogen levels whereas grain yield decreased after 90 kg N ha^{-1} (Fig.3) thus resulting in a decrease of harvest index at higher nitrogen levels. This is in agreement with the result obtained by Prasad (1981) who observed that higher nitrogen application favoured higher vegetative growth and production of unproductive tillers leading to an increase in biological yield but decrease in harvest index. Yoshida (1972) also noticed with higher N application a decrease in the translocation of photosynthates from vegetative parts to grain leading to a decline in the value of harvest index.

The interaction effect was not significant.

5.2.8 Economics of cultivation (Tables 36 to 38)

It can be seen from the Tables that Culture 10-1-1 recorded the highest gross income, net income and the benefit cost ratio followed by Jyothi and Triveni. Culture 10-1-1 had the highest straw yield (Fig.3) and with grain yield being similar, it is natural that Culture 10-1-1 recorded the highest value for the above factors.

Nitrogen enhanced gross income, net income (Fig.8) and benefit cost ratio upto 110 kg ha^{-1}. Nitrogen

Table 36. Gross income ha^{-1}

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	11254.3	12896.3	14159.7	15396.3	14344.7	13606.8
V_2 (Culture 10-1-1)	11942.0	14007.7	15557.3	15657.3	14595.3	14351.9
V_3 (Triveni)	10998.3	12679.0	14260.0	13938.3	13551.0	13085.3
Mean	11398.2	13187.7	14659.0	14997.3	14163.7	

Not statistically analysed

Table 37. Net income ha^{-1}

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	1400.3	2914.3	4091.7	5222.3	4064.7	3538.8
V_2 (Culture 10-1-1)	2086.0	4045.7	5489.3	5483.3	4315.3	4283.9
V_3 (Triveni)	1142.3	2717.0	4192.0	3764.3	3271.0	3017.3
Mean	1542.2	3225.0	4591.0	4823.3	3883.7	

