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**INFLUENCE OF GRADED LEVELS OF NITROGEN ON GRAIN
FILLING POTENTIAL OF RICE VARIETIES**

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

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BAPATLA
1989

C E R T I F I C A T E

Eri K. SURYA RAMESH has prosecuted the course of research and that the thesis entitled "INFLUENCE OF GRADED LEVELS OF NITROGEN ON GRAIN FILLING POTENTIAL OF RICE VARIETIES" submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any University.

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C E R T I F I C A T E

This is to certify that the thesis entitled "INFLUENCE OF GRADED LEVELS OF NITROGEN ON GRAIN FILLING POTENTIAL OF RICE VARIETIES" submitted in partial fulfilment of the requirements for the degree of Master of Science in Agriculture of the Andhra Pradesh Agricultural University, Hyderabad is a record of the bonafide research work carried out by Sri K. SURYA RAMESH under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma or has been published. The assistance and help received during the course of the investigations have been fully acknowledged.

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LIST OF ABBREVIATIONS

BMP	=	Biomass production
cm	=	Centimetre
DAP	=	Days after planting
g	=	gramme
HIG	=	High density grain
kg/ha	=	Kilogramme per hectare
LAI	=	Leaf area index
mg	=	milligram
NS	=	Non significant
PF	=	Partially filled
SLW	=	Specific leaf weight
t/ha	=	Tonnes per hectare

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Date:

K.S. Rah
(K.S. RAMESH)

DECLARATION

I, K. Surya Ramesh, hereby declare that the thesis entitled "INFLUENCE OF GRADED LEVELS OF NITROGEN ON GRAIN FILLING POTENTIAL OF RICE VARIETIES" submitted to the Andhra Pradesh Agricultural University is the result of original research work done by me. I also declare that my material contained in the thesis has not been published earlier.

Date:

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ABSTRACT

INFLUENCE OF GRADED LEVELS OF NITROGEN ON GRAIN FILLING POTENTIAL OF RICE VARIETIES

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A field experiment was conducted at Agricultural College Farm, Bapatla during the year 1988 to find out the influence of graded levels of nitrogen (0, 40, 80 and 120 kg/ha) on the growth parameters and potential grain filling in six rice varieties of three growth duration crops (early, medium and late). The effect of N levels and the varietal variation in the growth parameters, yield components and productivity were studied by collecting the data as per the standard procedures. The grain filling potential was assessed by the specific gravity method.

Late duration varieties (MTU 2067 and MTU 2077) were superior in their productive efficiency due to high source capacity (LAI and biomass) sink components (panicles and

spikelet number) and harvest index. The grain filling potential also was high in the late varieties followed by medium and early varieties.

Nitrogen levels have favourably influenced the growth parameters, yield components and total productivity and an enhancement in all these parameters were observed with an increase in the N level from 0 to 120 kg N.

Grain filling potential in terms of HD grain also was high at higher levels of N (80 and 120 kg N). The higher response of HD grain at higher N levels in this investigation can be attributed to the prevalence of optimum temperatures, bright sunshine and absence of rainfall at the reproductive and ripening phases of the varieties.

Correlation studies and path coefficient analysis have revealed that HD grain which is the main component of grain yield has increased with the total duration of the crop and is directly influenced by the panicle number per square metre.

INTRODUCTION

CHAPTER I

INTRODUCTION

Rice, one of the major staple food crops occupies an area of about 41 million hectares in India producing 60 million tonnes of rice annually. In Andhra Pradesh, it is grown in an area of 3.1 million hectares producing 7.0 million tonnes of rice (1987-88) with an average productivity of 2.26 t/ha (Reddy, 1989).

A plateau in grain yield was reached in the modern rice varieties while the subsequent varieties showed only marginal variation and could not yield higher, despite management excellence. A breakthrough in this situation is only possible through physiological manipulation of the plant. Of the various means suggested for this purpose, the concept involving the magnitude of grain filling, which is referred to as High Density Grain (HDG) is the most important one having a direct bearing in enhancing the yield potential of rice (Venkateswarlu et al. 1986 a).

Rice is a mixture of different grades of grain such as chaff, partially filled (PF), poor, average, good and high density grain. These grain grades are classified based on the specific gravity method. The specific gravity of a grain indicates the degree to which the cavity of

the hull is filled and the density of carbohydrate deposition in the grain. At 1.20 sp.gr., maximum filling of grain is realized, and these grains are known as 'high density grains' and exhibit maximum potential filling and test weight.

It is estimated that the yield potential in rice can further be increased upto 30 per cent through greater number of High Density Grain per panicle (Vankateswarlu et al., 1986 b). Rice varieties vary widely in the production of HD Grain, indicating that an increase in the percentage of heavier grains would correspondingly improve the yield.

The nutritional significance of nitrogenous fertilizers in crop production is well known to plant researchers as well as the farmers. This is basically related to the major involvement of nitrogen in the plant metabolism, which ultimately influences the growth and productivity of crops. The importance of fertilizer nitrogen in rice cultivation has been stressed by several workers (Ten Have, 1971; Verma, 1974 and Mahapatra, 1981).

Rice farmers are in the habit of applying higher levels of nitrogen than the recommended dose, with a view to realise higher grain yields. But contrary to the farmers belief, increased nitrogen application will not

result in the proportionate increase of grain yield, but instead leads to a high cost-benefit ratio. Further, nitrogen application has a varied influence on grain filling also. It is therefore essential to identify the optimum level of nitrogen at which the maximum percentage of High Density Grain and grain yield can be realised.

The present investigation was undertaken to assess the grain filling potential in six rice varieties of different durations under four levels of nitrogenous fertilization.

The following were the specific objectives with which the investigations were initiated:

- 1 To find out the varietal variation in the growth parameters and grain filling potential of rice varieties.
- 2 To study the effect of nitrogen levels on the growth parameters with specific emphasis on potential grain filling of rice varieties and
- 3 To evaluate the effect of growth duration on the grain filling potential of rice varieties.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Grain filling in rice (Oryza sativa L.) assumes a predominant role in view of its direct influence on grain yield. Filling of the spikelets to its full potential by carbohydrates results in an increase of high density grains and maximum grain filling leads to enhanced yield potential. Any factor that affects grain filling will have a definite effect on grain yield more particularly so with the applied nitrogen.

This review presents the findings of earlier workers on the varietal variation in grain filling and influence of nitrogen on the growth parameters and other physiological parameters including grain filling.

2.1 WEATHER PARAMETERS

Rice yields are generally low during kharif season (wet monsoon) during which a majority of India's rice crop is grown. Such low yields are generally attributed to unfavourable weather conditions like overcast sky, cloudy weather, high night temperatures etc. which limit the expression of the yield potential (Murthy and Murty, 1978).

Climatic factors greatly influence grain filling in rice. Low grain filling in early varieties during wet season might be attributed to the adverse influence of high rainfall, low solar radiation and high night temperatures (Togari and Kashiwakura, 1958 and Murty and Murty, 1981).

The expression of the panicle number is the function of the environment particularly the light intensity within 26 to 39°C range of mean maximum temperature (Venkateswarlu et al., 1977).

The climatic conditions especially that of low solar radiation during anthesis and ripening periods play a crucial role in grain filling (Murty and Murty, 1981).

2.2 GROWTH PARAMETERS

2.2.1 Plant height

Experiments conducted at IARI, during kharif season with seven rice varieties at four nitrogen levels (0, 30, 60 and 90 kg/ha) indicated that increased supply of nitrogen from 0 to 90 kg/ha resulted in an increase in plant height (Mishra et al., 1986). Similar findings were also reported by Kalyanikutty et al. (1969) and Panchekeharajah et al. (1972).

Experiments conducted at Maruteru during rabi 1986 with five early rice varieties at four nitrogen levels (0, 60, 120 and 180 kg/ha) indicated that an increase in plant height was observed with an increase in N level from 0 to 180 kg/ha (Murty et al., 1986). Similar findings were also observed by Reddy et al. (1987) during kharif season.

2.2.2 Number of tillers

Prasad et al. (1982) reported that tiller number significantly increased with increased 'N' levels from 0 to 150 kg/ha. Similar results were reported by Pandhi and Mishra (1968); Kalyenikutty et al. (1969) and Natarajan et al. (1974).

Murty et al. (1986) observed an increase in tillering ability with an increase in 'N' level ranging from 0 to 180 kg/ha in rabi rice. Similar findings were also observed by Reddy et al. (1987) and Prasad et al. (1988).

2.2.3 Biomass production

The experiments of Ramenujam and Eakharan Rao (1971 b) with seven nitrogen levels revealed that biomass production of rice plants per hill increased with an increase in nitrogen level.

Murty et al. (1986) reported that increased application of 'N' from 0 to 120 kg/ha to rice crop had increased the biomass production but reduced the same at the highest 'N' level (180 kg/ha).

2.2.4 Leaf area index

Fegade and Dedatta (1977) conducted field experiments on rice at IIRI with three levels of nitrogen (0, 60 and 120 kg/ha) and concluded that higher LAI values were observed with the application of highest level of nitrogen i.e., 120 kg/ha at flowering stage. Similar results were reported by Thorat and Patil (1977).

Reddy et al. (1987) observed that leaf area index increased with an increase in N level from 0 to 90 kg/ha. This was supported by the findings of Prasad et al. (1987) and Murty et al. (1988).

2.3 YIELD AND YIELD COMPONENTS

2.3.1 Panicles/m² and panicle weight

Vergara et al. (1964) observed that plants with shorter growth duration produced fewer panicles as well as spikelets/panicle.

Ten Have (1971) reported an increase in panicle weight with increase in N level upto 120 kg/ha. Similar findings were reported by Verma (1974).

Experiment conducted at Maruteru with four rice varieties at four nitrogen levels (0, 30, 60 and 90 kg/ha) indicated that panicle number/m² increased with an increase in N levels from 0 to 90 kg/ha (Reddy et al., 1987). Similar findings were observed earlier by Ten Have (1971), Rajagopalan et al. (1974), Subbaiah and Morahan (1974) and Mishra et al. (1986).

2.3.2 Filled grains/panicle

Tanaka et al. (1964) indicated that reduction in the percentage of filled grains with high nitrogen application was due to mutual shading of leaves. Further with heavy 'N' application, number of grains per panicle would be less since there were many sinks when compared to the capacity of source (Tanaka, 1972).

Bathkal and Patil (1968) reported increased number of grains per panicle with increased N levels. Similar findings were also reported by Kalyanikutty et al. (1969).

2.3.3 Grain yield

Mahapatra and Sharma (1973) and Venkatesh et al. (1978) found that grain yields in rice increased with an increase in N level from 0 to 200 kg/ha. Similar findings were observed by Bathkal and Patil (1968); Engenio et al. (1970), Dev et al. (1971) and Yogeswara Rao et al. (1980).

Experiments with six mid duration cultivars at Mandya showed that grain yield increased upto 120 kg N/ha (Einglacher, 1973). Similar results were reported by Verma (1974), Thorat and Patil (1977) and Munegowd Paniker (1977).

2.3.4 Straw yield

Increased supply of nitrogen (upto 90 kg/ha) had increased the straw yield (Mishra et al., 1986). Similar results were earlier reported by Thorat and Patil (1977).

2.3.5 Harvest index

Field experiments with five early rice varieties at three nitrogen levels (0, 60 and 120 kg/ha) indicated that harvest index was slightly reduced at higher level of nitrogen (Thorat and Patil, 1977). However, experiments on sandy loam soils of Rajendranagar indicated that harvest index increased with increase in nitrogen level upto 135 kg/ha (Letchanna and Yogeswara Rao, 1977).

2.4 GRAIN FILLING

2.4.1 Spiklet sterility

Togari and Kashivakura (1958) reported an increase in sterility at higher level of nitrogen and low light intensity in rice. Similar findings were reported by several workers

(Krishnagwamy and Chandrasekharan, 1960; Relwani, 1962; Kalyanikutty et al., 1969; Pande and Khan, 1969; Ramanujam and Sakheram Rao, 1971 a).

Grain filling in rice is dependent mainly on the supply of the nutrients from the source (leaf) to the sink (spikelet and panicle) at the crucial period of crop growth (Pande and Khan, 1969; Sikder and Das Gupta, 1976; and Murty and Murty, 1983). In view of this it is suggested that source capacity at flowering should be higher to realise high filled grain number (Murty and Murty, 1983). Vergara et al. (1966) reported the occurrence of lower grain filling in early and long duration varieties, while Murty et al. (1975) and Murty and Murty (1980) observed lower grain filling in medium and early types.

It was opined that grain filling is only dependent on the climatic conditions at the ripening phase but not on the duration of variety (Sikder and Das Gupta, 1975 and Murty and Murty, 1980).

The higher spikelet sterility in tropical areas may be caused by reduced light intensity, heavy nitrogen supply (Ota and Yamada, 1965), mutual shading (IRR, 1965), varietal characteristics (Murata 1969 and IRRI, 1968), cool temperatures at anthesis (Vergara et al., 1970) or

genotype season interactions (Guevarra and Chang, 1965 and IRRI, 1967 b) or by combination of any of these factors.

2.4.2 High density grain

Varietal variation was observed in the proportion of potential grain filling while a gradual increase in test weight was observed among different grades of grain starting from chaff to high density grain (Anonymous, 1984).

High density grain was found to be the dominant grade among the grains contributing 50 per cent of the total spikelets at various N levels (0-200 kg/ha). Test weight increased from poor to high density grain (Anonymous, 1987).

Experiments conducted at seven locations of India by the cooperators of the Directorate of Rice Research, Rajendranagar indicated that high density grain was the dominant component of any genotype and the cultivars possessing higher proportion of high density grain will have higher yields. High density grain did not improve beyond 50 kg N (Anonymous, 1987).

Reddy et al. (1988) reported that high density grain index varied from 41 to 65 in early varieties, 50 to 61 in mid duration varieties and 81 to 85 in late duration varieties.

Trials at IRRI, Philippines indicated that high density grain did not differ significantly among varieties of different growth durations (Venkateswarlu et al., 1987).

Venkateswarlu (1987) reported that increased N application from 0 to 250 kg/ha did not increase the number of HD grains. Among the four cultivars tested, three did not show much variability in HD grain at higher levels of N. On the other hand, in some varieties, the number of HD grain increased with increased N application.

Experiments conducted at CRRI, Cuttack with twelve high yielding rice varieties (late, medium and early) revealed that duration of crop growth had a significant influence on the proportion of HDG. The late duration varieties showed higher percentage of HDG and filled grains than early and medium types (Sementasinha and Sahu, 1987).

Padmaja Rao (1988) reported that among early, mid and late duration rice varieties, late duration varieties in general expressed better index than the medium and early varieties.

The production of superior grade grains was not favoured by N application. The grain grade index declined with increase in nitrogen level in all the cultivars tested, irrespective of crop duration. However, higher levels of nitrogen contributed to more number of tillers, panicles,

LAI and total drymatter with no influence on 1000-grain weight, but delayed the crop maturity by 5 to 8 days (Padmaja Rao, 1988).

A study on the production status of high density grain in rice with early, medium and late varieties at 5 nitrogen levels (0, 50, 100, 150 and 200 kg/ha) indicated that increased nitrogen level gave higher yields, but high density grain was not significantly improved (Rao, 1987).

2.5 CORRELATIONS

High density grain was reported to be associated positively with growth durations, percentage of filled grains, total spikelet number and grain weight per panicle and negatively with chaff number per panicle (Sementasinha and Sahu, 1986). The close relationship of duration and grain yield with percentage of filled grains was also reported by Rao (1987). A positive relationship between HDG and grain yield in all the duration groups of varieties was observed by Padmaja Rao (1988).

Path coefficient analysis revealed that a high, direct and positive association of percentage of filled grain and total N uptake existed with HDG per panicle (Sementasinha and Sahu, 1987).

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The details pertaining to the materials used and the methodology adopted in the investigation on "Influence of graded levels of nitrogen on grain filling potential of rice varieties" are described hereunder.

3.1 LOCATION

Studies on influence of graded levels of nitrogen on grain filling potential of rice varieties were carried out at the Agricultural College Farm, Bapatla campus of Andhra Pradesh Agricultural University.

The College Farm is located at an altitude of 5 m above MSL, 15°54'N latitude and 80° 30'E latitude and 6 km away from Bay of Bengal.

3.2 SEASON

The main rice crop season is kharif (wet monsoon: June - November, 1988).

3.3 EXPERIMENTAL SOIL

The experimental soil was of medium N (350 kg/ha), low in available P (5.62 kg/ha) medium in available K (235 kg/ha) with a pH 8.2 and EC 0.64 (m.mhos/cm at 25°C).

3.3.1 Climate

Meteorological data during crop period (June to December, 1988) are furnished in the Table 1.

3.3.2 Temperature

The weekly mean maximum and minimum temperatures during the crop growth period (12-7-88 to 12-12-88) ranged from 34.4°C to 28.8°C and 26.°C to 19.28°C respectively with an averages of maximum 31.8°C and minimum 23.12°C. The mean weekly temperatures are highest during the month of July with a maximum of 34.4°C and minimum of 25.1°C.

3.3.3 Relative humidity

The weekly mean relative humidity during crop period ranged between 69.0 to 84.4 per cent with an average of 77.07 per cent.

3.3.4 Rainfall

A total of 888.2 mm rainfall was received in 31 rainy days during the crop growth. The rainfall was normal except for two months (August and September). August and September are the peak rainy months (365.1 mm and 207.7 mm) respectively. A majority of 87 per cent of the total rainfall was received within 90 days from sowing.

3.4 EXPERIMENTAL DETAILS

The experiment was laid out in split-plot design with three replications (Fig.1). The treatments consisted of six varieties as main plots and four nitrogen levels as sub-plots.

A) Main plots - Varieties : 6

(Two early duration, two mid duration and two late duration varieties).

- | | | | |
|-------|-------|---|--------------------------|
| Early | V_1 | - | Rasi (IET 1444) |
| | V_2 | - | Ihanyalakshmi (BPT 1235) |
| Mid | V_3 | - | Prabhat (MTU 3626) |
| | V_4 | - | MTU 2400 |
| Late | V_5 | - | Chaitanya (MTU 2067) |
| | V_6 | - | Krishnaveni (MTU 2077) |

B) Sub-plots - Levels of nitrogen - 4

- | | | |
|-------|---|-----------|
| N_0 | - | 0 kg/ha |
| N_1 | - | 40 kg/ha |
| N_2 | - | 80 kg/ha |
| N_3 | - | 120 kg/ha |

Nitrogen was applied in the following three split doses uniformly to all the nitrogen treatments.

1st dose $\frac{1}{3}$ basal

2nd dose $\frac{1}{3}$ th at active tillering stage

3rd dose $\frac{1}{3}$ th at panicle initiation stage.

