TO STUDY THE YIELD POTENTIAL OF SIX PROMISING PADDY VARIETIES UNDER DIFFERENT NITROGEN LEVELS

DISSERTATION SUBMITTED TO THE
PUNJABRAO KRISHI VIDYAPEETH, IN PARTIAL
FULFILMENT FOR THE DEGREE OF
MASTER OF SCIENCE (AGRICULTURE)
IN AGRONOMY

BY

GANESH SHANKAR PATWARDHAN
B. Sc (Agri)

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE, NAGPUR
PUNJABRAO KRISHI VIDYAPEETH

1975

UNIVERSITY DEPARTMENT OF AGRONOMY
POST GRADUATE INSTITUTE,
PUNJABRAO KRISHI VIDYAPEETH,
AKOLA.

Enrolment No. AGNG/1/846/70

CANDIDATE'S DECLARATION

I, hereby declare that the dissertation or any part thereof has not been previously submitted by me for a degree of any University.

NAGPUR :

Dt/- 1st oct '75

G. S. Patwardhan

(G.S.Patwardhan)

Enrolment No. AGNG/1/846/70

*****

C E R T I F I C A T E

TO STUDY THE YIELD POTENTIAL OF SIX PROMISING PADDY VARIETIES UNDER DIFFERENT NITROGEN LEVELS

DISSERTATION SUBMITTED TO THE
PUNJABRAO KRISHI VIDYAPEETH, AKOLA,
IN PARTIAL FULFILMENT FOR THE
AWARD OF THE DEGREE OF
MASTER OF SCIENCE (AGRICULTURE)
IN AGRONOMY
1975

BY

GANESH SHANKAR PATWARDHAN
B.Sc.(Agri.)

Approved by the Advisory Committee :

1. Major Advisor : Shri K.G.Hatwar _____
M.Sc.(Agri.)
Reader in Agronomy,
College of Agriculture,
Nagpur.

2. Members : 1. Shri Y.S.Pokle _____
M.Sc.(Agri.)
Reader in Agril.Botany,
College of Agriculture,Nagpur.

2. Shri G.C.Malavi _____
M.Sc.(Agri.)
Asstt.Professor of Agronomy,
College of Agriculture, Nagpur.

*****

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

I take this opportunity of expressing my deepest sense of gratitude to Shri K.G.Hatwar, Reader in Agronomy, College of Agriculture,Nagpur, for his constant inspiration, constructive criticism and valuable guidance right from the selection of my research problem upto the final shaping of this dissertation.

I gratefully acknowledge my indebtedness to Shri J.R. Kakde, Ex.Associate Dean and Dr. V.N.Shukla, Associate Dean, College of Agriculture,Nagpur, for providing necessary facilities during the conduct of the present investigation.

I respectfully acknowledge my gratitude to Shri P.S. Mahalle, Professor of Agronomy, College of Agriculture,Nagpur, for his helpful suggestions.

I am availing this opportunity to record my sincere thanks to S/shri Y.S.Pokle, Reader in Agril.Botany, C.S.Chaudhari, G.N.Bobde and G.C.Malavi, Assistant Professors of Agronomy, College of Agriculture,Nagpur, for their valuable suggestions given to me from time to time.

I am also grateful to all teaching, research and farm staff of Agronomy Section, College of Agriculture,Nagpur, for their co-operation during the conduct of the present investigation.

Lastly, I express a sense of gratitude to my friends for their co-operation during the course of this study.

College of Agriculture,
Nagpur.

G. S. Patwardhan

(G.S.Patwardhan)

Dated : 1st October'75.