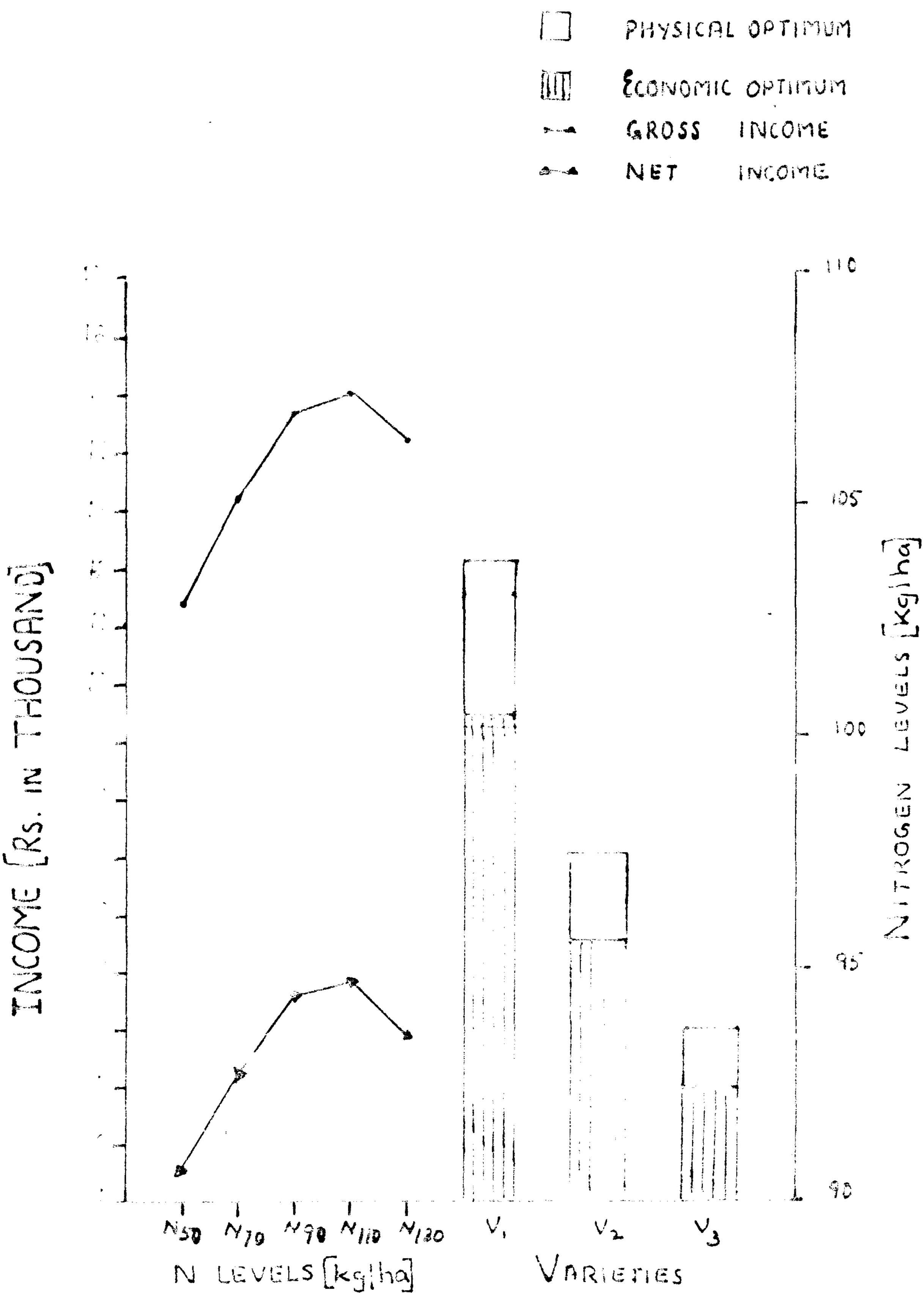
Not statistically analysed

Table 38. Benefit cost ratio

N levels kg ha^{-1} / Varieties	N_1 50	N_2 70	N_3 90	N_4 110	N_5 130	Mean
V_1 (Jyothi)	1.35	1.49	1.61	1.71	1.59	1.57
V_2 (Culture 10-1-1)	1.42	1.61	1.74	1.74	1.61	1.64
V_3 (Triveni)	1.32	1.47	1.62	1.57	1.51	1.51
Mean	1.36	1.53	1.66	1.67	1.57	

Not statistically analysed

Fig 8. INCOME AT N LEVELS, PHYSICAL AND ECONOMIC OPTIMUM N DOSES OF DIFFERENT VARIETIES.



applied beyond this level however, caused reduction in these aspects. A similar pattern can also be observed in straw yield.

It is evident from the Figure 8 that Culture 10-1-1 recorded the highest net income at 90 kg N ha^{-1} though the gross income was increased upto 110 kg N ha^{-1}. Jyothi increased gross and net income upto 110 kg N ha^{-1}, which was lower than that obtained by Culture 10-1-1 at 90 kg N ha^{-1}. Triveni increased gross income and net income upto only 90 kg N ha^{-1} and the value recorded was lowest. It can be seen from Figure 4 that straw yield increased significantly upto 110 kg N ha^{-1} for all the cultivars. Jyothi increased grain yield upto 110 kg N ha^{-1} and Culture 10-1-1 had similar yields recorded at 90 and 110 kg N ha^{-1}. However, Triveni registered a significant decrease at 110 kg N ha^{-1} which may be attributed as the probable reason for obtaining differential response to nitrogen among cultivars.

The physical optimum was worked out to be 103.74, 97.48 and 93.07 kg N ha^{-1} respectively for Jyothi, Culture 10-1-1 and Triveni (Fig.9). However, when these values are rounded to the nearest five it works out to 105 kg for Jyothi and 95 kg each for Culture 10-1-1 and Triveni. At the same time, the economic optimum was found to be at 100.5, 95.64 and 92.24 kg N ha^{-1}, respectively, for cultivars Jyothi, Culture 10-1-1 and Triveni.