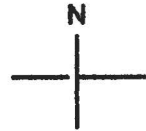
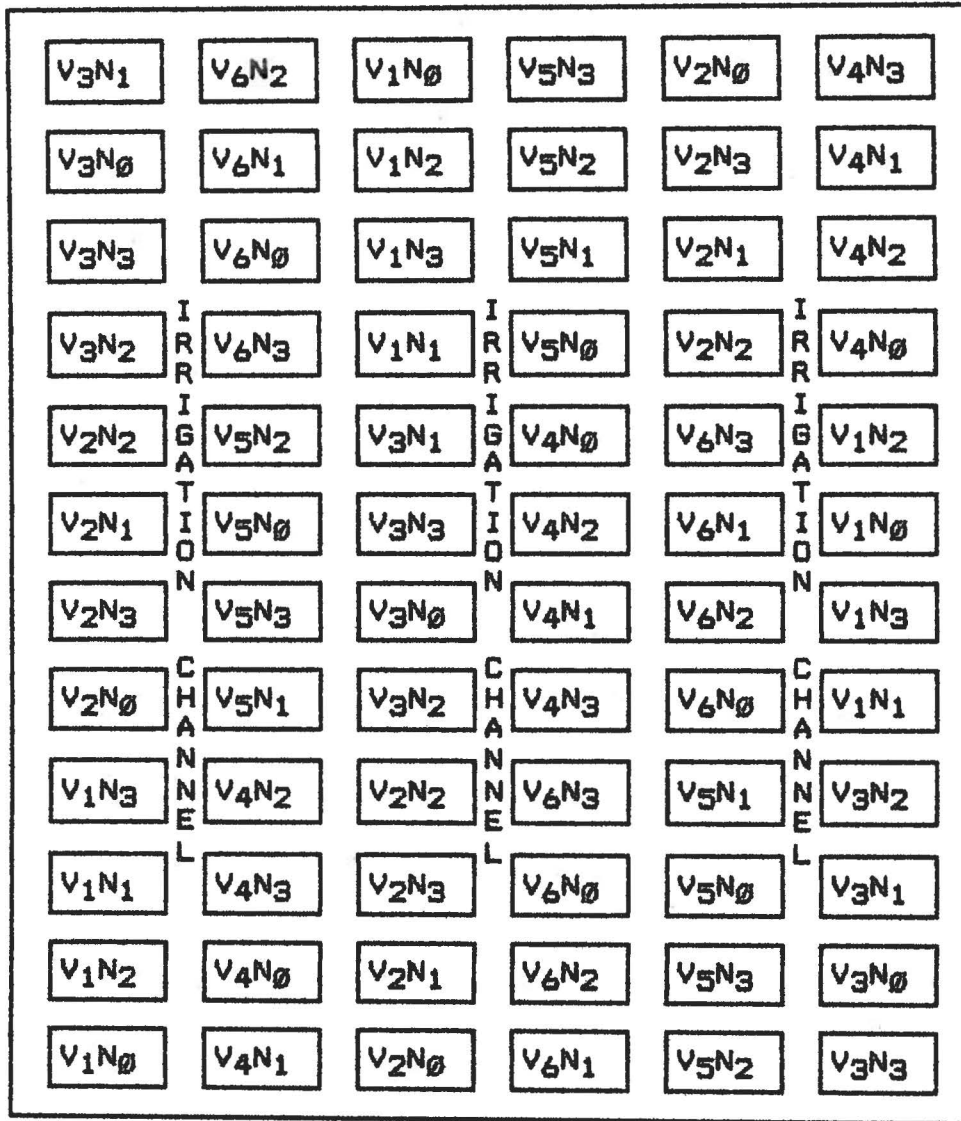


Fig. 1 FIELD LAYOUT PLAN



R₁

R₂

R₃

Design: Split-Plot

Replications: 3

Spacing: 20 x 15 cm

Gross Plot: 4 x 3 m

Net Plot: 3.2 x 2.4 m

Season: Kharif 1988

The gross and net plot size were 4 x 3 m and 3.2 x 2.4 m respectively. The spacing adopted was 20 x 15 cm.

Necessary plant protection measures were adopted as and when required and care was taken to protect the crop from pests and diseases.

Varieties

The characteristics of the early, medium and long duration rice varieties used in this study are given below.

Particulars	Rasi	Dhanya-lakshmi	Prabhat	MTU 2400	Chaitanya	MTU 2077
Parentage	T(N)1 x Co 29	Sabermati x WGL 12708	IR Bx MTU 3	MTU 4407x WGL 26889 MTU 6027x IST 4620	MTU 4569x ARC 5984	MTU 4569x ARC 5984
Height (cm)	110	105	115	105	110	110
Duration (days)	105	120	130-135	135	150	150
Yield (t/ha)	5	5.5 to 6	5	5.5	6.5	6.0
Grain type	Medium slender	Long slender	Short bold	Medium slender	Medium slender	Medium slender
Resistant to	Blast	Stemborer & gallmidge	-	Gall midge	BPH	BPH

3.4.1 Nursery

Nursery was raised on a well prepared and levelled seed bed. Calculated seed rate based on the germination percentages, spacing and number of seedlings per hill was adopted. A seed rate of 62.5 kg/ha was adopted with a seed having 80 per cent germination in all the varieties. The sowing was done on 12-7-1988.

3.4.2 Main field preparation

The main field was dry ploughed with tractor drawn cultivar in the month of May, 1988. Water was let into the field and the field was puddled twice with tractor in June, 1988. Finally the field was levelled and laid out into 72 plots as per the field design, providing irrigation channels, bunds and drainage channels suitably.

3.4.3 Transplanting

Transplanting was done on 18-8-1988 with a spacing of 20 x 15 cm and two seedlings were planted per hill.

3.4.4 Manuring

Uniform dose of 40 P_2O_5 and 40 K_2O kg/ha in the form of single superphosphate and muriate of potash respectively was applied to all the plots and incorporated. Nitrogen was applied as per the treatments in the form of urea at three stages of crop growth.

3.4.5 Gap filling

Gap filling was done on the sixth day after transplanting to maintain uniform plant population in each treatment.

3.4.6 Weeding

Weeding was done twice on 20th and 40th day after transplanting.

3.4.7 Irrigation

A thin film of water (2 cm) was maintained at planting followed by about 5 cm of continuous submergence till physiological maturity. Whenever nitrogen was applied, water was drained out on the previous day and the field was reflooded 24 hours after nitrogen application.

3.4.8 Plant protection

Prophylactic measures were taken against brown plant hopper (BPH) and stem borer by spraying 0.05% monocrotophos and the crop was kept free of pests and diseases.

3.4.9 Harvesting

When a majority of the grains and straw turned yellow, border rows were harvested first, leaving the crop in the net plot area. The net plots were harvested after removing 5 sample hills in each treatment for recording observations.

Threshing was done separately for each plot. Grain and straw from each plot were sun dried to a constant weight and yield (t/ha) was recorded at 14 per cent grain moisture content.

3.5 OBSERVATIONS

3.5.1 Pre-harvest observations

The following data were collected replication and treatment wise.

3.5.1.1 Plant height: Plant height was measured from ground level to the tip of the youngest leaf four times at 20, 40, 60 DAP (IRRI, 1980).

3.5.1.2 Total tillers/m²: Tiller counts were taken at four times i.e., 20, 40, 60 and 80 days after planting in each plot.

3.5.1.3 Biomass production: Ten plants from one metre row, at random in the net plot were uprooted, washed to remove soil, sun dried and then oven dried at a temperature of 80°C for 72 hours till a constant weight (g) was obtained. Biomass of aerial shoot portions was recorded.

3.5.1.4 Leaf area index: Twenty leaf blades from the sample plants of 5 hills were taken at random and their total area was measured by length x breadth method using a constant factor of 0.75. The dry weights of leaves per cm² was

calculated. The leaf area per five hills was computed from the total leaf blade weight of five hills and the weight per cm^2 leaf area. Leaf area index was then computed as per the formula given by Tanaka et al. (1966).

$$\text{LAI} = \frac{\text{Leaf area per five hills}}{\text{Land area covered by five hills}} \times 6.6$$

3.5.1.5 Specific leaf weight (SLW): Leaf thickness is expressed as the dry weight of the leaf blade per unit leaf area i.e., mg/cm^2 (Yoshida et al., 1972). Twenty leaf blades from five hills were taken out at random and the total leaf area of the 20 leaf blades was measured and then dry weights of the 20 leaf blades was taken and then SLW was calculated.

$$\text{SLW} = \frac{\text{Weight of 20 leaves (mg)}}{\text{Area of 20 leaves (cm}^2\text{)}} \times$$

3.5.1.6 Panicle/m²: Number of panicles from one square metre in each plot was recorded.

3.5.2 Post harvest observations

3.5.2.1 Panicle weight: Twenty five panicles from third row in the net plot were collected randomly and the weight of the twenty panicles (g) was recorded.

3.5.2.2 Total and filled grains: Total number of grains and filled grains from twenty five panicles were counted seperately.

3.5.2.3 1000-grain weight: Random sample of 1000 grains from each treatment was taken and weight recorded (g).

3.5.2.4 Grain yield: Weight of grain from net plot was recorded after sundrying and expressed as t/ha at 14 per cent grain moisture content.

3.5.2.5 Straw yield: Weight of straw from net plot was recorded after thorough sundrying and expressed as t/ha.

3.5.2.6 Harvest index (HI): Harvest index was calculated as per the following formula was expressed as percentage.

$$\text{Harvest index} = \frac{\text{Grain yield (t/ha)}}{\text{Total biological yield (t/ha)}} \times 100$$

3.6 GRADES OF GRAIN

Different grades of grain viz., chaff, partially filled, poor, average, good and High Density Grain (HDG) were separated by specific gravity method (Padmaja Rao et al., 1985) using salt solutions.

The specific gravities were maintained at four levels by mixing the table salt (sodium chloride) in water as detailed below.

<u>Specific gravity</u>	1.00	- Tap water
	1.05	- 90 g salt/litre
	1.14	- 210 g salt/litre
	1.23	- 300 g salt/litre.

Powdered table salt was used for preparing the above solutions. The salt was mixed thoroughly until it is fully dissolved in water. A minimum of 2 litres solution was used at a time for each replication for convenience of separation of different grades of grain.

PROCEDURE

1. Salt solutions of different specific gravities were prepared in different containers i.e., glass troughs (Plate 1).
2. Fifty representative panicles from each plot were collected, dried uniformly so as to maintain uniform moisture content. The spikelets were threshed from the panicles and the mixture of grades of grain from 50 panicles was weighed.
3. The sample of the mixed grain was placed in the container having 1.0 specific gravity solution (tap water) and was thoroughly stirred. All the floated spikelets were strained using a plastic mesh. The floated spikelets consisting of chaff and partially filled (PF) spikelets were physically separated and their number counted.
4. The grains submerged in the first container (sp.gr.1.0) were taken out and placed in the second glass trough

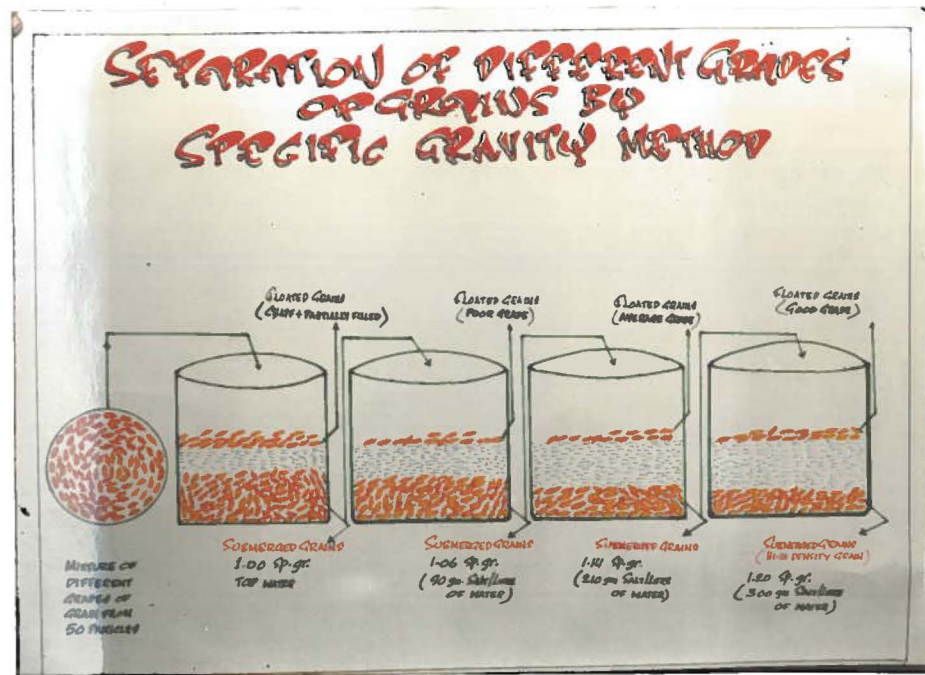


Plate 1: Separation of different grades of grain by specific gravity method

having salt solution of the 1.06 specific gravity and thoroughly stirred. The floated grains in this container were taken out, washed, dried and their number counted. These floated ones represent poor grade grains.

5. The submerged grains in the second container were taken out and placed in the third container having salt solution of the specific gravity of 1.14 and stirred thoroughly. The floated grains in this container were taken out, washed, dried and their number was counted. These floated ones represent average grade grain.
6. The submerged grains in the third container were again taken out and placed in the fourth container having salt solution of the specific gravity of 1.20 and stirred thoroughly. The floated grains in this container were taken out, washed, dried and their number counted. The floated grains represent good grade grain.
7. Finally the grains submerged in the fourth container having specific gravity 1.20 are the High Density Grain (HDG). These grains were taken out, washed thoroughly, dried and number counted.

By following the above procedure the different grades of grains obtained were as follows:

<u>Specific gravity</u>		<u>Grade</u>
1.00 (tap water)	- Floated	Chaff + partially filled (PF) (To be separated physically)
1.06 salt water	- Floated	Poor
1.14 salt water	- Floated	Average
1.20 salt water	- Floated	Good
1.20 salt water	- Submerged	High Density Grain

After separation of different grades of rice grain, the percentage and 1000-grain weight of the different grades were assessed.

3.7 CHEMICAL ANALYSIS

Nitrogen: Plant samples taken at flowering and harvesting stages were utilized to estimate the nitrogen content in leaves, stems and grain following the micro-kjeldahl method (AOAC, 1965) as detailed below.

100 mg of the plant material was taken into a 50 ml micro kjeldahl flask to which 2 ml H_2SO_4 was added. The contents were left overnight. Later they were heated at low temperature. H_2O_2 was added in drops until the digesting solution becomes clear. After digestion the contents were transferred to micro digestion set. 4% boric acid was taken in 150 ml beaker to which 1-2 drops of mixed indicator (Bromocresolgreen- 3 parts + methyl red-2 parts) was added. The tip of condenser was dipped into this solution. 10 ml of 40% NaOH was added in distillation

flask and the digestion was continued till NH_3 was completely released. The contents of the beaker were titrated against 0.05N H_2SO_4 . Nitrogen per cent was obtained by using the following formula.

$$\text{N\%} = \frac{\text{Titre value} \times 0.0007}{\text{Weight of the substance}} \times 100$$

3.8 STATISTICAL ANALYSIS

The data were subjected to statistical scrutiny to find out the significance or otherwise of the treatments using micro computer (DCM Spectre 31 Kof60). Critical difference was calculated wherever 'f' test was significant. Simple correlation coefficients were worked out wherever necessary, as per Snedecor and Cochran (1967). The correlation coefficients were partitioned into their direct and indirect influences through other ancillary components on high density greins as per Dewey and Lu (1959).

RESULTS

CHAPTER IV

RESULTS

Results of field experiment on response of nitrogen levels on grain filling potential of rice varieties on sandy loam soils of Agricultural College Farm, Bapatla in kharif 1988 are presented in this chapter.

4.1 VARIETIES

Varieties tried in this experiment were of early (Rasi, BPT 1235), medium (Prabhat, MTU 2400) and late (MTU 2067 and MTU 2077) duration.

4.2 GROWTH PARAMETERS

4.2.1 Plant height at different stages of crop growth (Table 2)

Significant variation in plant height was observed among varieties, nitrogen levels and their interactions. The variety MTU 2077 was the tallest of all the test varieties at all stages of crop growth viz., 20, 40 and 60 days after planting (45, 71 and 84 cm) (Fig. 3).

Nitrogen level of 120 kg/ha resulted in maximum plant height of 44, 75 and 85 cm at 20, 40 and 60 DAP followed by 80 kg/ha (42, 69 and 82 cm) which was at par with it. Lowest plant height was recorded in all the test varieties at '0' N level (37, 62 and 70 cm).