***

C O N T E N T S

***

LIST OF TABLES

Page

*****

LIST OF ILLUSTRATIONS

*****

I. INTRODUCTION

Rice is the staple food of more than half the population in the Indian Union and forms the most important food crop. India has the largest area (excepting probably the Peoples Republic of China) under this crop and it is the second biggest producer of rice in the world. Rice occupies nearly 35 million hectares in India but the average yield is only 1.1 tonnes per hectare in contrast to about 4 tonnes per hectare in Japan, Thailand, Italy, China, Phillipines, Spain and Formosa. Though the area under this crop is large, the total production falls short of its requirements, because the average yield of rice is disappointedly poor and there is a heavy population pressure. This suggests need for enhancing the per hectare per unit time outturn.

Maharashtra State during the year 1973-74 had about 13.59 lakh hectares under paddy with total production of 16.40 lakh tonnes. Bhandara and Chandrapur districts, which are major rice producing areas of Vidarbha, contribute about 91.6 per cent to the production of rice in this region and cover nearly 5.00 lakh hectares under paddy with an annual production of approximately 4.7 lakh tonnes. The per hectare yield in Vidarbha is low as to that of Maharashtra which is the same story of our national yield of paddy per hectare. As such, in order to increase the yield of this crop it is essential to find out or select varieties which will be

suitable for lowland conditions, where adequate manuring, irrigation and timely cultural operations could be given. Amongst these, varieties and fertilizers are of paramount importance in improving the yield.

The lodging nature and low fertilizer response of traditional tall indicas have been overcome to some extent with the introduction and selection of dwarf varieties though they still need improvement in quality and other desirable characters to make them marketable and profitable to the cultivators. The work on this direction has been taken-up by breeders since last few years at AICRIP, Hyderabad and CRRI, Cuttack. As a result varieties possessing the type of morphological structure and developmental pattern favourable for the efficient utilization of sunlight, water and fertilizer and consequently with a high yield potential have been evolved. The pay off started with release of a coarse grain high yielding dwarf variety Jaya in 1968. Subsequently the fine grain varieties like Sona and Jayanthi were released, which have shown good results in mini-kit trials conducted in various states under AICRIP. Simultaneously the new medium grain hybrids Satya, Soorya and Suhasini have also shown promising results in the demonstrations plots and mini-kit trials conducted in the Konkan region of Maharashtra under the supervision and guidance of Mahatma Phule Krishi Vidyapeeth, Rahuri. The promising results of all these varieties in the various parts of the country have given a new hope to increase the yield. The full

genetic potential of these varieties can only be exploited under adequate fertility conditions.

Nitrogen has been called the "King-pin" in paddy fertilization (Lindt 1953), due to almost universal response to its application under most of geophysical conditions. Many investigators reported that the nitrogen deficiency is extremely wide spread in paddy soils of India. There is no place where the application of nitrogen has failed to give response (Ramiah 1951, Ray Chaudhari 1952 and Sethi et al. 1952).

With application of higher doses of nitrogen, there are correspondingly higher needs of phosphate for balanced fertilization. If phosphate is limited plants do not grow normally and yields are depressed as reported by Sircar and Sen (1941) and Aiyer (1946). Phosphate fertilization is essential not only for increasing the yield, but is also beneficial for growth, tillering, root development of paddy and counteracting the adverse effects of excess application of nitrogenous fertilizers. Response of nitrogen varies depending on factors like climate, soil fertility, method of cultivation, the amount of nutrients supplied and the variety grown (Ishizuka 1965). The nitrogenous fertilizer requirement of high yielding varieties of paddy are very high. The optimum requirements of fertilizers of these high yielding varieties of paddy are not yet clearly known. A clear idea of the nitrogenous fertilizer requirements for these varieties will greatly reduce the possible wastage

of applied fertilizers, especially in the context of economising the fertilizer use, on one hand and also bring about the full expression of the genetic potential of these varieties which is very urgently needed today. However, data on fertilizer responses and economics of fertilizer use for these high yielding paddy varieties are rather limited under Nagpur conditions.

With this background in view, an investigation was carried out " To study the yield potential of six promising paddy varieties viz. Jaya, Sona, Jayanthi, Satya, Soorya and Suhasini under different nitrogen levels " during Kharif 1974 at Agricultural College Farm, Nagpur.