5.3 Chemical studies

5.3.1 Protein content of the grains (Table 23)

It can be clearly seen from Fig.3 that Triveni recorded the lowest value for yield compared to the other two cultivars whereas N uptake (Table 26 and Fig.10) was similar for all the three cultivars. Triveni registered the highest protein content compared to the other cultivars. Hence it is presumed that some sort of dilution effect had taken place in cultivar which had recorded highest yield. Sreedharan (1975) also observed similar result. From Fig.6 it was observed that Culture 10-1-1 had higher thousand grain weight and lower protein content which indicate that the balance between carbohydrate synthesis and protein synthesis was shifted towards the former resulting in decreased protein content. Rao (1972) also obtained similar results. Variation in protein content among cultivars were also brought out by Kurup and Sreedharan (1971) and Kadrekar and Mehta (1974).

Protein content was increased upto 110 kg N ha^{-1}. Increase in protein content with increase in nitrogen is well known (Kothandaraman et al., 1975 and Pisharody et al., 1976). It may be noted that grain yield was increased upto

90 kg N ha^{-1} (Table 20). This shows that nitrogen beyond a certain level has resulted in increasing the protein content. It is probable that the balance between carbohydrate synthesis and protein synthesis shifts in favour of protein synthesis beyond a certain level of nitrogen in rice (Sreedharan, 1975). This may be the reason for recording a higher protein content at higher levels of nitrogen without registering a proportionate increase in grain yield.

It can be seen that Jyothi showed an increasing trend upto the highest nitrogen level whereas Triveni and Culture 10-1-1 recorded an increase upto 110 kg N ha^{-1}. It is important to note that Triveni recorded higher values even at the initial levels of nitrogen and reached the highest value of 12.59 per cent at 110 kg N ha^{-1}, which might be attributed as its inherent capacity to apportion the nitrogen assimilated more to grain filling than for vegetative purpose. Triveni and Culture 10-1-1 recorded an increase only upto 110 kg N ha^{-1}. It is well known that the percentage of nitrogen translocated to grain decreases after a certain level (Varma, 1972). In the case of Jyothi, it is probable that the particular level of nitrogen required for obtaining the highest protein content might not have