Table 1: Weekly meteorological data during crop season

Stan- dard week	Date and month	Mean temperature(°C)		Mean relative humidity (%)	Rain- fall (mm)	No.of rainy days
		Maximum	Minimum			
28	8 - 14 July	34.4	26.0	69.0	26.0	1
29	15 - 21 "	33.0	24.8	76.86	88.0	3
30	22 - 28 "	31.7	25.1	76.64	23.8	2
31	29 - 4 Aug.	31.7	24.9	72.07	33.50	2
32	5 - 11 "	32.1	24.7	85.71	146.1	3
33	12 - 18 "	32.6	24.7	82.57	88.7	3
34	19 - 25 "	32.1	25.6	76.57	10.10	1
35	26 - 1 Sept.	32.0	24.9	86.71	86.70	2
36	2 - 8 "	32.3	25.7	80.57	23.30	2
37	9 - 15 "	31.9	25.3	79.21	6.20	2
38	16 - 22 "	31.2	25.0	81.28	89.20	2
39	23 - 29 "	31.5	25.2	84.86	84.00	2
40	30 - 6 Oct.	31.6	25.7	84.57	51.2	2
41	7 - 13 "	32.3	23.7	76.43	10.30	1
42	14 - 20 "	33.4	21.2	68.07	-	-
43	21 - 27 "	32.4	25.5	76.43	-	-
44	28 - 3 Nov.	30.9	22.1	77.71	5.8	-
45	4 - 10 "	31.4	21.0	69.90	-	-
46	11 - 17 "	31.3	19.2	66.21	-	-
47	18 - 24 "	31.0	18.0	71.57	-	-
48	25 - 30 "	30.4	15.9	66.00	-	-
49	1 - 7 Dec.	30.2	18.3	79.28	-	-
50	8 - 14 "	28.8	19.28	84.4	115.3	3
Total		731.5	531.78	1772.62	888.2	-
Mean		31.8	23.12	77.07	-	31

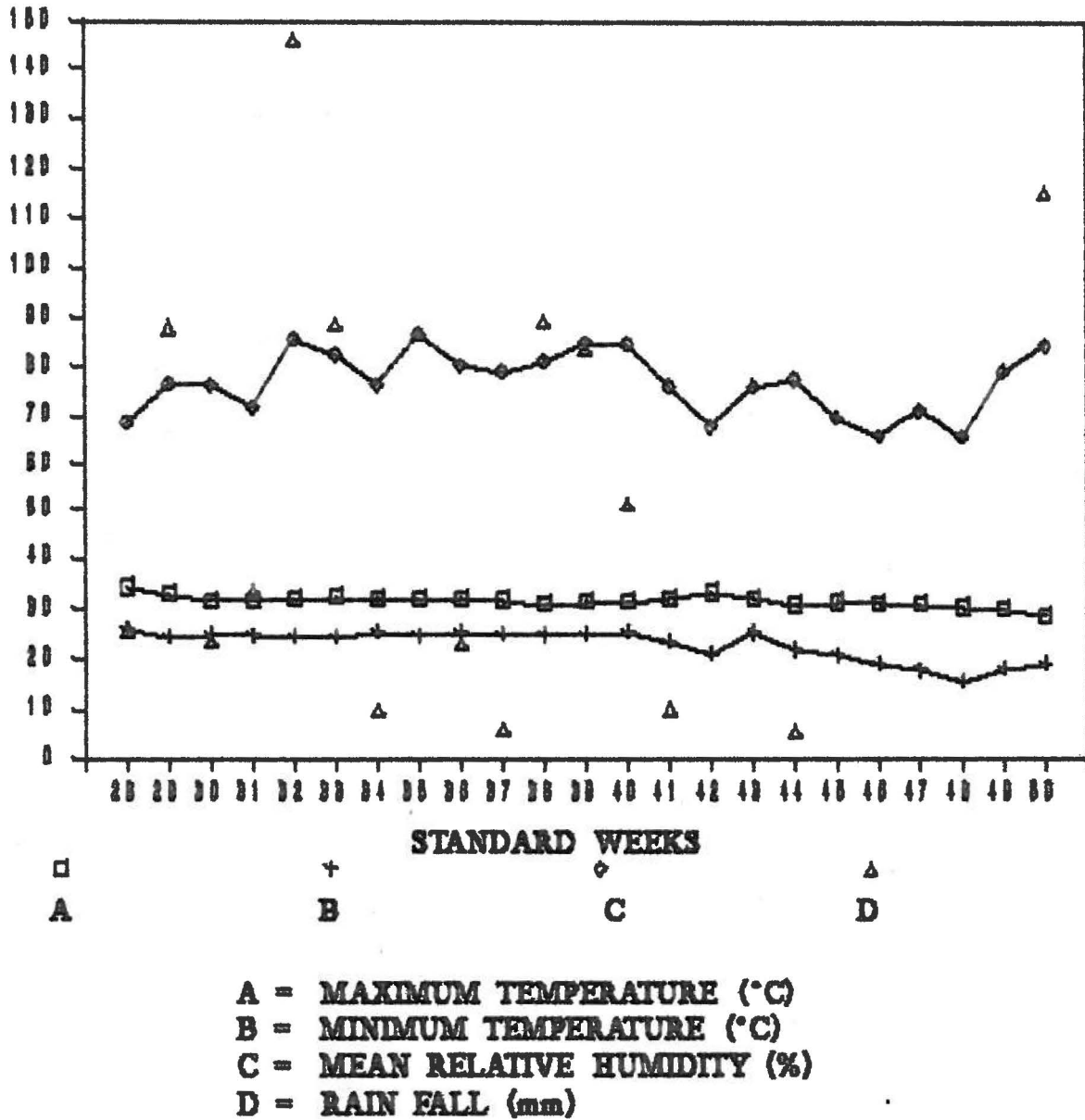


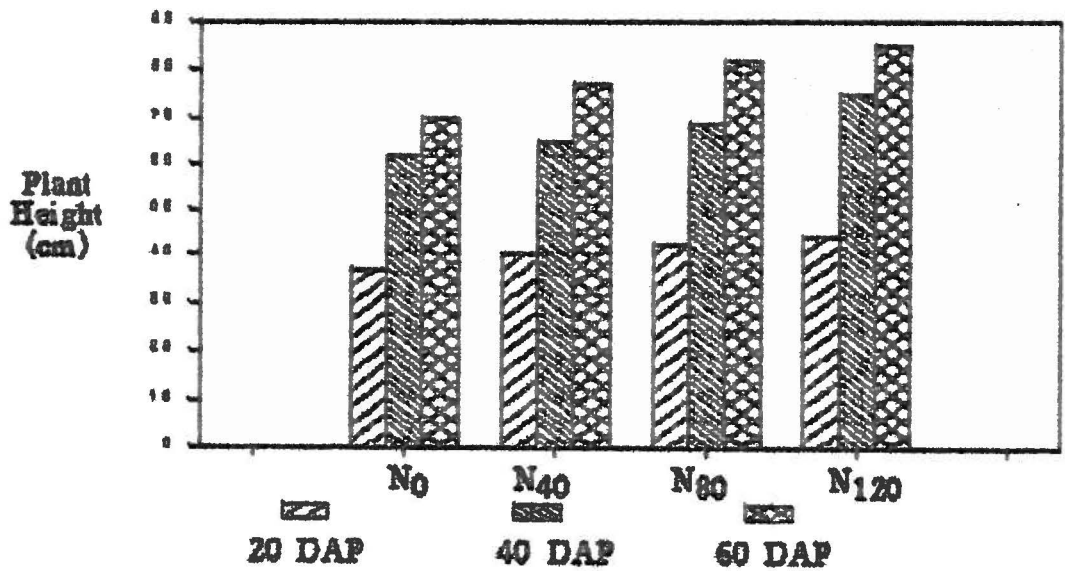
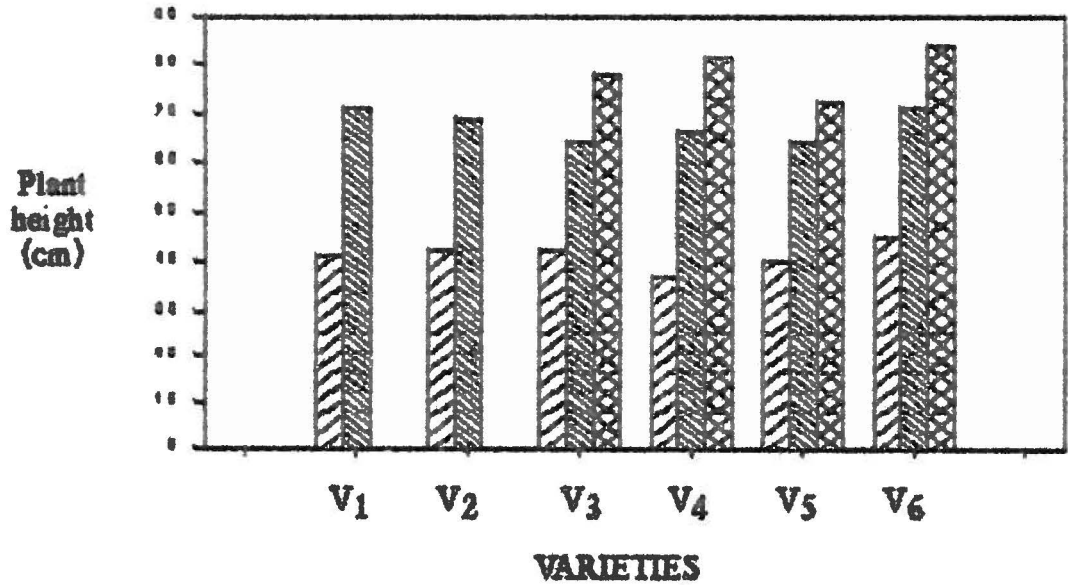
Fig. 2 WEEKLY METEOROLOGICAL DATA DURING THE CROP PERIOD

Table 7: Plant height (cm) at different stages of crop growth.

Nitrogen levels (kg/ha)	Plant height (cm)																				
	20 DAP							40 DAP							60 DAP						
	IET 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IET 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IET 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean
0	37.0	37.0	38.4	34.0	36.0	40.0	37.0	66.0	60.0	52.0	61.0	59.0	72.0	62.0	-	-	70.0	73.0	63.0	74.0	70.0
40	39.0	41.0	41.0	37.0	39.0	44.0	40.0	69.0	68.0	64.0	64.0	63.0	61.0	65.0	-	-	78.0	80.0	69.0	80.0	77.0
80	43.0	43.0	43.0	38.0	43.0	45.0	42.0	73.0	73.0	65.0	68.0	64.0	69.0	69.0	-	-	82.0	84.0	77.0	87.0	82.0
120	45.0	44.0	45.0	39.0	44.0	48.0	44.0	77.0	77.0	73.0	72.0	72.0	82.0	75.0	-	-	84.0	85.0	79.0	94.0	85.0
Mean	41.0	42.0	42.0	37.0	40.0	45.0	41.0	71.0	69.0	64.0	66.0	64.0	71.0	70.0	-	-	78.0	81.0	72.0	84.0	77.0

	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %
Varieties	Sig.	3.0	2.2	Sig.	2.0	2.5	Sig.	3.0	2.2
Nitrogen levels	Sig.	1.0	-	Sig.	1.0	-	Sig.	1.0	-
<u>Interaction</u>									
V x N	Sig.	1.5	-	Sig.	1.9	-	Sig.	2.5	-
N x V	Sig.	2.3	-	Sig.	2.6	-	Sig.	3.0	-

Fig. 3 PLANT HEIGHT AT DIFFERENT STAGES OF CROP GROWTH



V₁ - IET1444
 V₂ - BPT1215
 V₃ - MTU3626
 V₄ - MTU2400
 V₅ - MTU2067
 V₆ - MTU2077

N - NITROGEN (kg/ha)

DAP = DAYS AFTER PLANTING

4.1.3 Relative humidity

The weekly mean relative humidity during crop period ranged between 69.0 to 84.4 per cent with an average of 77.07 per cent.

4.1.4 Rainfall

A total of 888.2 mm rainfall was received in 31 rainy days during the crop growth. The rainfall was normal except for two months (August and September). August and September are the peak rainy months (365.1 mm and 207.7 mm) respectively. A majority of 87 per cent of the total rainfall was received within 90 days from sowing.

4.2 GROWTH PARAMETERS

4.2.1 Plant height at different stages of crop growth (Table 2)

Significant variation in plant height was observed among varieties, nitrogen levels and their interactions. The variety MTU 2077 was the tallest of all the test varieties at all stages of crop growth viz., 20, 40 and 60 days after planting (45, 71 and 84 cm) (Fig.3).

Nitrogen level of 120 kg/ha resulted in maximum plant height of 44, 75 and 85 cm at 20, 40 and 60 DAP followed by 80 kg/ha (42, 69 and 82 cm) which was at par with it. Lowest plant height was recorded in all the test varieties at '0' N level (37, 62 and 70 cm).

Table 3: Number of tillers at different stages of crop growth

Nitrogen levels (kg/ha)	Number of tillers per square metre													
	20 DAP							40 DAP						
	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean
0	233	259	255	266	237	273	254	254	274	270	286	299	320	308
40	289	297	290	303	288	296	293	302	300	330	320	349	342	364
80	340	336	290	332	357	341	349	351	361	360	424	430	448	438
120	400	373	356	357	409	359	377	448	466	400	448	486	475	468
Mean	317	316	298	314	320	317		338	350	340	369	391	396	

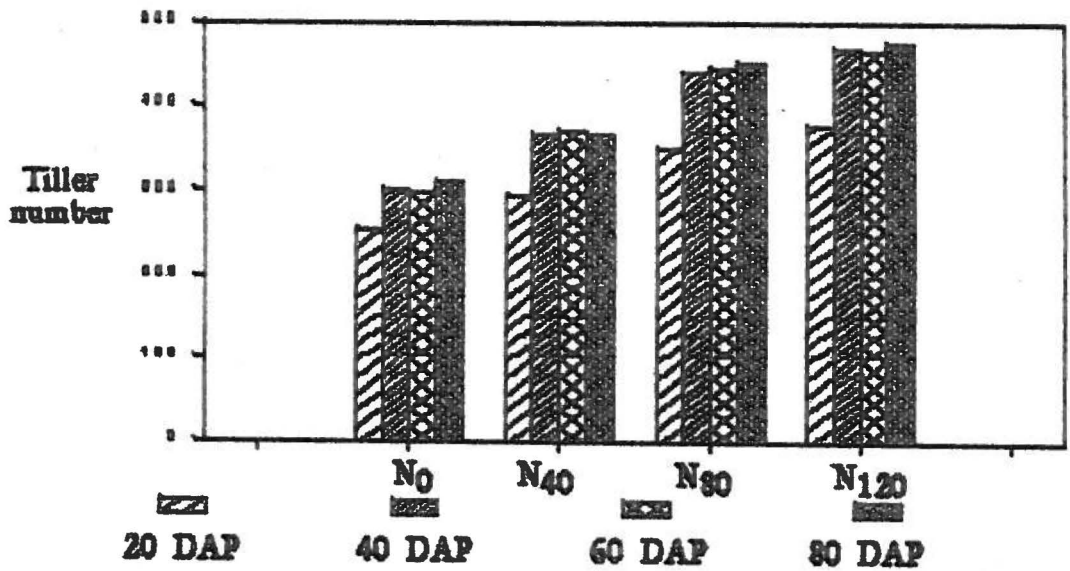
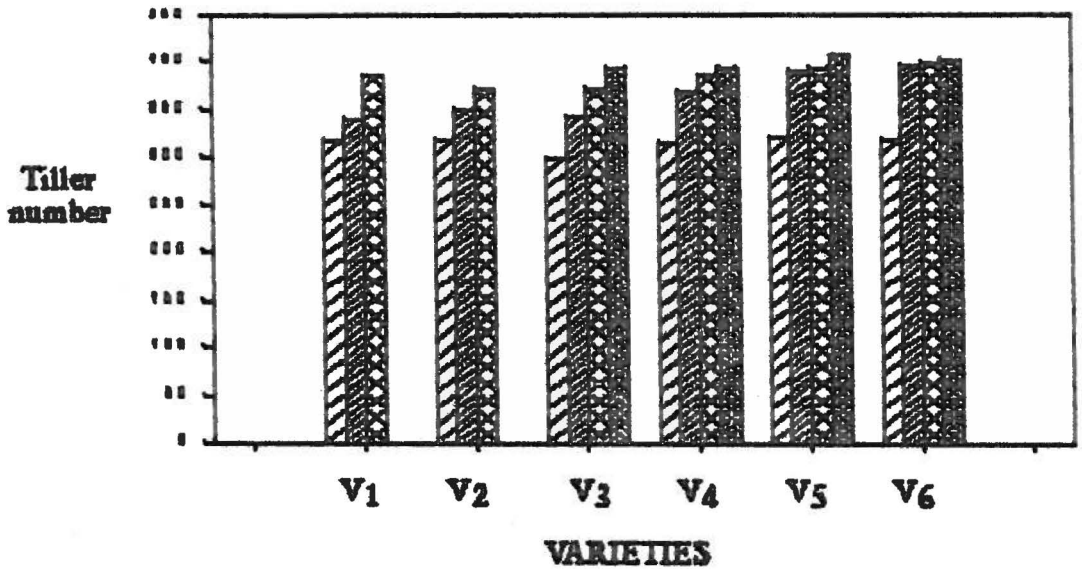
	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %
Varieties	NS	-	6.9	Sig.	30.0	4.2
Nitrogen levels	Sig.	14.0	-	Sig.	11.0	-
<u>Interaction</u>						
V x N	Sig.	35.0	-	Sig.	27.0	-
N x V	Sig.	35.0	-	Sig.	32.0	-

Table 3 contd...

Nitrogen levels (kg/ha)	Number of tillers per square metre													
	60 DAP							80 DAP						
	IST	BPT	MTU	MTU	MTU	MTU	Mean	IST	BPT	MTU	MTU	MTU	MTU	Mean
	1444	1235	3626	2400	2067	2077		1444	1235	3626	2400	2067	2077	
0	292	288	277	290	314	326	298	-	-	308	302	316	326	310
40	363	378	396	343	336	347	369	-	-	351	349	369	350	365
80	453	390	422	442	444	450	446	-	-	439	448	468	450	451
120	471	435	428	464	476	475	467	-	-	470	474	477	473	476
Mean	385	372	370	385	392	399		-	-	392	393	407	400	

	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %
Varieties	Sig.	13.0	4.9	Sig.	8.0	4.2
Nitrogen levels	Sig.	13.0	-	Sig.	14.0	-
<u>Interaction</u>						
V x N	Sig.	31.0	-	NS	-	-
N x V	Sig.	29.0	-	NS	-	-

Fig. 4 TILLER NUMBER AT DIFFERENT STAGES OF CROP GROWTH



V₁ = IET1444
 V₂ = BPT1235
 V₃ = MTU3626
 V₄ = MTU2400
 V₅ = MTU2067
 V₆ = MTU2077

N = NITROGEN (kg/ha)

DAP = DAYS AFTER PLANTING

The interaction effect of varieties and N levels on plant height also was significant at 20, 40 and 60 DAP indicating that increased plant height with increase in N levels was consistent in a variety and at a N level, the varietal behaviour also was uniform.

4.2.2 Tiller number per square metre (Table 3)

Tiller number per square metre exhibited significant differences among varieties, N levels and their interaction at 40 and 60 DAP. Varietal variation in tiller production was not significant at 20 DAP indicating that all the varieties had almost a tillering potential in the initial stages of crop growth while among N levels and V x N interaction significant differences were observed at 20 DAP.

Tillering potential was consistently high in MTU 2077 (396, 399 and 400 tillers/m²) and MTU 2067 (391, 392 and 407 tillers/m²) at 40, 60 and 80 DAP. However the increase in tiller number from 40 DAP to 80 DAP was negligible.

The highest N level of 120 kg/ha produced significantly high number of tillers per square metre at 20, 40, 60 and 80 DAP (377, 468, 467 and 476) followed by 80 kg N/ha (349, 438, 446 and 451) and these two levels of N were significantly superior to the rest of the N levels (Fig.4). Tiller number was lowest in all the varieties when no nitrogen was applied.