II. REVIEW OF LITERATURE

In the present investigation, attempts were made to study the yield potential of six promising rice varieties under different nitrogen levels. Therefore, the relevant research work carried out at different places on these aspects is reviewed in this Chapter.

1. Influence of nitrogen on growth, yield contributing characters and yield of paddy :

a. Effects of nitrogen on growth :

Tanaka et al. (1958) observed that the height of paddy was increased by nitrogen application.

Tanaka et al. (1959) found that maximum tiller number in all paddy varieties reached at about 30 to 35 days after transplanting and tillering was positively correlated with nitrogen content in plants.

Tanaka (1964) working at the Inter-National Rice Research Institute, Phillipines reported that shoot height, maximum number of tillers, percentage of effective tillers, LAI and panicle to straw ratio generally decreased with higher doses of nitrogen.

Tanaka and Kawano (1966) reported that LAI of paddy increased with the application of nitrogen due to increase in the number of tillers and leaf size.

Joshi (1967) found that nitrogen application enhanced the plant height, number of tillers per plant,

number of functional leaves, leaf area, LAI and dry matter production but delayed the flowering in T (N)-1 at Nagpur. Similar results were reported by Urkande (1968).

Kalyanikutty et al. (1969) found that increase in the level of nitrogen has increased the plant height. Similar results were reported by Singh (1971), Michael Raj et al. (1974) and Natrajan et al. (1974).

Sinha (1970) recorded increase in total dry matter production of paddy per kilogram of added nitrogen being 73.8, 42.2, 34.4, 32.6 and 13.8 kg for 40, 80, 120, 160 and 200 kg N per hectare treatments respectively.

Ramanujam and Sakharam Rao (1971) reported a positive relationship of shoot height with nitrogen levels, whereas the root length showed a negative trend. Number of tillers per hill, shoot weight, root weight and shoot / root ratio were evidently influenced by nitrogen levels.

Raut (1973) reported that application of fertilizers at the rate of 100 kg N and 50 kg P_2O_5 per hectare had significantly increased the mean plant height, number of tillers, functional leaves, leaf area and total dry matter accumulation per hill over the fertilizer combination of 50 kg N and 25 kg P_2O_5 per hectare. Similar results were reported by Mahant (1974).

b. Effects of nitrogen on yield contributing characters :

Panchabhai (1958) found that the length of earhead, number of spikelets per panicle, grains per panicle and

density of earhead increased with increase in the dose of nitrogen.

Yamada (1959) observed more number of panicles only at higher levels of nitrogen. He further recorded increase in percentage of sterility in paddy with increased dose of nitrogen.

Tanaka (1965) reported that the percentage of filled grains generally, decreased with the increase in nitrogen supply in either groups of varieties.

Koregave (1967) found that with increased nitrogen application i.e. 125 kg N per hectare, there was increase in number of panicles and grains per hill and to a little extent in test weight but beyond this there was a decrease in these characters.

Joshi (1967) reported that the number of panicles per hill and rachis per panicle, length of panicle and test weight were enhanced by nitrogen application in T(N)-1 at Nagpur.

Ray Chaudhari (1968) noted a striking increase in the panicle number per hill of T(N)-1 and Taichung 65 as a result of nitrogen fertilization.

Urkande (1968) found that the length of panicle, number of panicles per plant, number of grains per plant, weight of grain per panicle and yield of grain per plant were enhanced by nitrogen application.

Kalyanikutty et al. (1969) found that addition of nitrogen increased the number of tillers and weight of

thousand grains. The panicle length and number of grains per panicle got increased by higher levels of nitrogen in all the varieties tested.

Ranganathan et al. (1970) reported more panicle length, number of grains per panicle and test weight with 100 kg N over 50 kg N per hectare.