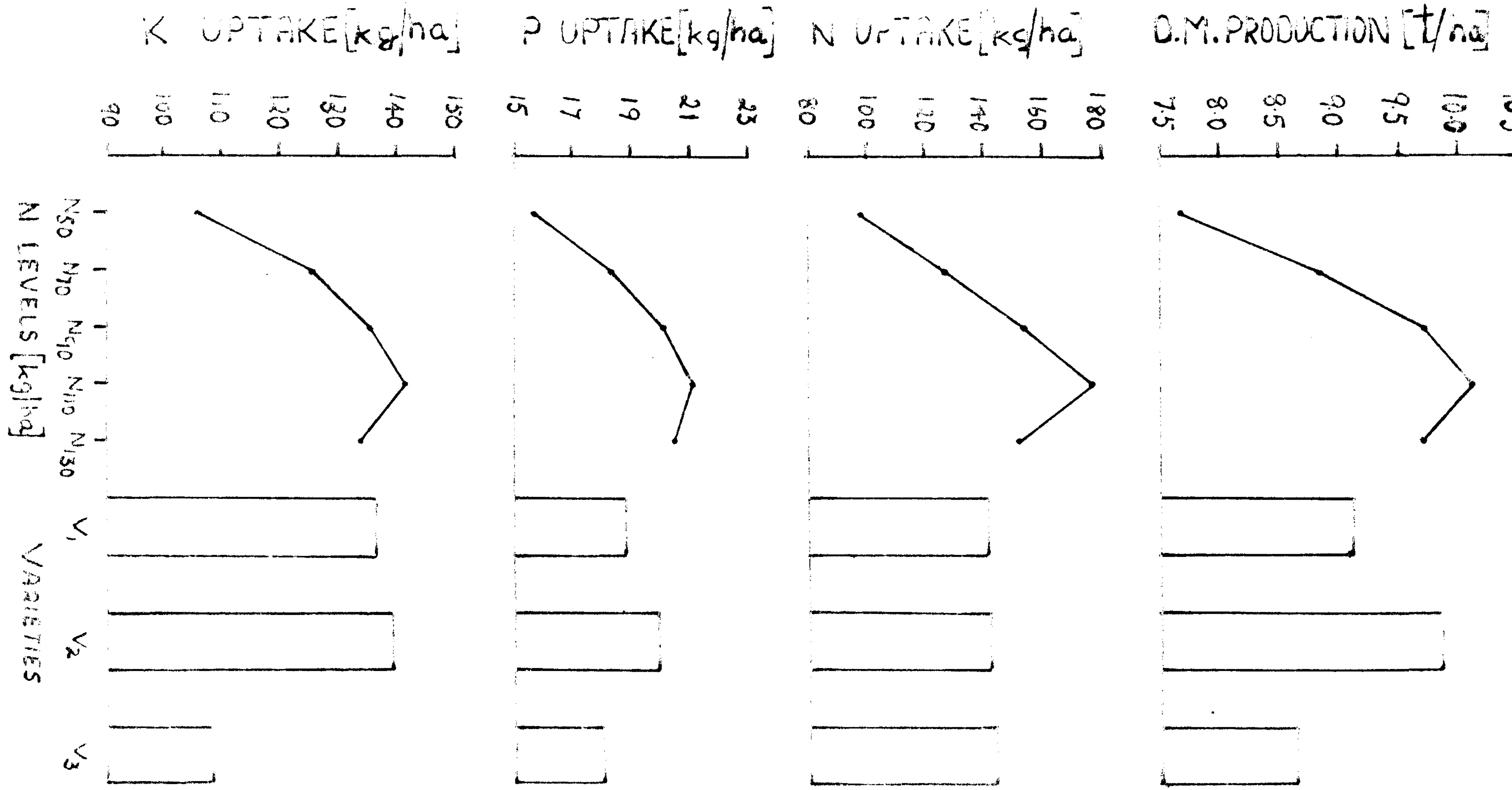


Fig.9. DRY MATTER PRODUCTION IN RELATION TO NPK UPTAKE AS INFLUENCED BY LEVELS OF NITROGEN AND VARIETIES.

been reached and hence the increase noticed upto the highest nitrogen level.

5.3.2 Uptake of nutrients

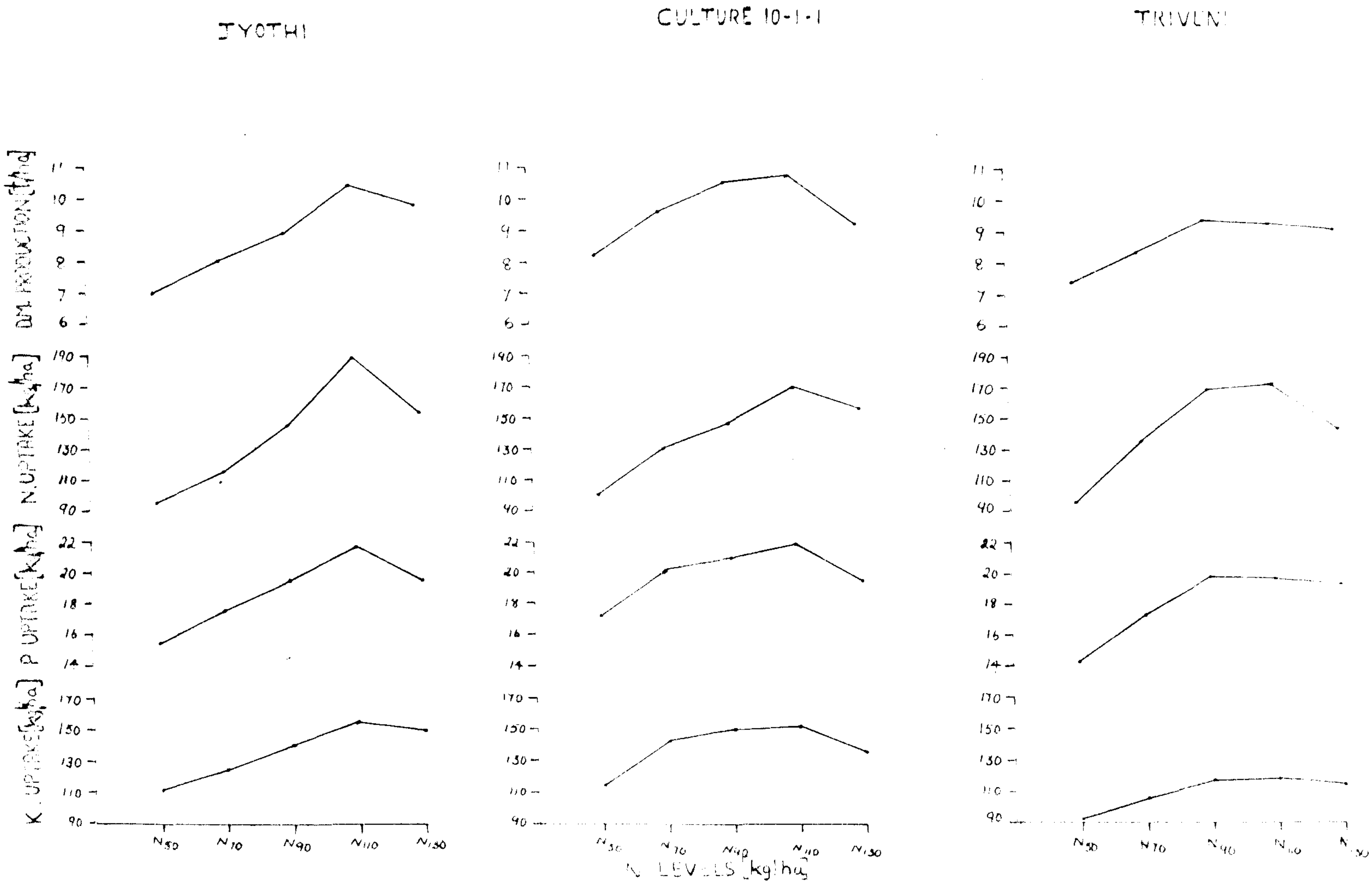
5.3.2.1 Uptake of nitrogen (Tables 24 to 26)