Table 4: Biomass production at different stages of crop growth

Nitrogen levels (kg/ha)	Biomass production per square metre(g)													
	20 DAP							40 DAP						
	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean
0	101	102	105	108	111	116	107	162	144	185	183	206	182	177
40	130	129	142	137	144	161	144	217	180	224	220	252	221	219
80	166	175	197	207	202	218	194	292	238	313	305	301	310	293
120	197	201	204	223	213	224	210	301	237	333	342	338	338	316
Mean	149	152	162	169	168	180		243	198	264	263	274	274	

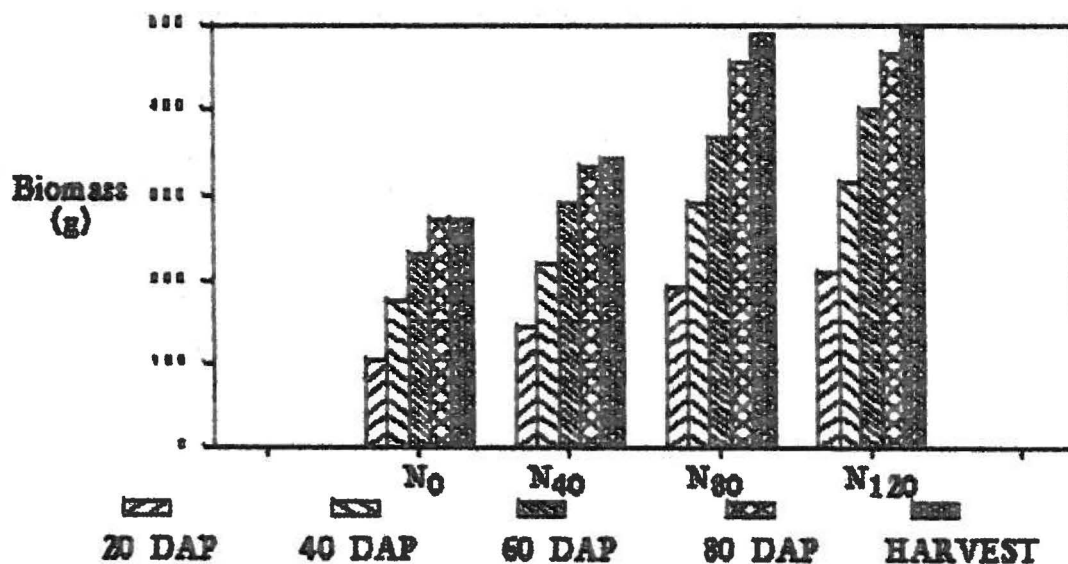
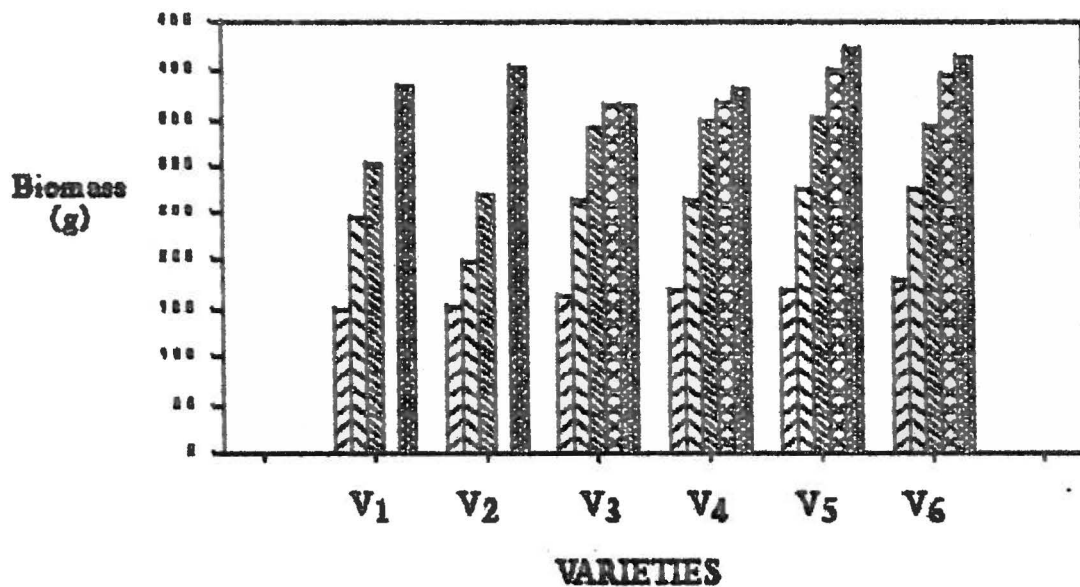
	F test	CD at 5%	CV %	*F* test	CD at 5%	CV %
Varieties	NS	-	5.8	Sig.	10.0	4.3
Nitrogen levels	Sig.	6.0	-	Sig.	7.0	-
<u>Interaction</u>						
N x V	Sig.	16.0	-	Sig.	18.0	-
N x V	Sig.	16.0	-	Sig.	17.0	-

TABLE 4 contd...

Nitrogen levels (kg/ha)	Biomass production per square metre (g)																				
	60 DAP							80 DAP							Harvest						
	IET 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IET 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IET 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean
0	196	185	245	271	249	259	233	-	-	251	252	310	286	275	230	276	278	254	321	291	275
40	272	229	314	322	330	317	293	-	-	324	335	331	342	333	324	348	338	346	353	350	343
80	365	317	377	385	396	364	367	-	-	439	431	470	475	454	495	493	483	452	501	501	486
120	382	340	420	421	428	430	400	-	-	446	448	491	482	467	495	494	488	470	512	511	495
Mean	304	267	340	350	351	343	-	-	365	367	402	396	-	384	403	365	381	422	413	-	-

	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %
Varieties	Sig.	11.0	3.8	Sig.	8.0	4.8	Sig.	13.0	1.8
Nitrogen levels	Sig.	8.0	-	Sig.	10.0	-	Sig.	5.0	-
<u>Interaction</u>									
V x N	Sig.	20.0	-	Sig.	19.0	-	Sig.	12.0	-
N x V	Sig.	19.0	-	Sig.	18.0	-	Sig.	14.0	-

Fig. 5 BIOMASS PRODUCTION AT DIFFERENT STAGES OF CROP GROWTH



V₁ - IET1444
 V₂ - BPT1235
 V₃ - MTU3626
 V₄ - MTU2400
 V₅ - MTU2067
 V₆ - MTU2077

N - NITROGEN (kg/ha)

DAP - DAYS AFTER PLANTING

Tillering ability was significantly influenced by V x N interaction at all the stages of crop growth except at 80 DAP.

4.2.3 Biomass production (g) per square metre (Table 4)

The data pertaining to the biomass production (g) per square metre revealed that the differences in this parameter among the varieties, N levels and their interaction was significant at 40, 60 DAP and harvest. At 80 DAP, the biomass production varied significantly among varieties and N levels but the interaction of V x N had no significant effect.

In the initial stages of crop growth i.e., at 20 DAP all the varieties produced similar quantity of biomass and the varietal variation was negligible and non-significant, while N levels and V x N interaction had a significant influence.

Biomass production was significantly high in MTU 2067 and MTU 2077 at 40, 60 and 80 DAP and harvest (274, 351, 401 and 422 in MTU 2067; 274, 343, 396 and 413 in MTU 2077) and it was lowest in the early varieties.

Application of 120 kg N/ha resulted in significantly high biomass production of 210, 316, 400, 467 and 495 g at 20, 40, 60, 80 DAP and harvest and it has declined

Table 5: Leaf area index at different stages of crop growth

Nitrogen levels (kg/ha)	Leaf area index													
	20 LAP							40 LAP						
	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean
0	2.0	1.9	1.5	1.6	1.5	1.4	1.6	2.6	2.1	2.3	2.4	2.4	2.4	2.4
40	2.2	2.0	1.9	2.0	1.9	1.9	2.0	3.2	3.3	2.7	2.8	3.1	3.0	3.0
80	2.3	2.2	2.6	2.2	2.4	2.4	2.3	4.0	4.3	3.8	4.1	4.6	4.4	4.2
120	2.8	2.4	2.9	2.3	3.0	2.1	2.6	4.6	4.7	4.5	4.5	5.4	5.3	4.8
Mean	2.2	2.1	2.2	2.0	2.3	1.9		3.6	3.6	3.3	3.4	3.9	3.8	

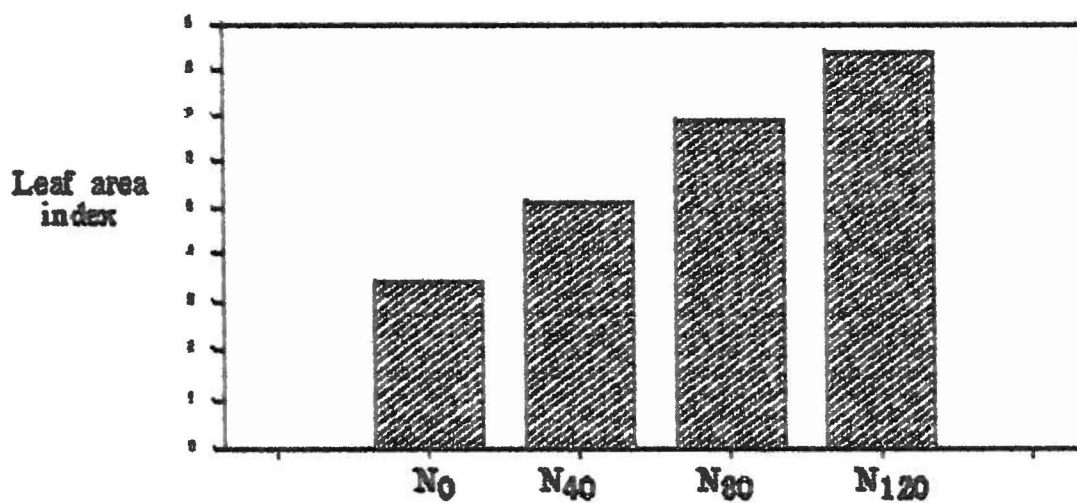
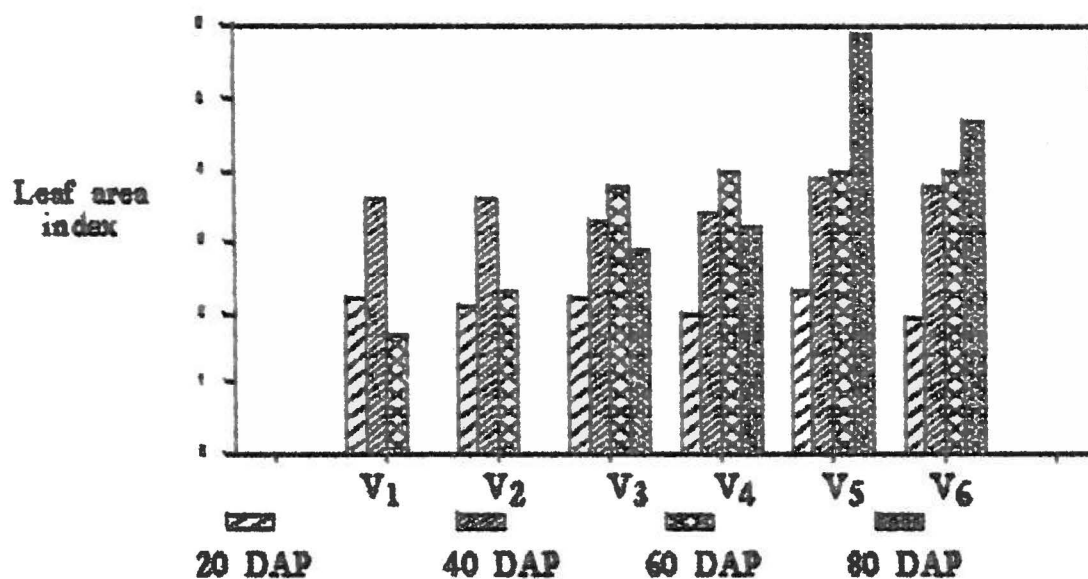
	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %
Varieties	NS	-	9.8	Sig.	0.4	8.0
Nitrogen levels	Sig.	0.1	-	Sig.	0.2	-
Interaction						
V x N	Sig.	0.1	-	NS	-	-
N x V	Sig.	0.4	-	NS	-	-

Table 5 contd...

Nitrogen levels (kg/ha)	Leaf area index													
	60 DAP							80 DAP						
	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean
0	1.4	1.4	2.4	2.8	2.5	2.6	2.2	-	-	1.5	1.8	3.4	2.8	2.4
40	1.4	2.2	3.3	3.4	3.2	3.4	2.8	-	-	2.0	2.5	5.1	3.3	3.2
80	2.1	2.9	4.5	4.8	4.7	4.6	3.9	-	-	4.0	4.1	6.9	5.6	5.1
120	2.0	2.8	4.9	4.9	5.5	5.4	4.2	-	-	4.3	4.3	8.4	7.0	6.0
Mean	1.7	2.3	3.8	4.0	4.0	4.0		-	-	2.9	3.2	5.9	4.7	

	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %
Varieties	Sig.	0.3	7.0	Sig.	0.4	12.0
Nitrogen levels	Sig.	0.8	-	Sig.	0.4	-
<u>Interaction</u>						
V x N	Sig.	0.4	-	Sig.	0.2	-
N x V	Sig.	0.4	-	Sig.	0.8	-

Fig. 6 LEAF AREA INDEX AT DIFFERENT STAGES OF CROP GROWTH



V₁ - IET1444
V₂ - BPT1235
V₃ - MTU3626
V₄ - MTU2400
V₅ - MTU2067
V₆ - MTU2077

N - NITROGEN (kg/ha)

DAP - DAYS AFTER PLANTING

Table 6: Specific leaf weight at different stages of crop growth

Nitrogen levels (kg/ha)	Specific leaf weight(mg)													
	20 DAP							40 DAP						
	IET 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IET 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean
0	5.8	5.8	6.4	5.4	6.0	5.7	5.9	6.5	6.3	6.4	6.2	6.5	6.4	6.4
40	6.7	5.6	6.5	6.3	5.9	5.7	6.1	6.3	6.4	6.3	6.4	6.6	6.4	6.4
80	6.8	6.8	6.9	6.6	6.8	6.7	6.8	6.5	6.5	6.5	6.4	6.6	6.5	6.5
120	6.6	6.8	6.3	6.3	7.9	7.5	6.9	6.3	6.5	6.6	6.5	6.9	6.9	6.5
Mean	6.5	6.3	6.5	6.2	6.6	6.4		6.5	6.4	6.5	6.5	6.6	6.5	

	F test	CD at 5%	CV %	*F* test	CD at 5%	CV %
Varieties	Sig.	0.2	2.4	Sig.	0.1	1.4
Nitrogen levels	Sig.	0.1	-	Sig.	0.06	-
<u>Interaction</u>						
V x N	Sig.	0.2	-	Sig.	0.2	-
N x V	Sig.	0.2	-	Sig.	0.2	-

Table 6 contd...

Nitrogen levels (kg/ha)	Specific leaf weight(mg)													
	60 EAP							80 EAP						
	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean
0	7.2	6.8	6.9	5.9	7.7	8.1	7.1	6.5	-	6.5	6.0	6.5	6.3	6.3
40	7.3	6.7	6.6	6.2	7.7	8.3	7.1	-	-	6.6	6.0	6.5	6.5	6.3
80	7.3	7.7	7.3	6.2	7.9	8.9	7.5	-	-	6.7	6.1	6.7	6.5	6.5
120	7.1	7.8	7.4	6.5	7.8	9.1	7.6	-	-	6.7	6.9	6.9	6.7	6.8
Mean	7.2	7.3	7.0	6.2	7.8	8.6		-	-	6.6	6.3	6.7	6.4	

	'P' test	CD at 5%	CV %	'P' test	CD at 5%	CV %
Varieties	Sig.	0.3	5.0	Sig.	0.1	4.7
Nitrogen levels	Sig.	0.2	-	Sig.	0.1	-
<u>Interaction</u>						
V x N	NS	-	-	NS	-	-
N x V	NS	-	-	NS	-	-

gradually and significantly with a reduction in the N level. The lowest biomass production was realised at the '0' N level (Fig.5).

Variety nitrogen interaction significantly influenced the biomass production at 20, 40, 60 DAP and harvest.

4.2.4 Leaf area index at different stages of crop growth (Table 5)

Leaf area index (LAI) differed significantly among the varieties, N levels and their interaction at different stages of crop growth. But the interaction was not significant at 40 DAP. Increased nitrogen application significantly increased the leaf area index. Application of 120 kg N/ha resulted in maximum leaf area index (6.0) than the other N levels (Fig.6). Significantly higher LAI values were recorded in MTU 2067 (8.4) at 120 kg N/ha followed by 80 kg N/ha (6.9). LAI was minimum with all test varieties when no nitrogen was applied. The superiority of MTU 2067 was maintained with regards to LAI throughout the crop growth.

4.2.5 Specific leaf weight (SLW) at different stages of crop growth (Table 6)

Significant differences in specific leaf weight were observed among varieties, N levels and their interactions at different stages of crop growth. But the interaction was not significant at 60 and 80 DAP. Application of

Table 7: Number of panicles per square metre and panicle weight(g)

Nitrogen	Number of panicles per square metre							Panicle weight(g)						
	Varieties							Varieties						
	IET	BPT	MTU	MTU	MTU	MTU	Mean	IET	BPT	MTU	MTU	MTU	MTU	Mean
	1444	1235	3626	2400	2067	2077		1444	1235	3626	2400	2067	2077	
0	243	234	225	265	252	259	246	1.2	1.7	2.0	1.8	1.9	2.2	1.8
40	323	264	252	289	340	282	292	1.3	1.8	2.1	1.9	2.1	2.7	2.0
80	355	294	277	317	374	336	325	1.6	2.1	2.5	2.6	2.6	3.8	2.5
120	374	318	289	323	381	365	341	1.8	2.0	2.8	2.5	2.9	3.7	2.6
Mean	324	277	261	298	337	310		1.5	1.9	2.3	2.2	2.4	3.1	

	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %
Varieties	Sig.	6	1.6	Sign	0.2	6.7
Nitrogen levels	Sig.	4	-	Sig.	0.1	-
<u>Interaction</u>						
V x N	Sig.	8	-	Sig.	0.2	-
N x V	Sig.	8	-	Sig.	0.2	-

120 kg N/ha resulted in maximum specific leaf weight than the other 'N' levels. Significantly higher ELW values were recorded in MTU 2067 at 120 kg N/ha (6.9 mg) followed by 80 kg N/ha (6.7 mg). ELW was minimum in all test varieties when no nitrogen was applied. The superiority of MTU 2067 in ELW was maintained throughout the crop growth.

4.3 YIELD COMPONENTS AND GRAIN YIELD

4.3.1 Panicles/m² and panicle weight

Panicles/m² and panicle weight differed significantly among varieties, nitrogen levels and their interactions (Table 7). The variety MTU 2067 produced significantly high number of panicles (337) and was superior to Rasi (324), MTU 2077 (310), MTU 2400 (298), BPT1235 (277) and Prabhat (261). The variety MTU 2077 produced heavier panicles (3.1 g) compared to other varieties.

Application of 120 kg N/ha resulted in maximum number of panicles per square metre (343) and panicle weight (2.6 g) and with a reduction in the nitrogen level, the panicle number and panicle weight have decreased gradually (Table 7).

Interaction between N levels and varieties was significant. MTU 2067 recorded maximum panicles (381) at 120 kg N/ha and was on par with 80 kg N/ha (374). MTU 2077 recorded

maximum panicle weight (3.8 g) at 80 kg N/ha and was on par with 120 kg N/ha (3.7 g). Lowest number of panicles and panicle weight were recorded in all the varieties when nitrogen was not applied.