Ramteke (1971) working at the College of Agriculture, Nagpur observed that 100 kg N per hectare significantly increased the number of fertile spikelets per panicle, length of panicle, weight of panicle, number of panicles per hill and test weight than 50 kg N per hectare.

Majumdar and DilipKumar (1971) reported that nitrogen fertilization significantly increased the yield attributes and maximum increase in yield components was obtained with 74 kg N per hectare. Test weight of grain recorded significant decrease with increasing doses of nitrogen.

Singh (1971) reported that effective tillers, panicle length, number of fertile and sterile spikelets and grain yield per panicle increased with the increase in nitrogen level from 0 to 160 kg N per hectare in the varieties T(N)-1 and Tainan-3.

Panchaksharaiah et al. (1972) reported that Jaya produced maximum number of panicles per square metre under all the nitrogen levels viz. 0, 40, 80, 120 and 160 kg N per hectare, which was followed by Padma and S-705. Maximum panicle length was noticed in the local variety S-705,

which was followed by Jaya and Padma. The number of spikelets per panicle were maximum in Jaya followed in the order by Padma and S-705.

Raut (1973) noted a prominent effect of fertilizer application on yield contributing characters. Fertilizer application at the rate of 100 kg N + 50 kg P_2O_5 per hectare was significantly superior to 50 kg N + 25 kg P_2O_5 per hectare in increasing the number of panicles per hill, weight of panicles per hill, rachis number per panicle, weight of fertile spikelets per panicle, hulling percentage and the test weight.

Michael Raj et al. (1974) reported increase in number of fertile grains per panicle and length of panicle with increase in the level of nitrogen. Highest levels of nitrogen tried i.e. 250 kg N per hectare has recorded maximum mean length of panicle.

Natrajan et al. (1974) observed significant increase in the length of panicle with increase in the level of nitrogen, however the number of productive tillers, number of grains per panicle and test weight were not influenced significantly.

c. Effects of nitrogen fertilization on yield :

Sharma and De (1969) observed that the response to nitrogen was quadratic and the optimum dose was between 120 to 150 kg N per hectare for variety Padma under Delhi conditions.

Lenka and Behera (1967) reported that the grain yield of introduced short strawed rice varieties increased linearly with increase in the rate of nitrogen upto 120 kg N per hectare, but long strawed local cv. showed significant responses upto 80 kg N per hectare only.

Rao (1969) while studying the response of high yielding varieties at C.R.R.I., Cuttack noted that medium duration varieties Jaya and IR-8 produced significant differences in yield upto 150 kg N per hectare but the economic level was found to be 100 kg N per hectare only.

Sinha (1970) found a progressive increase in the grain and straw yield of paddy with additional application of nitrogen. The optimum dose of nitrogen for IR-8 was found to be 120 to 160 kg per hectare.

Raut (1970) reported 100 kg N per hectare as an optimum dose for variety Jaya.

Ramanujam and Sakharam Rao (1971) observed a quadratic response with regard to grain yield and concluded that nitrogen, beyond 90 kg per hectare did not contribute for the yield.

Kulandavivelu and Kallapan (1971) conducted trials with rice cv. ADT-27 where 0 to 180 kg N per hectare was applied in equal split dressings at planting and 30 days latter and found that the yield of paddy increased upto 120 kg N per hectare, but the optimum rate was 78.5 kg N per hectare.

Verma and Srivastava (1972) reported that IR-8 paddy gave the maximum yield of 40.46 quintals per hectare with maximum net profit of Rs.2,344.57 per hectare by using 140 kg N per hectare as against 80 and 100 kg N per hectare.

Singh and Malik (1972) observed that the dwarf rice cv. IR-8, Padma and T(N)-1 showed greater yield responses to nitrogen applied at the rates of less than 100 kg per hectare. Maximum paddy yields of Padma and T(N)-1 were given by application of 179.3 and 137.0 kg N per hectare, respectively. The most profitable level of N application for T(N)-1 and Padma were 116.85 and 139.01 kg per hectare respectively.