The result show that at active tillering Culture 10-1-1 recorded the highest nitrogen uptake followed by Jyothi and Triveni. Similar trend in dry matter production was also noticed at active tillering which might be the reason for similar uptake noticed here. There was no difference in N uptake at flowering and harvest stages among the cultures. Latif (1982) also reported no variation in N uptake among varieties.

N uptake was enhanced by nitrogen application. The higher uptake of nitrogen noticed might be due to higher dry matter production (Fig.9). Similar results were reported by Abraham et al.(1976), Habeeburrahman (1983) and Reddy (1985).

From the Figure 10 it can be seen that Jyothi and Culture 10-1-1 registered an increase upto 110 kg N ha^{-1} whereas Triveni recorded increase only upto 90 kg N ha^{-1} at harvest. Table 13 and the Figure mentioned above indicate that the biological yield was increased upto 110 kg N ha^{-1}

Fig.10. DRY MATTER PRODUCTION OF VARIETIES AT DIFFERENT LEVELS OF N AS INFLUENCED BY NPK UPTAKE



for Jyothi and Culture 10-1-1 and upto 90 kg N ha^{-1} for Triveni which may be the probable reason for obtaining difference in nitrogen response among the cultivars.

5.3.2.2 Uptake of P (Tables 27 to 29)

Culture 10-1-1 recorded the highest value followed by Jyothi and Triveni (Fig.9). It may also be noted from the same Figure that Culture 10-1-1 had the highest biological mass production and Triveni the lowest which may be attributed as the reason for Culture 10-1-1 achieving the highest P uptake.

Nitrogen enhanced P uptake at all the stages. The increase in uptake of nitrogen probably resulted in the increase in P uptake. With the increase in top growth along with nitrogen application, root growth will also be proliferated. This increase in root growth would have enabled them to get in contact with more soil particles leading to an increase in absorption of P. At active tillering P uptake increased only upto 90 kg N ha^{-1}. It can be said that P absorbed would have been enough for the initial root formation at this level. Alexander <u>et al</u>.(1974) and Latif (1982) has observed increase in P uptake with nitrogen.

It can be seen from Fig.10 that P uptake was increased in Jyothi upto 110 kg N ha^{-1} and in Culture 10-1-1 and Triveni upto 90 kg N ha^{-1}. P uptake is a factor greatly influenced by dry matter production which followed an almost similar trend (Fig.10).