4.3.2 Spikelet number per square metre (10^{-3}) (Table 8)

Table 8: Spikelet number per square metre (10^{-3})

Nitrogen levels (kg/ha)	Varieties						Mean
	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	
0	125	196	173	203	232	321	208
40	190	231	214	232	335	389	265
80	244	277	244	296	387	610	343
120	287	308	294	291	476	651	385
Mean	212	253	231	255	357	493	
				F test	CD at 5%	CV %	
Varieties				Sig.	6	5.7	
Nitrogen levels				Sig.	4	-	
<u>Interaction</u>							
V x N				Sig.	8	-	
N x V				Sig.	9	-	

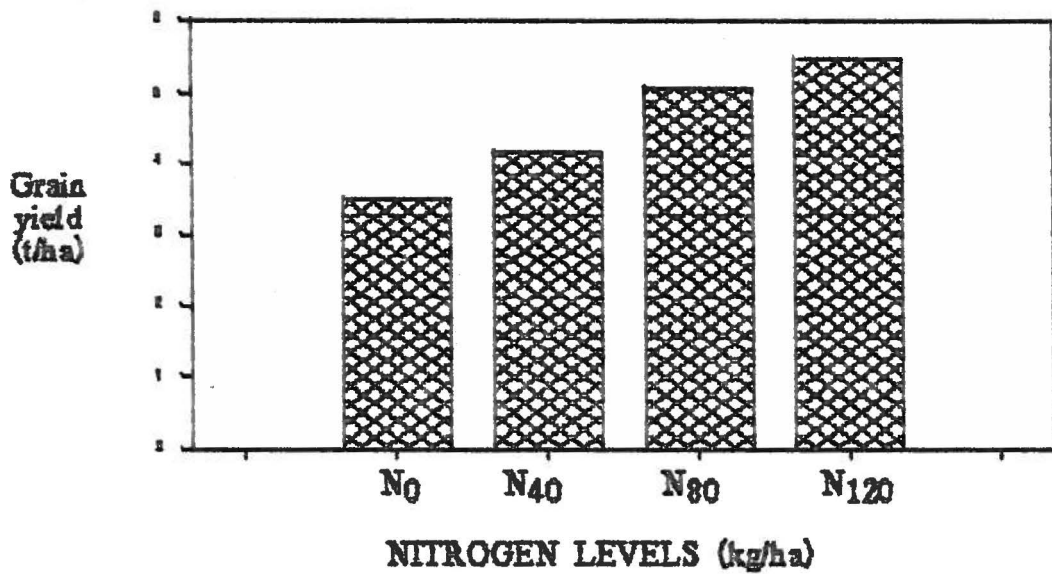
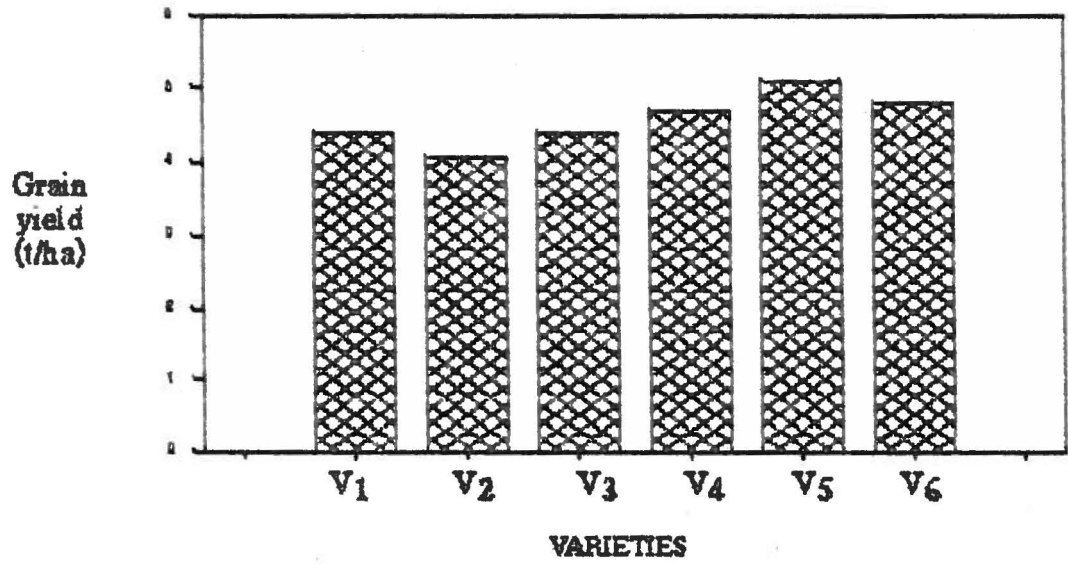
Number of spikelets per square metre exhibited significant variation among varieties and nitrogen levels. It was highest in the variety MTU 2077 (498×10^{-3}) and was gradually decreased in MTU 2067 (357×10^{-3}), MTU 2400 (255×10^{-3}), BPT 1235 (253×10^{-3}), MTU 3626 (231×10^{-3})

Table 9: Grain and straw yields

Nitrogen levels (kg/ha)	Grain yield(t/ha)							Straw yield(t/ha)						
	Varieties							Varieties						
	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean
0	3.0	2.8	3.6	3.7	4.2	3.8	3.5	4.1	3.5	4.3	3.9	4.9	4.5	4.2
40	3.9	3.4	4.2	4.6	4.8	4.4	4.2	4.3	3.9	4.8	4.7	5.9	5.1	4.8
80	5.3	4.8	4.9	5.2	5.5	5.4	5.1	5.6	5.1	6.0	5.8	7.2	6.4	6.0
120	5.4	5.3	5.0	5.4	6.1	5.8	5.5	6.2	5.6	6.1	5.9	7.5	7.0	6.4
Mean	4.4	4.1	4.4	4.7	5.1	4.8		5.1	4.5	5.3	5.1	6.4	5.7	

	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %
Varieties	Sig.	0.2	4.3	Sig.	0.2	4.3
Nitrogen levels	Sig.	0.1	-	Sig.	0.2	-
<u>Interaction</u>						
V x N	Sig.	0.3	-	Sig.	0.4	-
N x V	Sig.	0.3	--	Sig.	0.3	-

Fig. 7 GRAIN YIELD (t/ha)



V₁ = IET1444
 V₂ = BPT1235
 V₃ = MTU3626

V₄ = MTU2400
 V₅ = MTU2067
 V₆ = MTU2077

and IET 1444 (212×10^{-3}). Among nitrogen levels, the spikelet number per square metre was maximum at 120 kg N (385×10^{-3}) followed by 80 kg N (343×10^{-3}), 40 kg N (265×10^{-3}) and '0' N (208×10^{-3}). The interaction effect of V x N and N x V also was significant.

4.3.3 Grain yield (t/ha)

Variation in the grain yield was significant among the varieties, nitrogen levels and varietal nitrogen interaction (Table 9). Significantly highest grain yield of 5.1 t/ha was realised in MTU 2067 followed by MTU 2077 (4.8 t/ha) which was on par with MTU 2400 (4.7 t/ha) and superior to Rasi (4.4 t/ha) and Prabhat (4.4 t/ha) which in turn were superior to BPT 1235 (4.1 t/ha). Application of 120 kg N/ha resulted in maximum grain yield of 5.5 t/ha and was superior to 80 kg N/ha (5.1 t/ha) followed by 40 kg N/ha (4.2 t/ha) and no nitrogen (3.5 t/ha).

All the varieties yielded the lowest at the '0' N level and exhibited a progressive increase in grain yield with an increase in nitrogen level. However no significant differences in grain yield were observed between 120 and 80 kg N/ha in Prabhat, Rasi and MTU 2400 (Fig. 7).

4.3.4 Straw yield

Straw yield differed significantly among varieties, nitrogen levels and their interaction (Table 9). Significantly maximum straw yield of 6.4 t/ha was recorded in MTU 2067 followed by MTU 2077. Application of 120 kg N/ha resulted in maximum straw yield (6.4 t/ha) and was superior to the rest of the nitrogen levels. Lowest straw yield (4.2 t/ha) was recorded when nitrogen was not applied.

Varietal nitrogen interaction had significantly influenced the straw yield. MTU 2067 recorded maximum straw yield of 7.5 t/ha at 120 kg N/ha and was on par with 80 kg N/ha (7.2 t/ha). All the six varieties recorded lowest straw yields in the non-nitrogen applied plots. MTU 2077 recorded maximum straw yield (17.0 t/ha) at 120 kg N/ha. MTU 2400 and Prabhat recorded maximum straw yields at 120 kg N/ha (5.9 and 6.1 t/ha) and were on par with 80 kg N/ha (5.8 and 6.0 t/ha), whereas Rasi and BPT 1235 recorded maximum straw yields at 120 kg N/ha (6.2 and 5.6 t/ha) and were superior to 80 kg N/ha.

4.3.5 Harvest index (HI)

Harvest index exhibited significant variation among varieties and nitrogen levels (Table 10). The varieties MTU 2067, MTU 2077 and Rasi had significantly highest harvest index (46%) and were on par with MTU 2400 (45%) and superior

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to Prabhat (44%) and BPT 1235 (44%). Application of 120 kg and 80 kg N/ha recorded maximum harvest index of 47 per cent which was superior to the rest of the nitrogen levels. The interaction of V x N (or) N x V was not significant.

Table 10: Harvest index

Nitrogen levels (kg/ha)	Harvest index(%) Varieties						Mean
	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	
0	42	41	42	42	42	42	42
40	45	43	44	43	43	44	44
80	47	45	48	47	49	47	47
120	48	44	47	46	49	48	47
Mean	46	44	46	45	46	46	
		F test		CD at 5%		CV %	
Varieties		Sig.		1.0		1.9	
Nitrogen levels		Sig.		1.0		-	
<u>Interaction</u>							
V x N		NS		-		-	
N x V		NS		-		-	

4.3.6 Productivity per field day (kg/ha/day)

The productivity per field day was high (55.7) in IST 1444 (Table 11) and was lowest in MTU 2077 (30.0). Rest of the varieties had a productivity ranging from 43.2 to 47.1 kg/ha/day. Among nitrogen levels, the productivity per field day was maximum (51.9) at 120 kg N/ha and has gradually declined with a decrease in the nitrogen level, the lowest being recorded at the lowest level of 0 kg N/ha (36.8).

Table 12: Phenological data

Nitrogen levels (kg/ha)	Total duration							Flowering duration						
	Varieties							Varieties						
	IET	BPT	MTU	MTU	MTU	MTU	Mean	IET	BPT	MTU	MTU	MTU	MTU	Mean
	1444	1235	3626	2400	2067	2077		1444	1235	3626	2400	2067	2077	
0	108	116	127	132	148	150	130	78	86	97	102	118	120	100
40	112	120	130	137	150	154	134	84	91	100	107	121	123	104
80	116	124	133	140	154	156	137	86	94	103	110	124	126	107
120	121	127	137	143	158	160	141	91	97	107	113	128	130	111
Mean	114	122	132	138	153	155		85	92	102	108	123	125	

Table 11: Productivity per field day (kg/ha/day)

Nitrogen levels (kg/ha)	Varieties						Mean
	IST 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	
0	41.1	34.6	39.6	38.1	37.2	33.0	36.8
40	50.6	40.0	44.2	45.1	41.7	37.1	42.4
80	65.4	54.0	50.0	49.5	46.2	44.6	50.0
120	62.8	57.6	49.0	50.0	49.6	46.4	51.9
Mean	55.7	47.1	45.4	45.6	43.2	40.0	

4.3.7 Phenological data

The flowering duration was longer (123 and 125 days) in late duration varieties (Table 12) viz., MTU 2067 and MTU 2077 followed by (102 to 118) medium duration varieties (MTU 3626 and MTU 2400) and early duration varieties (85 to 92). A similar trend was observed in the total duration.

4.4 GRAIN FILLING POTENTIAL.

4.4.1 Percentages of different grades of rice grain (Table 13 and Fig.8)

4.4.1.1 Chaffy grain: Percentage of chaffy grain differed significantly among varieties and nitrogen levels. Chaffy grains were maximum in BPT 1235 (15.4%) followed by Prabhat (8.0%) and MTU 2400 (7.2) which were at par with each other.

Table 13: Percentages of different grades of rice grain

Nitrogen levels (kg/ha)	Chaf (%)							Partially filled (%)							Poor (%)						
	IET 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IET 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean	IET 1444	BPT 1235	MTU 3626	MTU 2400	MTU 2067	MTU 2077	Mean
0	6.4	18.3	8.8	8.4	9.7	9.0	10.1	1.7	6.7	10.1	4.6	6.8	6.6	6.1	1.8	3.9	4.5	0.9	2.7	3.1	2.8
40	4.5	12.5	8.0	7.2	8.1	8.4	8.1	1.5	7.1	11.5	4.6	5.9	4.0	5.8	2.5	3.6	4.7	0.7	4.1	1.8	2.9
80	3.0	11.6	7.9	6.3	4.2	3.4	6.1	1.4	10.6	9.0	4.4	1.8	1.7	4.8	3.3	3.1	4.7	2.1	1.9	2.0	2.9
120	5.5	19.3	7.4	6.8	4.7	5.9	8.3	2.6	9.4	5.9	2.5	1.3	3.3	4.2	1.8	4.7	3.3	2.0	2.0	2.0	2.6
Mean	4.9	15.4	8.0	7.2	6.7	6.7		1.8	8.5	9.0	4.0	4.0	4.0		2.4	3.8	4.3	1.4	2.7	2.2	

	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %
Varieties	Sig.	1.0	14.9	Sig.	1.0	16.0	Sig.	0.6	28.6
Nitrogen levels	Sig.	0.8	-	Sig.	0.5	-	NS	-	-
<u>Interaction</u>									
V x N	NS	-	-	NS	-	-	NS	-	-
N x V	NS	-	-	NS	-	-	NS	-	-

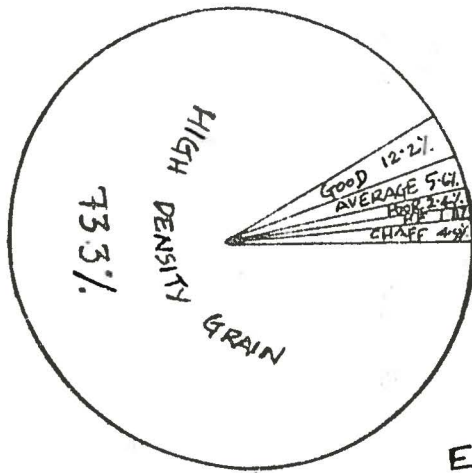
TABLE 13 CONTD...

Nitrogen levels (kg/ha)	Average (%)							Good (%)							High density grain (%)						
	IET	BPT	MTU	MTU	MTU	MTU	Mean	IET	BPT	MTU	MTU	MTU	MTU	Mean	IET	BPT	MTU	MTU	MTU	MTU	Mean
0	4.9	5.3	7.0	2.3	4.2	2.4	4.4	15.6	9.9	15.4	3.5	4.9	3.1	8.7	69.6	55.1	53.6	80.0	71.7	75.9	67.7
40	4.5	6.1	6.2	2.2	3.4	2.9	3.2	6.7	7.4	12.9	3.5	6.1	4.2	6.8	80.3	60.6	56.6	81.8	74.0	78.5	72.0
80	7.6	6.4	10.0	2.6	4.5	2.0	5.5	14.4	10.3	11.8	4.7	5.8	3.7	8.9	70.3	64.2	56.5	83.3	82.4	87.1	74.0
120	5.3	8.2	8.3	3.5	2.5	2.7	5.1	11.9	7.8	11.2	6.2	5.2	3.7	8.7	72.9	47.6	61.0	78.9	82.7	82.3	71.0
Mean	5.6	6.5	7.9	2.7	3.7	2.5	4.4	12.2	8.9	13.6	4.5	5.5	3.7	8.7	73.3	56.9	57.0	81.0	77.7	81.0	71.0

	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %
Varieties	Sig.	1.0	10.0	Sig.	0.5	17.0	Sig.	3.0	5.0
Nitrogen levels	Sig.	0.6	-	Sig.	0.9	-	Sig.	2.0	-
Interaction	Sig.	-	-	-	-	-	-	-	-
V x N	NS	-	-	NS	-	-	NS	-	-
N x V	NS	-	-	NS	-	-	NS	-	-

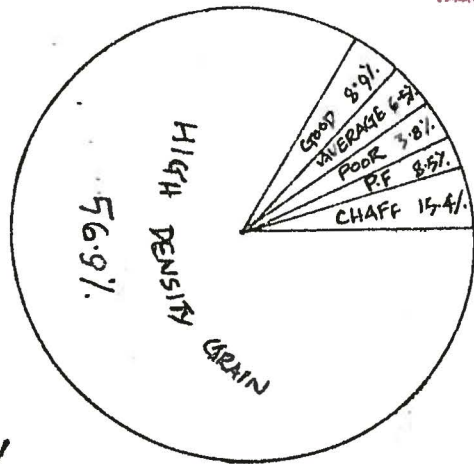
Fig.8. PERCENTAGES OF DIFFERENT GRADES OF RICE GRAIN - DURATION GROUPS

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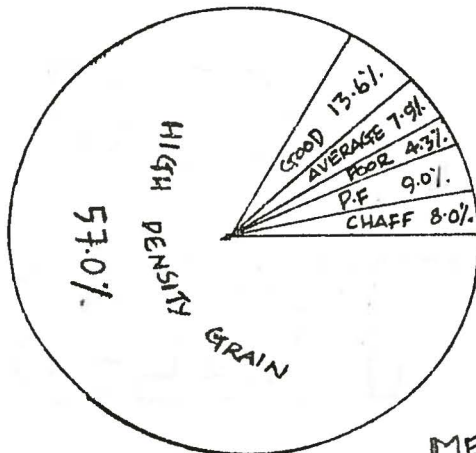