Pillai et al.(1972) reported that yield response to nitrogen was quadratic, the optimum rate being 94.4 kg N per hectare and the economic rate was 76.6 kg N per hectare in dwarf indica paddy cv. Annapurna.

Panchaksharaiah, et al. (1972) reported that Jaya and Padma responded upto 160 kg N/ha and the economic dose was found to be only 120 kg N per hectare.

Rethinam (1974) reported that quadratic form of response curve was found to be the best fit in Padma and it was found that additional yield due to fertilizer application was maximum at the level of 160 kg N per hectare and the additional income at this level was Rs.1,694.50 per hectare.

Natrajan, et al. (1974) reported 180 kg N per hectare as an economical dose for the variety Jaya.

Kalyanikutty and Morachan (1974) reported that the varieties differ in their response to nitrogen fertilization. The optimum doses of nitrogen were 39 kg per hectare for TKM.6, 106 kg per hectare for ADT-27 and 157 kg per hectare for CO-33.

Rajgopalan et al. (1974) found that the response to nitrogen was quadratic and the optimum economic level of nitrogen for varieties IR-20, CO-36, Bhavani, Jayanthi and Sona was 102.5, 92.6, 87.7, 110.3 and 82.9 kg per hectare respectively when the price of nitrogen was considered as Rs. 3=00 per kg and paddy as Re.1=00 per kg.

2. Performance of different paddy varieties under varying fertility conditions :

Bathkal and Patil (1968) studied the grain yield response of four rice cv. to the application of 0 to 150 kg N per hectare in the Kharif season and found that the rice cv. T(N)-1 showed a progressive yield response to the application of nitrogen upto 100 kg per hectare whereas rice cv. Dodga, E.K.70 and Basmathi showed a response upto 50 kg per hectare.

Bhapkar and Jadhao (1969) and Shastry (1969) reported the superiority of Jaya by recording 10 per cent higher grain yield than that of IR.8 in all the trials conducted under All India Co-Ordinated Rice Improvement Project in most of the rice growing states of India. Padma had produced 10 to 20 per cent less yield than IR.8. These findings have been confirmed by Kanwar and Mahapatra (1971).

Shastry (1969) from the yield data of 8 locations for Kharif 1968 at 50 and 100 kg N per hectare levels indicated that the lowering order of superiority for nitrogen responsiveness in four paddy varieties was Jaya, IR-8, T(N)-1

and Padma. The percentage increase in yields from 50 to 100 kg N per hectare for T(N)-1 , IR-8 and Jaya was 14, 14 and 18 respectively.

Mahapatra and Panda (1969) observed that 100 kg N per hectare was by far the optimum dose in case of all the three varieties tested (Jaya, Padma and B.G.6) and higher levels of nitrogen at 150 and 200 kg per hectare did not significantly increase the yield over 100 kg N per hectare.

Yogeswara Rao and Padmanabham (1971) obtained significant differences regarding grain yield among different varieties viz. IR-8, Padma, Cauvery, Jaya and MTU-20. IR-8 recorded highest mean grain yield of 3,764 kg per hectare. Significant differences were also recorded among nitrogen levels. A dose of 150 kg N per hectare has recorded significantly higher grain yield over other levels.

Mahapatra and Bapat (1971) found that the yield response of high yielding rice variety 'Jaya' to 1 kg nitrogen applied at the rate of 120 kg per hectare was 14 kg paddy, compared with 7 kg in local variety. The response to 1 kg P_2O_5 at 60 kg per hectare level of application, in addition to 120 kg N per hectare was 20 to 25 kg paddy in varieties Jaya and Padma, and 16 to 18 kg in the variety IR-8.

Munegowda (1971) obtained 59.0 quintal per hectare yield in Kharif and 81.0 quintal per hectare in summer in case of variety Jaya. On an average, the grain and straw

yield was more by 2 and 3 quintals respectively in Jaya than IR-8. Among the finer strains, Padma and Hamsa were found to be at par.