5.3.2.3 K uptake (Tables 30 to 32)

From the Figure 9 it can be seen that Culture 10-1-1 recorded the highest potassium uptake followed by Jyothi and Triveni at all the stages. It can also be noted that the dry matter production also followed a similar trend as that of K uptake. It may be a point to observe that K uptake by Triveni was substantially lower even though grain yield produced were similar to other cultivars. This clearly shows the efficiency of this variety to effectively transfer the K absorbed more to grain filling rather than for vegetative purpose.

K uptake was enhanced by nitrogen upto 110 kg ha^{-1} (Fig.9). The increase in absorption of K probably resulted from a rise in the nitrogen in soil due to incremental nitrogen levels. Similar observations were also made by Raju (1978).

5.3.3 Soil analysis

5.3.3.a Total nitrogen (Table 33)

Varietal and N x V interaction effect was not significant.

Effect of N was pronounced . Soil nitrogen content where nitrogen applied at 90, 110 and 130 kg ha^{-1} were similar which means that the additional nitrogen had compensated the increased nitrogen uptake by plants at higher levels

5.3.3.b Available P and exchangeable K content(Tables 34 & 35)

Varietal effects were significant. Plots grown under Culture 10-1-1 had the lowest values for available P and exchangeable K which can be attributed to the higher dry matter production and uptake by this variety compared to other varieties.

Increased levels of nitrogen increased P uptake which resulted in reduction in available P content of soil.

Summary

SUMMARY

In *Kole* lands very few studies have been conducted with regard to the nutrition of rice. Levels of fertilization of rice varieties that are generally grown in *Kole* lands are recommended based on the experimental work conducted at other places or research stations. But *Kole* land situation is entirely a different one and specific recommendations havenot been evolved so far. Moreover, there was a feed back from the T & V workshop that the farmers were applying more than 100 N ha^{-1} for the varieties usually grown, though the recommended dose was only 70 kg N ha^{-1}. The present study was therefore undertaken to ascertain and compare the nitrogen requirement of short duration varieties and pre-release Culture 10-1-1. The pre-release Culture 10-1-1 has gained wide acceptance in *Kole* land and hence it is necessary that the nutritional requirement is found out before it is released.

The findings of the present study are summarised as follows.

1. Maximum plant height was recorded by Culture 10-1-1 followed by Jyothi and Triveni which were similar. Nitrogen enhanced the plant height upto 110 kg N ha^{-1}.

2. Culture 10-1-1 recorded significantly higher tiller number compared to other varieties. Nitrogen increased the tiller number upto 90 kg N ha^{-1}. The highest panicle number of 630 per m^2 was recorded by Culture 10-1-1 at 90 kg N ha^{-1}.

3. Leaf area index was highest in Culture 10-1-1. Nitrogen increased leaf area index upto flowering to the highest level of nitrogen applied.

4. Dry matter production was highest for Culture 10-1-1 at all stages when compared to other varieties and this was increased upto 110 kg N ha^{-1} after which a decrease was seen.

5. Maximum number of panicles per m^2 was registered by Culture 10-1-1. Nitrogen enhanced number of panicles upto 90 kg N ha^{-1}. In Jyothi panicle number was enhanced upto 110 N ha^{-1} where as Culture 10-1-1 and Triveni showed increase only upto 90 kg N ha^{-1}.

6. Nitrogen influenced the length of panicle to the highest level tried. Triveni recorded the highest value which was comparable to Jyothi.

7. Triveni registered the maximum panicle weight followed by Culture 10-1-1. The weight per panicle was increased upto 110 kg N ha^{-1}.

8. Triveni recorded the highest number of filled grains per panicle. In Culture 10-1-1 and Triveni, filled grains per panicle was increased upto 90 kg N ha^{-1}, where as in Jyothi it was enhanced upto 110 kg N ha^{-1}.

9. Percentage of filled grains was highest for Jyothi. It was highest at 50 kg N ha^{-1} and lowest at 130 kg N ha^{-1}.

10. Culture 10-1-1 recorded significantly higher values for thousand grain weight. Nitrogen exerted its influence in increasing thousand grain weight upto 90 kg N ha^{-1}.