1. IET 1444

EARLY DURATION

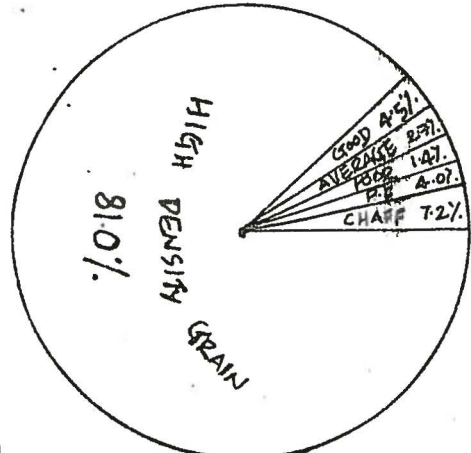


2. BPT 1235

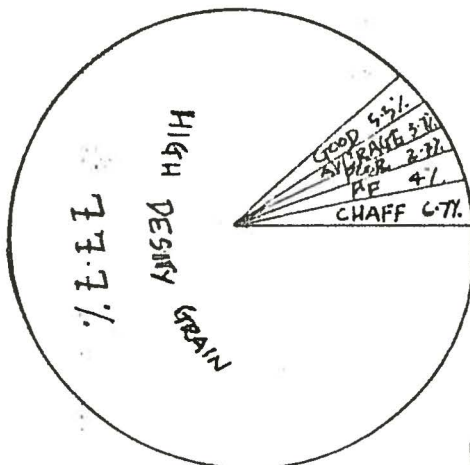


1. MTU 3626

MEDIUM DURATION

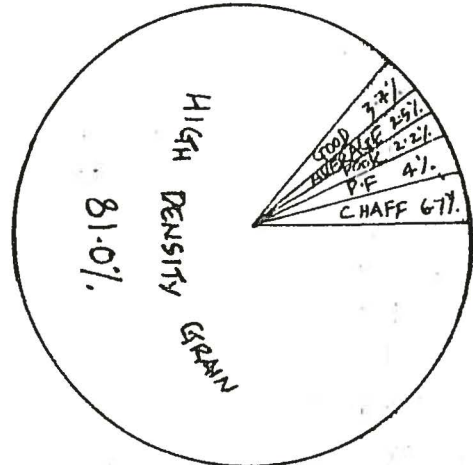


2. MTU 2400



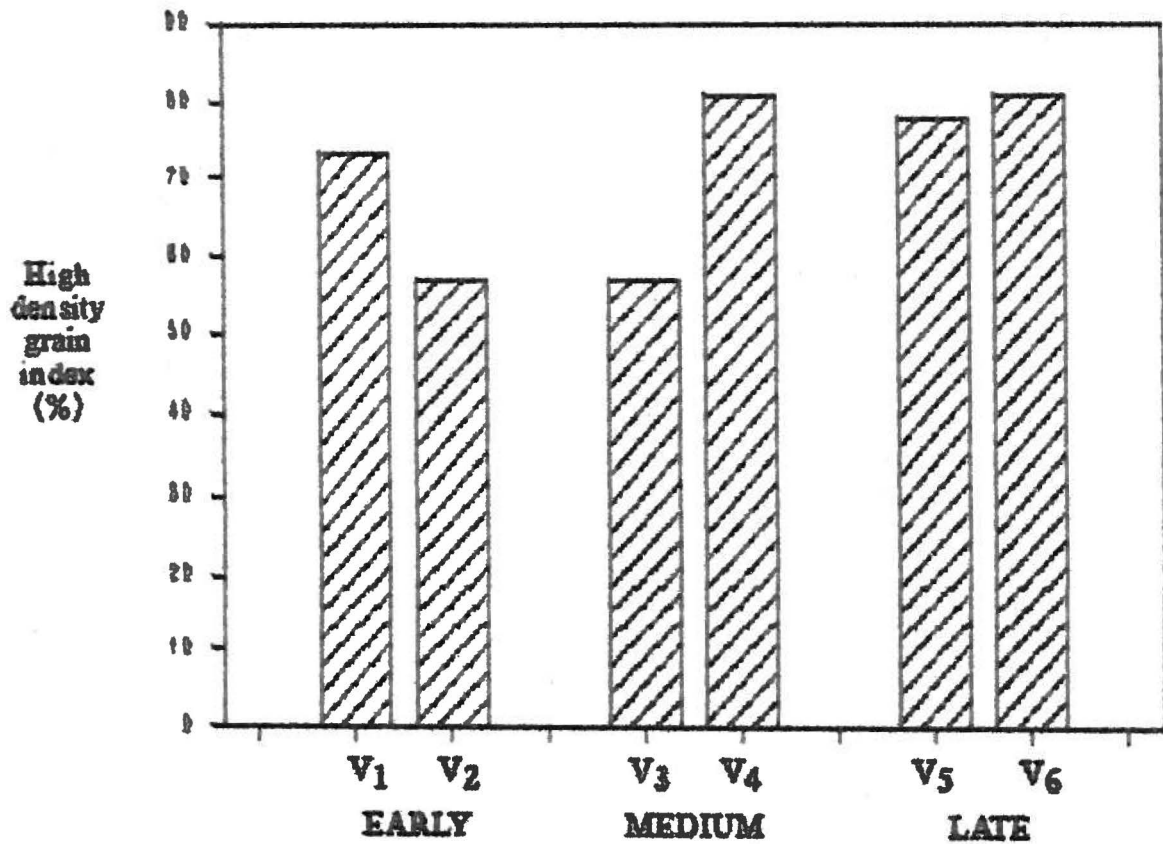
1. MTU 2067

LATE DURATION



2. MTU 2077

Fig. 9 HIGH DENSITY GRAIN INDEX AMONG DURATION GROUPS



V₁ = IET1444
V₂ = BPT1235

V₃ = MTU3626
V₄ = MTU2400

V₅ = MTU2067
V₆ = MTU2077

In turn Prabhat, MTU 2067 and MTU 2077 (7.2, 6.7 and 6.7%) were on par with each other. Rasi exhibited lowest number of chaffy grains (4.7%).

Though nitrogen levels differed significantly, no consistent trend was observed among the nitrogen levels with regards to the percentage of chaffy grains. However percentage of chaffy grains were high at '0' N level. The variety-nitrogen interaction was not significant.

4.4.1.2 Partially filled (PF) grain: Partially filled grain differed significantly among varieties and nitrogen levels. Maximum PF per cent was observed in Prabhat (9.0) which was on par with BPT 1235 (8.5). The lowest percentage of PF was recorded by Rasi (1.8).

PF per cent was maximum (6.5) when nitrogen was not applied. While no consistent trend was observed among the other nitrogen levels. The interaction effect of V x N or N x V was non-significant.

4.4.1.3 Poor grade grain: Significant variation among varieties was observed with regards to poor grade grain, while the differences among nitrogen levels (or) the interaction effect was non-significant. Prabhat recorded higher number of poor grade grains (4.3%), followed by BPT 1235 (3.8%) which was at par with it while the rest of the varieties had a significantly lower number of poor grade grains.

4.4.1.4 Average grade grain: The differences among varieties and nitrogen levels in the average grade grain were statistically significant. The average grade grain was maximum in Prabhat (7.9%) followed by BPT 1235 (6.5%) which were at par with IET 1444 (5.6%). The average grade grain per cent was lowest in MTU 2077 (2.5) and MTU 2400(2.7).

The average grade grain per cent was maximum at 80 kg N/ha and it was on par with 120 kg N level and significantly higher than the other nitrogen levels (0 and 40 N). The interaction effect was non-significant.

4.4.1.5 Good grade grain: Good grade grain differed significantly among varieties and nitrogen levels. Prabhat had maximum good grain per cent (13.6) and it was superior to the rest of the varieties.

The trend of good grade grain among different nitrogen levels was inconsistent, as also is the case with interaction of variety-nitrogen.

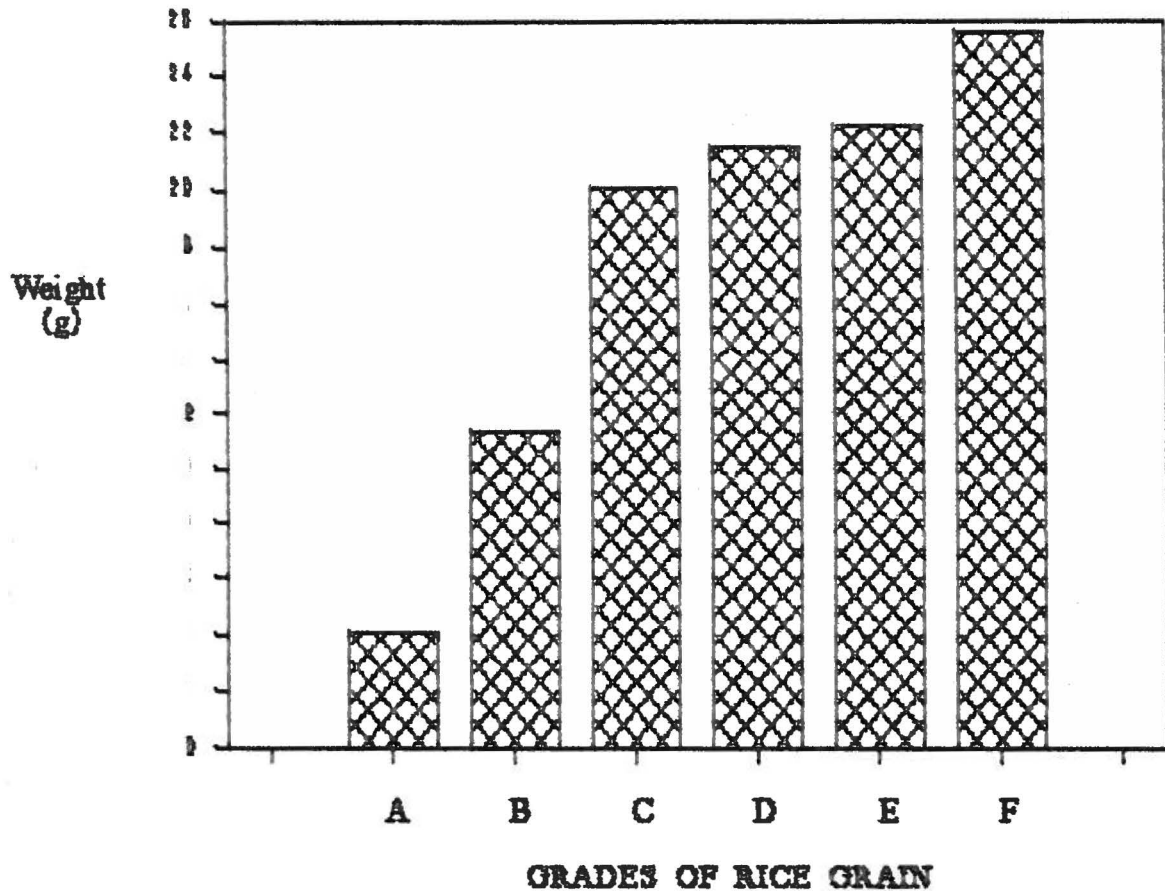
4.4.1.6 High Density Grain(HDG): Percentages of high density grains exhibited significant variation among varieties and nitrogen levels. The varieties, MTU 2077 and MTU 2400 were superior to the rest of the varieties and had maximum high density grain percentages (81 and 81). The lowest percentage of high density grain were observed in MTU 3626 (57.0) and BPT 1235 (56.9).

Table 14: Weight of different grades of rice grain (g)

Nitrogen levels (kg/ha)	Chaff							Partially filled							Poor						
	IET	BPT	MTU	MTU	MTU	MTU	Mean	IET	BPT	MTU	MTU	MTU	MTU	Mean	IET	BPT	MTU	MTU	MTU	MTU	Mean
	1444	1235	3626	2400	2067	2077		1444	1235	3626	2400	2067	2077		1444	1235	3626	2400	2067	2077	
0	1.3	3.2	4.9	4.4	2.8	3.2	3.5	11.4	7.9	15.7	12.3	13.6	10.5	12.0	12.2	18.3	22.8	20.4	17.4	17.6	18.1
40	2.9	3.9	5.7	3.7	3.3	4.2	4.0	12.3	6.8	14.6	6.5	11.1	15.5	9.4	16.4	18.3	23.8	22.9	17.8	17.9	19.5
80	2.0	5.5	5.8	2.9	6.9	6.7	5.0	13.1	11.8	16.1	14.3	10.4	6.3	12.0	18.5	21.4	24.4	23.5	18.8	23.5	21.7
120	2.3	4.4	4.4	2.7	6.1	3.9	4.0	12.6	9.9	17.5	16.3	11.2	7.1	12.4	14.6	19.5	22.5	23.4	24.0	20.6	20.8
Mean	2.4	4.2	5.2	3.4	4.8	4.5		12.3	9.1	15.8	12.3	11.6	7.3		15.4	19.4	23.4	22.6	19.5	20.0	

	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %
Varieties	Sig.	0.6	19.7	Sig.	0.8	8.5	Sig.	1.5	6.4
Nitrogen levels	Sig.	0.50	-	Sig.	0.6	-	Sig.	0.8	-
<u>Interaction</u>									
V x H	NS	0.60	-	NS	0.71	-	Sig.	1.03	-
H x V	NS	1.21	-	NS	1.45	-	Sig.	2.12	-

Fig. 10 THOUSAND GRAIN WEIGHT OF DIFFERENT GRADES OF RICE GRAIN



A = CHAFF
B = PARTIALLY FILLED
C = POOR
D = AVERAGE
E = GOOD
F = HIGH DENSITY GRAIN

Application of 80 kg N/ha resulted in maximum percentage of high density grains (74) and it was at par with 40 kg N/ha (72) and superior to the rest of the nitrogen levels. High density grain percentage increased upto 80 kg N/ha (74) and then decreased at 120 kg N/ha (71.0) showing that high nitrogen levels HDG % decreased (Fig.7). The interaction effect was non-significant.

4.4.2 Weight of different grades of grain (g) (Table 14)

4.4.2.1 Chaffy grains: Weight of thousand chaffy grains differed significantly due to varieties and nitrogen levels. Maximum weight (5.2) was recorded in Prebhat and MTU 2067 (4.8) compared to other varieties. The chaffy grain weight was highest at 80 kg N/ha while the weights at the other nitrogen levels did not differ significantly. The variation due to interaction was non-significant.

4.4.2.2 Partially filled grain: Thousand grain weight of partially filled grain differed significantly among varieties and nitrogen levels. In Prebhat maximum weight (15.8) was recorded compared to the varieties MTU 2400 (12.3), Rasi(12.3), MTU 2067 (11.6) and MTU 2077 (7.3). Application of 120 kg N/ha resulted in maximum weight (12.4) which was on par with 80 kg N/ha (12.0) and 0 nitrogen. The interaction effect was non-significant.

4.4.2.3 Poor grade grain: The weight of thousand poor grade grains exhibited significant variation among varieties and nitrogen levels. Prabhat recorded maximum weight of poor grade grain (23.4) and was at par with MTU 2400 (22.6) but superior to MTU 2077 (20.0), MTU 2067 (19.5), BPT 1235 (19.4) and Rasi (15.4). Among nitrogen levels 80 kg N/ha resulted in maximum weight of poor grade grains (21.7) followed by 120 kg (20.8) and 40 kg N/ha (19.5). Lowest thousand grain weight was recorded at 0 nitrogen level. Interaction effect of V x N was not significant.

4.4.2.4 Average grade grain: Average grade grain weight differed significantly among varieties and nitrogen levels. Prabhat recorded highest average 1000-grain weight (27) followed by MTU 2400 (23.4), BPT 1235 (21.5), MTU 2067 (19.8), MTU 2077 (20.5) and Rasi (19.0). Application of 80 kg N/ha resulted in maximum grain weight (23.0) compared with other three nitrogen levels. Lowest 1000-grain weight was recorded at 0 nitrogen level. The interaction effect was non-significant.

4.4.2.5 Good grade grains: The thousand grain weight of good grade grain exhibited significant variation due to varieties and nitrogen levels. Prabhat recorded highest 1000-good grain weight (28.0) followed by MTU 2400 (23.0) and lowest grain weight was observed in MTU 2067 (19.5) and Rasi (20.0). Nitrogen level of 80 kg N/ha resulted in

maximum grain weight (22.8) but was at par with 120 kg N/ha and superior to the rest of the nitrogen levels. The interaction effect was non-significant.

4.4.2.6 High density grain: HDG weight differed significantly among varieties and nitrogen levels. Prabhat recorded significantly higher high density grain weight (30.6) followed by MTU 2400 (28.9), BPT 1235 (26.7), Rasi (24.3), MTU 2067 (22.6) and MTU 2077 (21.5). Application of 80 kg N/ha resulted in maximum grain weight (26.7) which was on par with 120 kg N/ha (26.0). Lowest weight of 1000 high density grains was recorded at '0' N level and it was on par with 40 kg N/ha. V x N (or) N x V interaction effect was non-significant.

4.5 NITROGEN % AT FLOWERING (Table 15)

4.5.1 Leaves

Nitrogen per cent differed significantly due to varieties and nitrogen levels. MTU 2077 recorded highest nitrogen per cent in leaves (1.0). There are no significant differences in the leaf nitrogen among other varieties. Application of 120 kg N/ha resulted in maximum nitrogen per cent (1.2) which was on par with 80 kg N/ha (1.1). There was no significant interaction between varieties and nitrogen levels.

Table 16: Nitrogen per cent at harvest

Nitrogen levels (kg/ha)	N % in leaves							N % in stem							N % in grain						
	Varieties							Varieties							Varieties						
	IET	BPT	MTU	MTU	MTU	MTU	Mean	IET	BPT	MTU	MTU	MTU	MTU	Mean	IET	BPT	MTU	MTU	MTU	MTU	Mean
1444	1235	3626	2400	2067	2077		1444	1235	3626	2400	2067	2077		1444	1235	3626	2400	2067	2077		
0	0.42	0.42	0.46	0.37	0.42	0.46	0.43	0.18	0.28	0.18	0.18	0.23	0.28	0.22	0.84	0.93	0.88	0.88	0.93	0.98	0.91
40	0.51	0.56	0.51	0.51	0.51	0.60	0.53	0.23	0.32	0.32	0.28	0.28	0.37	0.30	1.10	1.16	1.07	1.16	1.16	1.21	1.14
80	0.65	0.79	0.74	0.70	0.74	0.74	0.73	0.37	0.37	0.37	0.37	0.37	0.51	0.39	1.40	1.68	1.68	1.54	1.72	1.77	1.63
120	0.74	0.79	0.79	0.79	0.79	0.84	0.79	0.37	0.42	0.42	0.45	0.45	0.60	0.46	1.68	1.68	1.77	1.72	1.91	1.86	1.76
Mean	0.58	0.64	0.63	0.59	0.62	0.66		0.29	0.34	0.32	0.32	0.34	0.44		1.30	1.33	1.35	1.32	1.43	1.46	

	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %	'F' test	CD at 5%	CV %
Varieties	Sig.	0.06	13.2	Sig.	0.06	26.2	Sig.	0.12	7.8
Nitrogen levels	Sig.	0.05	-	Sig.	0.06	-	Sig.	0.07	-
Interaction									
V x N	NS	-	-	NS	-	-	NS	-	-
N x V	NS	-	-	NS	-	-	NS	-	-

4.5.2 Stem

Significant differences in nitrogen per cent were observed among varieties and nitrogen levels. MTU 2077 recorded highest nitrogen per cent (0.57) in stem compared to other five varieties. Maximum stem N % (0.6) was observed at 120 kg N/ha which was on par with 80 kg N/ha (0.51). Lowest nitrogen per cent was recorded when nitrogen was not applied. Interaction was not significant due to varieties and nitrogen levels.

4.6 NITROGEN % AT HARVEST (Table 16)

4.6.1 Leaves

Significant variation in leaf N % was observed among varieties and nitrogen levels. Maximum nitrogen per cent of 0.66 was observed in MTU 2077 when compared with other varieties. Application of 120 kg N/ha resulted in maximum N % (0.84) followed by 80 kg N/ha (0.74). N % increased with increased nitrogen levels. Interaction was not significant due to varieties and nitrogen levels.

4.6.2 Stem

Significant differences were observed in N % among varieties and nitrogen levels. MTU 2077 exhibited maximum N % (0.44) followed by MTU 2067 (0.34). Application of 120 kg N/ha resulted in maximum N % (0.46) followed by 80 kg N/ha (0.39). Interaction had no significant effect on varieties and nitrogen levels.

4.6.3 Grains

Nitrogen % differed significantly among varieties and nitrogen levels. Grain N % was maximum (1.46) in MTU 2077 followed by MTU 2067 (1.43). Maximum grain N % of 1.76 was recorded at 120 kg N/ha followed by 80 kg N/ha (1.63). Variation due to varietal nitrogen interaction was non-significant.

4.7 CORRELATION COEFFICIENTS

The values of simple correlation coefficients between high density grain and other growth parameters are presented in the Table 17. Positive and significant correlations were observed between HDG and grain yield (0.3072), plant height (0.4483), Biomass production (0.3358), leaf area index at flowering (0.4364), Panicles/m² (0.5077) and filled grains per panicle (0.3540). Significant and negative correlation was observed between HDG and test weight.