Saini (1971) reported from trials conducted at Ludhiana, Gurdaspur and Kapurthala in the Punjab State that rice cv. Jaya gave average paddy yield of 87.0 quintals per hectare compared with 82.5 quintals per hectare in cv. IR-8. In 126 trials on formers fields Jaya outyielded. IR-8 by an average of 333 kg per hectare.

Singh and Varma (1971) observed in T(N)-1 that increasing the rates of nitrogen from 40 to 160 kg per hectare increased the average paddy yields from 2.93 to 4.96 tonnes per hectare.

Veeraraja Urs and Mahadevappa (1972) stated that IR-8 and Jaya responded upto 120 kg N per hectare whereas IR-5 responded only upto 80 kg N per hectare, when a basal application of 5000 kg green manure per hectare was done.

Sumbali and Gupta (1972) found that the varieties Jaya and IR-8 exhibited almost similar performance under all the five levels of nitrogen tried. The highest grain yield was obtained with 155 kg N per hectare application.

Dayanand et al. (1972) concluded that all the varieties responded to 150 kg N per hectare while few of them like T(N)-1, Tainan-3, Jaya and B.G.6 showed significant increase in grain yield even upto 200 kg N per hectare.

Rangiah (1973) suggested 180 kg N per hectare as the optimum dose for high yielding varieties. The yield

potential of different varieties was found to be proportionate to the duration of the crop. Varieties IR-5 and IR-8 were on par and were found to be better than Jaya which was superior to Padma and Hamsa. Varieties IR-8 from long duration group and Padma from short duration group recorded highest profit per hectare.

3. Manuring x varieties interaction :

Raut (1970) reported significant nitrogen x variety interaction at Agricultural College Farm, Nagpur.

Ramteke (1971) out of the several interactions studied, found that nitrogen x varieties interaction was found to be significant in very few characters namely, dry matter production at 65 days, weight of panicles per hill, rachis number per panicle, weight of sterile spikelets per hill and grain yield. In general these characters were found to increase with increase in nitrogen doses in all the varieties tested.

Yogeswara Rao and Padmanabham (1971) found the interaction between variety and nitrogen levels to be highly significant. In case of IR-8, 100 kg N level was found to be significant over 0 and 50 kg N levels, but on par with 150 kg N level. The highest grain yield was recorded by IR-8 at 200 kg N per hectare.

Singlachar (1973) reported that the grain yield differences due to nitrogen, variety and nitrogen x variety interaction were significant. Jaya outyielded all other varieties and showed higher response upto 150 kg N per hectare.

Raut (1973) stated that nitrogen x varieties interaction was found to be significant in dry matter production per hill and weight of fertile spikelets per hill. Maximum dry matter was produced by Jaya with 100 kg N + 50 kg P_2O_5 per hectare. Weight of fertile spikelets was recorded more in Jaya with 100 kg N + 50 kg P_2O_5 per hectare.

4. Effects of nitrogen fertilization on grain : straw ratio :

Panchabhai (1958) reported that the increasing doses of nitrogen recorded increase in grain and straw yield and widened the straw : grain ratio.

Tanaka et al. (1958) reported that the grain to straw ratio generally decreased with the increase in applied nitrogen particularly at higher levels. This decrease was more prominent in low nitrogen responsive varieties.

Koregave (1967) reported that grain to straw ratio progressively dropped with increased nitrogen levels.

Joshi (1967) reported that the grain to straw ratio in T(N)-1 was highest i.e. 1.31 in the control. With the nitrogen fertilization this ratio was dwindled down and was 1.12 in 150 and 300 kg N per hectare.

Lakhdive (1968) found that the grain to straw ratio was lowered with an increase in nitrogen levels in both the varieties T(N)-1 and N.P.130. The average grain to straw ratio for N.P.130 was 0.75 and that for T(N)-1 was 1.06.