11. The field duration of Jyothi, Culture 10-1-1 and Triveni were 91, 77 and 79 days, respectively.

12. There was no difference in grain yield among the varieties and Culture 10-1-1. The highest value of grain yield was recorded by Jyothi at 110 kg N ha^{-1} (5112 kg ha^{-1}) which was similar to the yield obtained by Culture 10-1-1 and Triveni at 90 kg N ha^{-1} (5060 and 4988 kg ha^{-1}).

13. The per day production of Jyothi, Culture 10-1-1 and Triveni were 42.65, 51.63 and 49.88 kg, respectively at 90 kg N ha^{-1}. Jyothi increased per day production upto 45.64 kg at 110 kg N ha^{-1}.

14. Culture 10-1-1 registered the maximum straw yield. Nitrogen increased straw yield upto 110 kg N ha^{-1}.

15. Culture 10-1-1 recorded the highest benefit cost ratio. Nitrogen levels upto 110 kg N ha^{-1} increased the benefit cost ratio in Jyothi and upto 90 kg N ha^{-1} in Culture 10-1-1 and Triveni.

16. The optimum level of nitrogen was worked out to be 103.74, 97.48 and 93.07 kg ha^{-1} for Jyothi, Culture 10-1-1 and Triveni, respectively.

17. Culture 10-1-1 had the highest NPK uptake. Higher nitrogen levels increased the uptake of all the nutrients.

On concluding it could be stated that Culture 10-1-1 was found to be most promising. It not only had the highest per day productivity but also the benefit cost ratio. The present investigation shows that 95 kg N ha^{-1} each is required for Culture 10-1-1 and Triveni and 105 kg N ha^{-1} for Jyothi. This is in agreement with the feed back from the T & V workshop that the farmers are applying higher levels of fertilizers than the recommended dose. However, since this is only a one year trial further experimentation is required to substantiate the same.

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RESPONSE OF MODERN VARIETIES OF RICE TO NITROGEN IN KOLE LANDS

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ABSTRACT OF THE THESIS

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ABSTRACT

An experiment was carried out in *Kole* lands during the *Kole* season of 1985 (December-January to March-April) to ascertain and compare the nutritional requirement of short duration rice varieties and pre-release Culture 10-1-1. The treatments consisted of factorial combination of 3 varieties (Jyothi, Culture 10-1-1 and Triveni) and 5 levels of nitrogen (50, 70, 90, 110 and 130 kg N ha^{-1}) in Randomised Block Design, replicated thrice.

It was found that the pre-release Culture 10-1-1 had significantly higher plant height, tiller number, leaf area index, dry matter production, number of panicles per m^2 and thousand grain weight over other varieties. Triveni recorded the highest filled grains per panicle and weight per panicle. There was no variation in grain yield among the cultivars tested. Culture 10-1-1 registered the highest straw yield and nutrient uptake. Culture 10-1-1 also recorded the highest net income over the varieties tested.

Application of nitrogen increased the vegetative characters and yield attributes of rice viz., plant height,

tiller production, number of panicles per m^2, panicle length, panicle weight, filled grains per panicle and thousand grain weight. The highest grain yield and net income was obtained by Jyothi at 110 kg N ha^{-1} and that for Culture 10-1-1 and Triveni at 90 kg N ha^{-1}. Straw yield and dry matter production were increased upto 110 kg N ha^{-1}. The uptake of nutrients were also influenced positively by nitrogen fertilization. The per day production of Jyothi, Culture 10-1-1 and Triveni was found to be 42.65, 51.63 and 49.88 kg, respectively at 90 kg N ha^{-1}.

The present investigation revealed that the optimum level of nitrogen fertilization to be 103.74, 97.48 and 93.07 kg ha^{-1} for Jyothi, Culture 10-1-1 and Triveni, respectively. It was also observed that the field duration of Culture 10-1-1 was only 77 days compared to that of 79 and 91 days of Triveni and Jyothi respectively. Benefit cost ratio was highest for Culture 10-1-1 thus indicating the scope of popularising this cultivar as a short duration variety in Kole land.