HDG was also negatively related to chaff and with all the other grades of grain except good grade grain with which it had a significant and positive relation (+0.6728) (Table 18).

Grain yield was also positively related to HDG (0.3072) and negatively related to chaffy grains (-0.4234) (Table 18).

Total duration of the crop, flowering duration and vegetative phase were significantly and positively related to HDG (0.544, 0.550, 0.5446) (Table 19).

Table 17: Interrelationships among physiological parameters in rice

	Grain yield (t/ha)	Plant height (flowering)	Tillers (flowering)	Biomass production (flowering)	Biomass production (harvest)	Leaf area index (flowering)	Panicles per m ²	Test weight	Filled grains/panicle	N % at flowering (leaves)	N % at flowering (stem)	N % at harvest (leaves)	N % at harvest (stem)	N % at harvest (grains)	High Density Grains
Grain yield(t/ha)	1.0000	-0.2374*	0.8559**	0.8710*	0.8928**	0.7854**	0.8543**	0.0074	0.6405**	0.8196**	0.6029**	0.7972**	0.0203	0.8360**	0.3000
Plant height(flowering)		1.0000	0.0730	-0.1008	-0.0308	-0.4016**	-0.2471*	0.5998**	-0.5836**	-0.0325	-0.1238	0.0074	0.1023	0.0642	0.4480**
Tillers(flowering)			1.0000	0.8038**	0.9327**	-0.7467**	3.7868**	0.0816	0.5155**	0.8516**	0.6556**	0.8515**	0.1297	0.8920**	0.1926
Biomass production (flowering)				1.0000	0.8701**	0.7790**	0.7436**	0.2949*	0.6185**	0.7291**	0.6262**	0.7853**	0.1351	0.8591**	0.2358
Biomass production (harvest)					1.0000	0.7640**	0.7685**	0.1475	0.5935**	0.8905**	0.7043**	0.8844**	0.0894	0.9413**	0.1384
Leaf area index (flowering)						1.0000	0.7210**	-0.0857	0.8393**	0.7639**	0.6950**	0.7522**	0.0811	0.8175**	0.4364**
Panicles/m ²							1.0000	-0.1944	0.5472**	0.7494**	0.4504**	0.6500**	0.0606	0.7253**	0.5077**
Test weight								1.0000	-0.1611	-0.0227	0.0774	0.1791	0.1739	0.1536	-0.7666**
Filled grains/panicle									1.0000	0.5742**	0.5950**	0.0674	-0.0381	0.6274**	0.3540**
Nitrogen % at flowering (leaves)										1.0000	0.6131**	0.7762**	0.0025	0.8379**	0.1221
Nitrogen % at flowering (stem)											1.0000	0.7194**	0.0941	0.7026**	0.0816
Nitrogen % at harvest (leaves)												1.0000	0.0662	0.8567**	0.1176
Nitrogen % at harvest (stem)													1.0000	0.0974	0.1120
Nitrogen % at harvest (grains)														1.0000	0.2169
High Density Grains															1.0000

* Significant at 5% level; ** Significant at 1% level

Table 18: Correlation coefficients between HDG and other important characters

HDG vs	'r' value	Grain yield vs	'r' value
Harvest Index	+ 0.3419	HD grain	+ 0.3072**
Good grade grain	+ 0.6728**	Good grade grain	- 0.2325 NS
Average grade grain	- 0.8370**	Average grade grain	- 0.0739 NS
Poor grade grain	- 0.8366**	Poor grade grain	- 0.1849 NS
Partially filled grain	- 0.7726 **	Partially filled grain	- 0.2163 NS
Chaffy grain	- 0.6998**	Chaffy grain	- 0.4234**
Total spikelet number/m ²	+ 0.4877**	Harvest Index	+ 0.8553**
		Total spikelet number/m ²	+ 0.6504**
		Spikelet number/m ² vs	
		Filled grain number/m ²	+ 0.9259**

Table 19: Correlation coefficients between HDG and growth duration

	'r' value
Vegetative phase	0.5446*
Flowering duration	0.550*
Reproductive phase	0.3559
Total duration	0.544*

4.8 PATH COEFFICIENT ANALYSIS

Path coefficient analysis is an effective tool in analysing the direct and indirect causes of different characters and paves way to examine specific forces that govern to produce a given correlation. Thus correlations in conjunction with path coefficient can give a better insight into the cause effect relationship between different pairs of variables (Plate 2).

Path coefficient analysis revealed that HDG was under the direct positive influence of panicles/m² (0.7577), LAI at flowering (0.5541), BMP at flowering (0.5350) and to a certain extent the number of tillers at flowering (0.2408) and grain N % at harvest (0.2294). High negative direct effect on HDG was manifested by the BMP at harvest (1.0406), followed by low negative direct effect by leaf N % (0.2468) and plant height at flowering (0.2460) (Table 20).

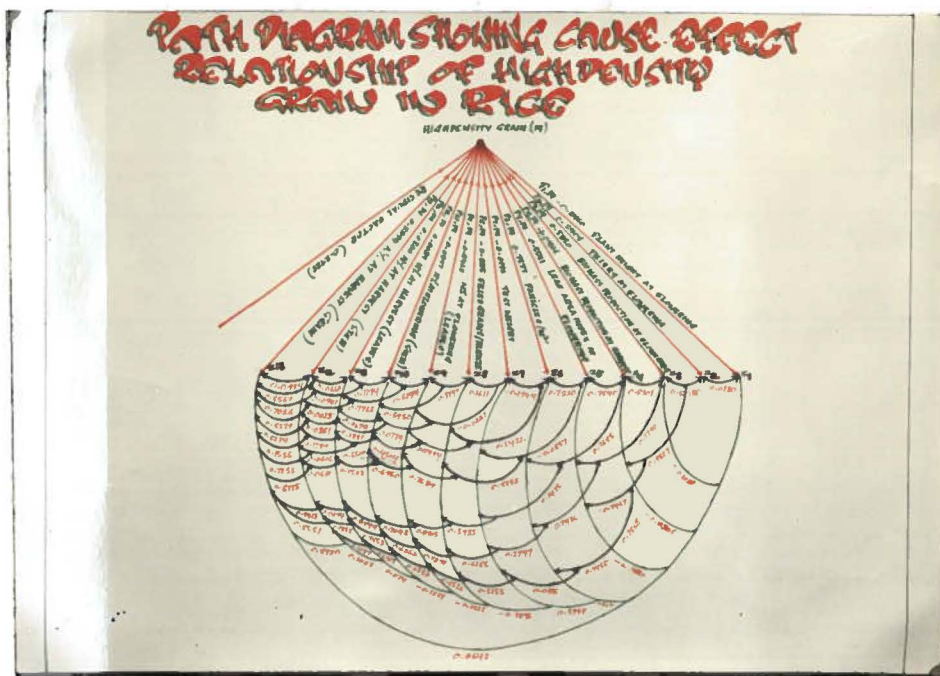


Plate 2: Path diagram showing cause-effect relationship of high density grain in rice

Number of panicles/m² had a positive direct effect on HDG and was supported by its indirect effect through tiller number at flowering (0.5962), BMP at harvest (0.5823), and flowering (0.5864), leaf N % at flowering and grain N % at harvest (0.5678 and 0.5498) and LAI at flowering (0.5463) which ultimately lead to a positive total effect of 0.5072.

The direct effect (0.5541) of LAI on HD grains was high and it had indirect influence also through filled grains/panicle (0.4651), grain N % at harvest (0.4530), BMP at harvest (0.4344), BMP at flowering (0.4316), leaf N % at flowering (0.4232), leaf N % at harvest (0.4168) and tillers at flowering (0.4138). Thus it has resulted in the total significant effect of 0.4364.

The HDG was under the direct positive influence of BMP at flowering (0.5350) which has exerted its effect indirectly through other parameters also namely BMP at harvest (0.4655), grain N % at harvest (0.4574), tillers at flowering (0.4300), leaf N % at harvest (0.4200) and LAI at flowering (0.4167). Its indirect effect via other parameters was of low magnitude.

Tillers/m² had a feeble positive direct effect (0.2408) on the HDG and it was supported by indirect effect through BMP at harvest (0.2246), grain N % at harvest (0.2146), leaf N % at flowering and harvest (0.2051). Its indirect

Table 20: Path coefficient analysis of growth and yield parameters on High Density Grain in rice

	Plant height (flowering)	Tillers (flowering)	Biomass production (flowering)	Biomass production (harvest)	Leaf area index (flowering)	Panicles per m ²	Test weight	Filled grains/panicle	N% at flowering (leaves)	N% at flowering (stem)	N% at harvest (leaves)	N% at harvest (stem)	N% at harvest (grains)
Plant height (flowering)	<u>-0.2460</u>	-0.018	0.0248	0.0076	0.0987	0.0608	-0.1475	0.1436	0.0080	0.0305	0.0018	-0.0252	0.0148
Tillers (flowering)	0.0176	<u>0.2408</u>	0.1936	0.2246	0.1798	0.1895	0.0196	0.1242	0.2051	0.1579	0.2051	0.0312	0.2148
Biomass production (flowering)	-0.0539	0.4300	<u>0.5350</u>	0.4655	0.4167	0.3978	0.1578	0.3309	0.3900	0.3350	0.4201	0.0725	0.4574
Biomass production (harvest)	0.0321	-0.9705	-0.9054	<u>-1.0406</u>	-0.8158	-0.7997	-0.1535	-0.6175	-0.9267	-0.7329	-0.9203	-0.0930	-0.9795
Leaf area index (flowering)	-0.2222	0.4138	0.4316	0.4344	<u>0.5541</u>	0.3995	-0.0475	0.4651	0.4232	0.3851	0.4168	0.0449	0.4530
Panicles m ⁻²	-0.1873	0.5962	0.5634	0.5822	0.5463	<u>0.7527</u>	-0.1475	0.4146	0.5678	0.3412	0.4925	0.0459	0.5495
Test weight	-0.0115	-0.0014	-0.0057	-0.0028	0.0016	0.0037	<u>-0.8192</u>	0.0031	0.0004	-0.0015	-0.0034	-0.0033	-0.0030
Filled grains/panicle	0.1234	-0.1090	-0.1308	-0.1255	-0.1775	-0.1157	0.0341	<u>-0.2115</u>	-0.1214	-0.1258	-0.1285	0.0081	-0.1104
N % at flowering (leaves)	-0.0080	-0.2102	-0.1799	-0.2198	-0.1885	-0.1850	0.0056	-0.1417	<u>-0.2468</u>	-0.1513	-0.1916	-0.0006	-0.2058
N % at flowering (stem)	0.0111	-0.0585	-0.0362	-0.0632	-0.0623	-0.0404	-0.0069	-0.0534	-0.0550	<u>-0.0897</u>	-0.0645	-0.0084	-0.0630
N % at harvest (leaves)	0.0000	0.0033	0.0031	0.0035	0.0029	0.0025	0.0007	0.0024	0.0030	0.0028	<u>0.0039</u>	0.0003	0.0034
N % at harvest (stem)	0.0031	0.0039	0.0041	0.0077	0.0024	0.0018	0.0052	-0.0011	0.0001	0.0028	0.0027	<u>0.0200</u>	0.0018
N % at harvest (grains)	-0.0471	0.2046	0.1962	0.2760	0.1876	0.1664	0.0352	0.1459	0.1922	0.1612	0.1965	0.0214	<u>0.2294</u>

The values underlined are direct effects and other values are indirect effects

Table 21: Influence of N levels on the grain filling potential

	Chaff %	PF %	Poor %	Average %	Good %	HD %
0	100	100	100	100	100	100
40	80	95	104	95	78	106
80	60	79	104	125	102	109
120	82	69	93	116	94	105

	Chaff %			PF %			Poor %			Average %			Good %			HD %		
	E	M	L	E	M	L	E	M	L	E	M	L	E	M	L	E	M	L
0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
40	69	88	88	102	109	75	107	100	108	104	89	97	55	86	130	113	104	103
80	59	83	40	143	91	27	110	141	69	137	134	100	97	87	120	108	105	115
120	101	83	56	143	57	34	114	100	69	133	123	79	77	107	113	97	105	112

E = Early

M = Medium

L = Late

effects through other parameters was of very low magnitude and the final result of all these effects was an insignificant low positive effect (0.1946).

Grain N % at harvest though had a direct influence was feeble and of very low magnitude.

The BMP at harvest exerted a high direct negative influence (-1.04) on the HDG mainly on its own strength and indirectly through the negative indirect influence of grain N % (-0.9795), tillers at flowering (-0.9705), leaf N % at flowering and harvest (-0.9267 and -0.9203) and BMP at flowering (-0.9054). However the feeble effect through other characters and the positive effect through plant height has finally led to an insignificant positive total effect of 0.1384.

The leaf N % and the plant height also exerted direct negative influence on HDG though a very low extent (-0.2468 and -0.2460), on their own strength. The direct effect of these two parameters could have increased to a large extent but for the nullifying effect of positive influence through test weight, in the case of leaf N % and LAI and panicles/m² in the case of plant height.

DISCUSSIONS

CHAPTER V

DISCUSSION

The observations recorded in the present study on the influence of graded levels of nitrogen on the growth parameters and grain filling potential of six rice varieties are discussed hereunder in the light of the available literature.

5.1 GROWTH PARAMETERS

5.1.1 Plant height

The plant height at 20, 40 and 60 DAP was uniformly high in the late duration varieties (MTU 2067 and MTU 2077) and at higher N levels (80 and 120 kg/ha). The plants in the no nitrogen plots invariably recorded lowest plant height. The trend of increased plant height with increased N level was uniformly observed in all the varieties, as has also been reported by Mishra et al. (1986); Kalyanikutty et al. (1969); Panchaksharaiah et al. (1972); Murty et al. (1986); Reddy et al. (1987) and Prasad et al. (1982). The variety MTU 2077 was the tallest (84 cm) of all the test varieties.

5.1.2 Tillers per square metre

In the initial stages of tillering (20 DAP), the varietal variation was not statistically significant indicating that

all the varieties had the same tillering potential. However, at the later stages of crop growth i.e., 40, 60 and 80 DAP, the tillering potential was highest in the late duration varieties (MTU 2067 and MTU 2077) followed by mid duration (Prabhat, MTU 2400) and early duration varieties (Rasi and BPT 1235).

At all the stages of crop growth the tillering was lowest in the non nitrogen applied plants and has progressively increased with increased levels of nitrogen. The same trend was observed in all the varieties. Similar results were reported by Murty et al. (1986); Reddy et al. (1987); Prasad et al. (1982); Pandey and Mishra (1968); Kalyanikutty et al. (1969) and Natarajan et al. (1974).

5.1.3 Biomass production

The vigour of the plants in the initial stages of crop growth (20 DAP) was similar in all the varieties but differed significantly at later stages. The biomass production was significantly high in the late duration varieties followed by medium duration varieties and was lowest in the early varieties at 40, 60 and 80 DAP.

Nitrogen application has markedly improved the biomass production in all the varieties, the maximum being recorded at the highest level of 120 kg N/ha and has decreased gradually to the lowest level of nitrogen in all the varieties as has also been reported by Murty et al. (1986) and Ramanujam and Sakheram Rao (1971 b).

5.1.4 Leaf area index (LAI)

The source capacity as evidenced by leaf area index did not differ markedly among the varieties at 20 DAP. However with advancement of crop growth at 40 DAP, the leaf area index was significantly high in the late and early duration varieties. In general the LAI in a variety was maximum at flowering and in the early varieties, LAI decreased at 60 DAP evidently due to the senescence of leaves in the post flowering phase. The late duration varieties maintained a uniformly high source capacity than the medium and early varieties.

The source capacity exhibited a significant and progressive increase from 0 N to 120 kg N/ha. A similar trend was observed by Reddy *et al.* (1987); Murty *et al.* (1988); Prasad *et al.* (1987); Pagade and Debatta (1977) and Thorat and Patil (1977). This can be attributed to the vigorous vegetative growth and higher tillering potential at higher N level.

5.1.5 Specific leaf weight (SLW)

The differences in SLW among varieties were not marked upto 40 DAP. However at 60 and 80 DAP, late varieties exhibited high SLW than early and medium duration varieties. Higher N levels (60 and 120 kg/ha) lead to higher SLW in all the varieties and SLW was least at the lower N level

(0 and 40 kg/ha). At 60 DAP, the varietal variation of SLW within a N level and among the N levels within a variety were inconsistent and statistically non-significant.

In general the vigour and growth of seedlings in terms of plant height, tillering, biomass production, LAI and SLW was high in the late duration varieties followed by mid duration varieties and early duration varieties. This can be ascribed to the longer field duration and a corresponding higher nutrient requirement of the varieties with an increasing field duration.

The source capacity, tillering and plant height have exhibited an increasing trend with an increase in N level from 0 to 120 kg and this may be attributed to the luxuriant vegetative growth at higher levels of nitrogen coupled with higher tillering potential.

5.2 YIELD COMPONENTS

5.2.1 Panicle number per square metre and panicle weight

In general late duration varieties had higher panicle number and heavier panicles than the early and medium duration varieties as has also been reported by Vergara et al. (1964).

Higher 'N' level of 120 kg invariably resulted in higher panicle number and heavy panicles in all the

varieties and a gradual reduction in the panicle number and weight was evident with a reduction in the N level. This is in agreement with the findings of Reddy et al. (1987); Mishra et al. (1986); Rajagopalan et al. (1974) and Ten Have (1971). This can be attributed to the effect of N levels on the tillering potential and source capacity.

5.2.2 Spikelets per square metre

Late duration varieties exhibited higher number of spikelets per square metre (425×10^{-3}) followed by medium duration varieties (243×10^{-3}) and early duration varieties (233×10^{-3}). The progressive and significant increase in spikelet number/m² was observed with an increase from '0' N (208×10^{-3}) to 120 'N' (385×10^{-3}) indicating that 'N' levels had a profound enhancing effect on the spikelet number.

5.2.3 Grain and straw yields

Late duration varieties were significantly superior in their productivity to the medium duration varieties followed by early duration varieties as can be seen from the high tillering potential, high source capacity, high biomass production, high panicle number and heavier panicles in the late duration varieties. These findings are contrary to the conclusions drawn by Venkateswarlu et al. (1977) from Rajendranagar who found that the medium duration varieties

yielded higher than the late varieties. The difference could be probably due to the climatic factors. The late duration varieties were exposed to bright sunlight right from September month onwards (maximum tillering phase) till the ripening phase. This has aided in the photosynthetic efficiency of the plants and accumulation of carbohydrates in the grain. Unlike the long duration varieties, the early duration varieties were exposed to relatively low light intensity and cloudy weather during the reproductive phase during September month and as such the maximum yield potential was not realised.

The grain yield per hectare was lowest at the '0' N level and has gradually increased with an increase in 'N' level evidently due to vigorous growth and increased physiological efficiency at higher 'N' levels. Similar findings were reported by Mahapatra and Sharma (1973); Yogeswara Rao et al. (1980); Dev et al. (1971). Singla et al. (1973); Verma (1974); Thorat and Patil (1977); Bathkal and Patil (1968). Similar trend was observed in straw yield also (Mishra et al., 1986). As such, higher N level of 120 kg/ha can be adopted to realise higher productivity during kharif.