Mahant (1974) found that higher fertilizer combinations recorded slightly less grain to straw ratio as compared to a lower fertilizer combination.

5. Quality studies in paddy :

a. Effects of nitrogen on quality :

Swaminathan (1964) reported the increase in protein content of rice with increasing levels of nitrogen.

Raut (1970) observed that the protein content of grain was enhanced by nitrogen application.

Baba (1971) found the grain protein content of 40 rice cv. given 90 kg N per hectare ranged from 6.56 to 12.86 per cent.

Muthuswamy et al. (1973) in an experiment to study the effect of forms and levels of fertilizer nitrogen on the quality of certain high yielding varieties, found that forms and levels of nitrogen had no effect on the crude protein of grain.

Sadayappan and Kolandaiswamy (1974) reported that protein content increased with increasing levels of nitrogen. The maximum content of 12.09 percent protein in the grain was recorded by 200 kg N per hectare. Similar results were recorded by Krishnaswamy et al. (1974).

Subramanian et al. (1974) in an experiment to study the effect of graded doses of nitrogen and the method of planting on the protein content of rice (IR-8) grain revealed that the nitrogen levels had no significant effect on the protein content of grain.

b. Varietal differences in respect of protein and hulling percentages :

Joshi and Bhapkar (1969) reported that IR-8 had more protein and milling percentage than T(N)-1.

Shastry (1970) at Hyderabad reported that the varieties Jaya, IR-8, Padma and T(N)-1 had 8.21, 7.67, 7.89 and 8.35 per cent protein and their hulling percentages were 70.5, 70.4, 76.1 and 76.2 respectively.

Ramteke (1971) reported that protein contents in Jaya, IR-8 and Padma were 9.03, 9.03 and 9.01 per cent respectively.

6. Correlation studies :

Sadanathan (1958) found that the yield of paddy was positively correlated with plant height, effective tillers , and length and density of panicle.

Sastry et al. (1967) found that grain yield of IR-8 was positively correlated with number of ear bearing tillers, plant height and number of sterile grains per plant.

Bains et al. (1969) reported positive and significant correlation of yield with the number of grains per hill and 1000 grain weight.

Sarathe et al. (1969) found that the yield was positively correlated with panicle length, the number of tillers per plant, and the 1000 grain weight in high yielding varieties T(N)-1, IR-8, Tainan, Norin-1 and Nushai. Further he found that the association of these component characters with

yield was significant at low fertility level (50 : 25 : 25) and non-significant at high fertility level (100 : 50 : 50). The high doses of fertilizers reduced the association among the yield and its component characters.

Raut (1970) observed that the correlation coefficients between grain yield and final plant height, weight of panicles, length of panicle, number of rachis per panicle, length and breadth of grain were positive and significant in all the varieties tested. However, the fertile grain number was significant only in Jaya, Bluebelle and IR-8. The varieties Padma, Jaya and T(N)-1 recorded significant values in case of 1000 grain weight.

Gupta and Padalia (1971) reported in trials with 6 rice cv. that the paddy yield per plant was positively correlated with number of effective tillers, number of grains per plant, number of grains per ear and ear weight.

Akio Osada et al. (1973) obtained a very high correlation of percentage of ripened grains and thousand grain weight with the yield.

Mishra et al. (1973) found out from the results of trials with 49 dwarf rice cv. that the contribution of yield components to grain yield was in the order of number of grains per panicle grain weight number of panicle bearing tillers.

Lenka and Misra (1973) studied the path-coefficient analysis of yield in rice varieties and reported that the number of panicles and grains per panicle were important

determinants of yield in varieties IR-8, T(N)-1, Bala and Ptb.10. Panicle length was a more important yield determinant in Ptb.10. The test weight was of minor importance in all the varieties except T(N)-1.