5.2.4 Harvest index (HI)

Harvest index was highest in the late duration varieties than the rest of the varieties indicating better physiological

efficiency in the late varieties. This is not agreement in the findings of Sahu (1980) who found that the HI was high in the early varieties than the medium duration and traditional tall types.

Harvest index at higher N levels (80 and 120 kg/ha) was high (47%) and was almost same indicating that beyond 80 kg N, the conversion of energy proportionate to the total biological yield will be almost same (Thorat and Patil, 1977). At lower 'N' level the total biomass production and consequent conversion of biomass into economic product is very low resulting in lower HI.

The present finding is in contradiction with the observation that a depression in HI occurs due to higher 'N' (Murty and Sahu, 1977; and Sahu et al., 1980). The higher HI at higher 'N' levels in the late varieties in the present investigation can be ascribed to the pattern of growth changes with season and variety (Tenake, 1969) which has resulted in luxuriant biological yield commensurating with economic yield.

5.2.5 Productivity per field day

Varietal variation was evident in productivity per field day with early varieties recording higher productivity per field day (51.4 kg/ha/day) followed by medium duration varieties (45.5) and late duration varieties (41.6). Though the late varieties were superior to the medium duration and early duration varieties in their total productivity per hectare. The per day productivity was low in these varieties because of

their longer field duration. Similarly the high productivity per field day in the early varieties can be ascribed to their relatively shorter field duration.

An increase in 'N' levels from 0 to 120 kg N resulted in a gradual increase in the productivity per field day in spite of the fact that the overall field duration has increased with increased 'N' levels. This is mainly because of the realisation of higher grain yields at higher 'N' levels.

In general the main yield contributing parameters namely panicles/m², panicle weight, spikelets/m² were high in the long duration varieties resulting in a higher HI and total productivity. This can again be attributed to the prevalence of favourable weather parameters namely high sunshine, optimum temperatures (25 to 35°C) from reproductive to ripening phases. Increased physiological efficiency at higher 'N' levels has resulted due to prevalence of bright weather and low night temperatures (18 - 21°C) finally leading to higher grain yields.

5.2.6 Phenological data

The flowering and total duration in the early varieties has increased gradually with increase in the duration of the variety to medium and late duration groups. Within a duration group, varieties exhibited slight variation of 2 to 8 days in the flowering and total duration.

Higher 'N' level had a delaying effect on the flowering and total duration and the duration was the least (130 days) in the '0' N level. This is in agreement with the statement of Ten Have (1971) that heading time depends on the levels of nitrogen and of Padmaja Rao (1988) that higher levels of nitrogen delay the crop maturity by 5 to 8 days.

5.3 GRAIN FILLING POTENTIAL

5.3.1 Percentage and weight of different grades of grains

5.3.1.1 Chaffy grain: The chaffy grain percentage in general was highest in early varieties (10.2) followed by medium duration varieties (7.6) and late varieties (6.7), while a reverse trend was observed in the chaffy grain weight. These results are in partial agreement with the findings of Vergara et al. (1966) and Murty and Murty (1980).

The differences among 'N' levels in the chaffy grain percentage and chaffy grain weight did not follow a consistent trend indicating that the varietal behaviour at different 'N' levels varied widely.

5.3.1.2 Partially filled grain (PF): The partially filled grain percentage was highest (6.5) in the medium duration varieties followed by early (5.2) and late duration varieties (4), while no definite trend was observed in the PF grain weight.

Though the 'N' levels differed significantly with regards to the percentage and weight of PF grain, the trend among different 'N' levels was inconsistent. However the chaff and PF grain percentage were high at '0' N level as has also been observed at Maruteru during 1987 (Anonymous, 1987-88). An exactly reverse trend of high percentage of chaff and PF at higher 'N' level also was reported from Maruteru during 1988 (Anonymous, 1988-89).

5.3.1.3 Poor grade grain: The poor grade grain percentage did not exhibit marked variation among the early, medium and late duration varieties while the weight of poor grade grain was high in the medium duration varieties (23.3 g) followed by late (19.7 g) and early (17.4 g) varieties.

The differences in the percentage of poor grade grain among the 'N' levels (or) the interaction of V x N did not

reach the level of statistical significance. The grain weight has significantly increased at higher 'N' levels (80 and 120 kg) in contrary to the results reported from Maruteru (Anonymous, 1987-88) and Rajendranagar (Anonymous, 1987).

5.3.1.4 Average grade grain: The average grade grain percentage was high in the early varieties (6.0) followed by medium (5.3) and late varieties (3.2), while the grain weight was high in the medium duration varieties (25.2 g) followed by early (20.2 g) and late varieties (19.1 g).

Higher 'N' levels of 80 and 120 kg/ha have lead to the realisation of higher percentage of average grade grains than 40 and 0 N levels, while no definite trend was observed among N levels in the weight of average grade grains. This is in agreement with the findings of scientists at Maruteru during kharif 1988 (Anonymous, 1988-89).

5.3.1.5 Good grade grain: Good grade grain percentage was highest in the early varieties (10.6) followed by medium (9.0) and late varieties (4.1). The weight of 1000 good grains was highest (25.5 g) in medium duration varieties followed by early (21.0 g) and late (20.3 g) varieties. Similar observations were reported from various locations in India (Anonymous, 1987).

The trend of good grade grain among different 'N' levels was inconsistent, while the weight of grain exhibited an increase at the higher N levels evidently due to higher carbohydrate deposition in the grains. This is in agreement with the results reported from Maruteru (Anonymous, 1987-88 and 1988-89).

5.3.1.6 High density grain (HDG): Late varieties exhibited potentially high grain filling in terms of realisation of higher percentage of high density grain (79.3%) followed by medium duration varieties (69%) and early varieties (65.1%) (Fig.9). Similar results were reported by Semantasingher and Sahu (1987). This clearly indicates that grain filling is associated with the duration of the crop at which the photosynthetic efficiency and translocation of photosynthates are more efficient. Since the vegetative period is slightly more in the late varieties than the early varieties, the contribution of accumulated carbohydrates influences greatly the production of HD grain. However among the duration group also variation was observed in the high density grain. This variation among the varieties in the same duration group can be ascribed to the inherent genetic potential of the variety and the influence of weather at the reproductive phase of the varieties (Murty and Murty, 1981). Maximum potential of grain filling in terms of 1000-grain weight was maximum

in HD grains and it was uniform in all the varieties as has also been reported earlier by various rice workers (Anonymous, 1984, 1987 and 1988). In general, medium duration varieties (Prabhat and MTU 2400) exhibited highest 1000-grain weight (29.3 g) followed by early (25.5 g) and the lowest was observed in the late varieties (24.3 g).

The percentage of HD grains has progressively increased from '0' N to 80 kg N/ha and declined thereafter at 120 kg N/ha. Reports in favour of increased number of HD grains with increased 'N' levels and contrary also are available in the literature (Venkateswerlu, 1989 and Anonymous, 1988-89). Highest 1000-grain weight of all the varieties was observed at 80 and 120 kg N. At the lower 'N' level, a reduction in 1000 HD weight was evident, contrary to the results reported from Maruteru (Anonymous, 1988-89).

The varietal variation in the grades of grain can be explained on the basis of the prevalence of climatic factors at the reproductive and ripening phases of the varieties. Unlike the normal kharif situation that exists at Bapatla wherein October and November are the months with many cloudy days and intermittent rainfall, the season of present experimentation i.e., kharif 1988 varied widely, in the sense that October and November months were dry with bright weather coupled with abundant sunshine and low night temperatures which were very much conducive for higher grain filling.

In the present trial, the early varieties were exposed to cloudy weather and higher rainfall of 194.7 mm at reproductive phase and 74.2 mm rainfall at ripening phase and relatively higher temperatures 19.7 to 27.3°C than the medium duration varieties (146.9 mm rainfall at reproductive phase and 2.7 mm rainfall at ripening phase and temperatures 16 to 27.8°C) and late duration varieties (2.7 mm rainfall at reproductive phase with temperatures 16 to 24.1°C). A perusal of one data (Table 1) also indicated that the reproductive and ripening phases of the late varieties were favoured with bright weather, absence of rainfall and low temperatures (16 to 21.3°C) at ripening phase, while a reverse trend was observed in the early varieties. High rainfall at flowering disturbs pollination and fertilization (Stansel, 1967) while high night temperatures enhance respiration losses (Yoshida, 1972) and low solar radiation impairs grain filling while high solar radiation is conducive for normal grain filling (Sato, 1955). Thus, it is evident that the grain filling is dependent on the climatic conditions during reproductive and ripening phases as has also been suggested by Sikder and Das Gupta (1975). Contrary to the normal belief that high 'N' levels result in high spikelet sterility as has been reported by Togari and Kashiwakura (1958); Krishnaswamy and Chandrasekhar (1960); Relvani (1962); Kalyanikutty *et al.* (1969) etc., the present investigation revealed that the chaff and partially filled grain were lower

at the high N (80 kg/ha), compared to '0' N level. The increase in the HD grain with increase in N level was marginal 5-9% (Table 21) indicating that HDG did not respond markedly for the increased levels of nitrogen. Contradicting reports are available in this regard. Some cultivars exhibited negligible variability at higher levels of N, while some varieties exhibited an appreciable increase in HD grain with increased N application (Venkateswarlu, 1989; Anonymous, 1987-88, 1988-89). However in the present study, the response of HD grain to higher levels of 'N' was high in the late varieties (15% at 80 N; and 12% at 120 N). Whereas in the medium and early varieties, the response was very low (5 to 8%). This is an indication that late varieties respond well during kharif for increased levels of nitrogen (80 and 120 kg N) both in terms of HD grain and grain yield. As such late varieties (MTU 2067 and MTU 2077) should be preferred for kharif conditions as has also been suggested by Venkateswarlu (1989), to realise higher grain filling potential and productivity.

The high responsiveness of the late varieties to higher levels of N (80 and 120 kg) in terms of HD grain in the present study can be attributed to the prevalence of bright weather, high light intensity (Tanaka and Vergara, 1967) and lower temperatures during heading which are conducive for realisation of HD grain (IRRI, 1987).

From the above discussion it can be surmised that the grain weight has gradually increased in all the varieties in order of the grains chaff, PF, poor, average, good and HD grain (Anonymous, 1984, 1986-87) (Fig. 10) indicating that maximum grain filling potential was realised in the HD grains followed by good grade grains.

Though it is normally thought that 1000-grain weight of a cultivar is a stable character with less variability (Matsushima, 1970), the present study has a contrary, indication that 1000-grain weight also exhibits variation among different grades of grain and N levels as has also been reported by earlier workers (Anonymous, 1984, 1987 and 1988).

5.4 NITROGEN PERCENTAGE AT FLOWERING AND HARVEST

In general late duration varieties exhibited high N % in all the plant parts at flowering and harvest. Among the late varieties, MTU 2077 had a uniformly high N % in the plant parts.

A progressive increase of N % was observed in all the plant parts with an increase N level from 0 to 120 kg N; evidently due to higher uptake of nitrogen at higher levels of N.

5.5 CORRELATION COEFFICIENTS

The duration of crop growth had a discernable influence on the proportion of HDG.

The duration of vegetative phase, flowering and the total duration were positively associated (r value 0.54**, 0.55**, 0.54** respectively) with the number of HDG (Table 19), indicating that HD grains will increase with increase in the duration of any of these phases. The high positive association of the number of HD grains with duration has also been reported by Sementasinha and Sahu (1986 and 1987).

The percentage of HDG exhibited a significant positive association with grain yield ($r = 0.307^{**}$) indicating that yield of a particular variety is mostly contributed by number of HD grains per unit area (Rao, 1987 and Sementasinha and Sahu, 1987).

The above results indicate that high density grain serves as a good screening index, as it is an integral part of assimilation, translocation and conversion of photosynthetic products (Anonymous, 1987).

Increase in cheffy grain will lead to a reduction in grain yield as revealed by the significant negative relationship (-0.4234) between these parameters. Such negative relationship has also been reported by Murty and Murty (1982).

The percentage of HDG showed significant positive association with percentage of filled grains ($r = 0.3540^{**}$) spikelet number/m² ($+0.4877^{**}$) and panicle per square metre ($r = 0.5077^{**}$) indicating that majority of spikelets and filled grains were high density grains as also has been reported by Semanthasinha and Sahu (1987). A significant and positive relation of HDG was also observed with plant height (0.4483^{**}), biomass production (0.3758^{**}), leaf area index at flowering (0.4364^{**}), the panicles/m² (0.5077^{**}). This gave an indication that high source capacity at flowering in terms of LAI and BMP lead to higher number of panicles per square metre as well as high density grains ultimately leading to high grain yield. Similar results were reported by Rao (1987) and Semanthasinha and Sahu (1987).

The interrelationship among different traits indicated that the filled grains percentage was positively related to the nitrogen % in leaves and stem at flowering which indirectly indicate that higher N % in the plant parts at flowering leads to higher filled grains and ultimately high density grains. The tillers/m² have exhibited a significant and positive association with panicles/m² ($r = 0.7868^{**}$) and filled grains/panicle ($r = 0.5155$). Thus to obtain high filled grain per unit area, the tiller number also should be high. The high, positive and significant relation between spikelet number and filled grain number indicates that to obtain higher number of filled grains, the spikelet

number also should be high. The high positive association of spikelet number and filled grains with HDG indicates that increase in HDG can be achieved by increasing the number of spikelets and filled grains per panicle, as has also been opined by Esmantthesinhar and Sahu (1987). Generally the % of filled grains have a tendency to decrease with increasing number of spikelets (Matsushima, 1980). However in the present study no such negative trend was noticed as has also been reported by Yoshida and Parao, (1976), suggesting the possibility of combining high spikelet number with high percentage of HD grains.

5.6 PATH COEFFICIENT ANALYSIS

High direct effect of number of panicles/m² on HD grain supported by the indirect effect via BMP, LAI, tillers and leaf N % at flowering and grain N % at harvest has resulted in a positive total effect (0.5072**). Selection of HDG can be exercised on the number of panicles/m² for realisation of HDG. Rangaswamy and Munegechan, (1973); Ishkumu and Saini (1973) and Gopinath (1981) also reported that in rice, number of ear bearing tillers had a direct effect on yield parameters.

Followed by characters panicles/m², LAI and BMP at flowering exercised direct and positive influence on the HDG, through their own strength and supported by the indirect

influence through other parameters finally resulting in a total significant and positive effects (0.4364** and 0.3358**). Thus these two parameters can also be taken as effective tools in screening varieties for HD grains. It is evident from the above observations that selection based on panicles/m², LAI and BMP at flowering would be rewarding for realisation of HDG in rice. These three characters were interrelated strongly among themselves indicating that selection of one character among these three may mean selection of other two characters also.

SUMMARY AND CONCLUSIONS

CHAPTER VI

SUMMARY AND CONCLUSIONS

An investigation on the influence of graded N levels on the growth parameters with specific emphasis on the grain filling potential of rice varieties of different durations was conducted at Agricultural College Farm, Bapatla during kharif 1988. The experiment was laidout in a split plot design with 6 varieties (Rasi, BPT 1235, Prabhat, MTU 2400, MTU 2067 and MTU 2077) as main treatments and 4 levels of nitrogen (0, 40, 80 and 120 kg N/ha) as sub treatments replicated thrice. Observations on growth parameters, yield and yield components and potential grain filling were recorded treatmentwise as per standard procedures. The grain filling potential was evaluated by the specific gravity method.

Growth parameters such as plant height, tillering and biomass production were high in late duration varieties (MTU 2067 and MTU 2077) followed by medium (Prabhat and MTU 2400) and early duration varieties (Rasi and BPT 1235), whereas LAI and SLW were high in late and early varieties followed by medium duration varieties. Late duration varieties were superior in the productive efficiency (grain and straw yields) and total productivity which can be attributed to the high sink capacity in terms of higher panicle number, heavier panicles, high spikelet number and harvest index.

Varietal variation was evident in the grain filling potential with the late duration varieties recording higher grain filling and higher HD grain than the medium and early groups. Among the varieties, MTU 2077 exhibited highest (81%) and BPT 1235 the lowest (56.9%) percentages of HD grain. The thousand grain weight of different grades of grain has gradually increased in all the varieties in progressive order of the grades of grain viz., chaff, partially filled (PF), poor, average, good and highly density grain indicating that maximum grain filling potential in terms of carbohydrate deposition in the kernel was realised in the HD grains followed by good grade grains.

In general the late duration varieties exhibited higher percentage of nitrogen in all the plant parts at flowering and harvest than the medium and early varieties.

Nitrogen levels have favourably influenced the plant height, tillering, biomass production, LAI and SLW in all the varieties, leading to a higher source capacity with an increase in N level from 0 to 120 kg/ha. An increase in the N level from 0 to 120 kg/ha has also resulted in a progressive increase in all the yield contributing characters and total productivity. The flowering and total duration were extended by 5 to 8 days at the higher N levels (80 and 120 kg/ha) in all the varieties compared to the lower N levels (0, 40 kg/ha). In spite of the delay in the total crop duration, the per day

productivity was high at higher N levels, because of realization of higher grain yield at higher N levels.

Nitrogen levels differed significantly in the grain filling potential in terms of percentages of chaff, PF, poor and good grade grain. But the trend among different N levels in these grain grades was inconsistent. The percentages of HD grain has progressively increased from 0 to 83 kg N/ha and declined thereafter at 120 kg N/ha. Contrary to the normal observations that grain filling will be poor at higher N levels, in the present investigation it was found that even at higher N levels, grain filling was high and spikelet sterility in terms of chaff and PF grains was low. This can be attributed to the prevalence of favourable climatic factors viz., optimum temperatures, bright sunshine and absence of rainfall at the productive and ripening phases of the varieties.

Correlation studies have revealed significant positive association of HIG with total crop duration (0.55**), grain yield (0.307**), filled grains (0.354**), spikelets/m² (0.4877**), panicles/m² (0.5077**), plant height (0.4483**), biomass production (0.3358**) and LAI at flowering (0.4364**). The positive association of grain yield with HIG and crop duration indicates that HIG which is the major component of grain yield increases with an increase in the duration of the crop. Path coefficient analysis indicated that

panicle number exerted a major direct and positive influence on the HD grain through its own strength and supported by the indirect influence through LAI and biomass at flowering. This parameter viz., panicle number/m² can be an effective selection index for realisation of higher HDG.

In the present study the response of HD grain and grain yield to the higher levels of N (80 and 120 kg/ha) was higher in the late varieties (HDG 15% higher at 80 N and 12% higher at 120 N) compared to medium and early varieties (HDG 5 to 8%) indicating that late varieties such as MTU 2067 (Chaitanya) and MTU 2077 (Krishnaveni) should be preferred for kharif conditions. A higher N level of 120 kg/ha can also be adopted to realise higher grain filling potential under favourable climatic conditions of kharif, such as those that existed during this season (kharif, 1988).

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