Palaniswamy (1974) reported that grain yield in rice possessed significantly high positive correlation with panicle length, number of grains and number of productive tillers. Neither the fertility status nor the number of seedlings per hill or differences in spacing between two adjacent plants in transplanted crop seem to affect the above relationship adversely.

III. MATERIALS AND METHODS

The main object of the experiment was " To study the yield potential of six promising paddy varieties under different nitrogen levels ". The details of the materials used and the methods followed during the course of the present investigation are given in this Chapter under the following heads.

1. Details of the experimental materials :

1:1. Experimental site :

The experiment was laid out on the Agricultural College Farm, Nagpur at Telangkhedi Block during Kharif 1974. The topography of experimental field was fairly uniform and levelled.

Soil samples upto 20 cm surface depth were taken at random from each plot before transplanting and were analysed for various physico-chemical properties of the soil. Mechanical analysis was done by International Pippete Method (Piper 1950). Nitrogen was estimated by the modified Kjeldhal's method (A.O.A.C. 1955). Total phosphorus was determined by ammonium molybdate method (Piper 1950). Total K_2O was estimated by using Flame Emmission Spectrophotometer (Jackson 1958) and pH by the Beckman's glass electrode pH meter (Jackson 1958). The data obtained on the mechanical and chemical analysis is presented in Table 1.

Table 1 : Mechanical and chemical composition of the soil (0 to 20 cm) af the experimental plot.

Particulars	Results of the analysis(per cent)
A. Mechanical composition	
1. Coarse sand	16.30
2. Fine sand	26.10
3. Silt	23.90
4. Clay	28.70
B. Chemical composition	
1. Total nitrogen	0.137
2. Total phosphorus	0.163
3. Total potash	0.028
4. Soil reaction (pH)	7.35

From Table 1, it is apparent that the soil was sandy loam in texture, high in total nitrogen with adequate total phosphorus and total potash. It was slightly alkaline in reaction.

1:2. Cropping history of the experimental plot :

The previous cropping history of the experimental field for the last three years is presented in Table 2.

Table 2 : Cropping history of experimental plot.

Year	Crops grown in	
	Kharif season	Rabi season
1971 - 72	Paddy	Wheat
1972 - 73	Paddy	Wheat
1973 - 74	Paddy	Paddy
1974 - 75	(Present investigation on paddy)	

1:3. Climate and weather conditions :

Nagpur (latitude 21°.10'N and longitude 79°.19'E) is situated 321.3 meters above the mean sea level and has a subtropical climate.

The meteorological data for the paddy growing period from June to December 1974 in comparison with last 23 years averages as recorded at Agricultural College Farm, Nagpur are presented in Table 3.

Data from Table 3 revealed that there was no substantial deviation in mean maximum and mean minimum temperatures of this year as compared to last 23 years average of different months, except in the month of September where this year mean maximum temperature was 3.07°C more than the last 23 years average. The rainfall recorded during the period of experimentation was 95.60 cm received in 58 rainy days as compared to last 23 years average of 112.17 cm received in 67.79 rainy days. The rainfall was

Table 3 : Meteorological data for Kharif 1974 in comparison with last 23 years averages.

Month	Mean monthly temperature °C				Mean monthly rainfall (cm)		No. of rainy days		Mean relative humidity
	Max. 23 Yrs.	Max. 1974	Mini. 23 Yrs.	Mini. 1974	Mean of 23 Yrs.	1974	Last 23 Yrs. mean	1974	1974 at 7.30 a.m. (Per cent)
June	35.22	37.6	25.28	26.1	20.55	17.02	11.26	13	50.75
July	32.29	32.4	24.23	24.6	34.78	28.08	17.39	18	87.80
August	29.33	29.8	23.96	23.7	26.71	23.92	19.93	13	85.50
September	31.73	34.8	23.69	23.9	21.90	3.80	13.14	5	80.50
October	32.59	31.5	19.86	20.7	5.02	22.78	4.31	9	80.60
November	30.57	29.8	13.87	13.3	1.47	-	1.04	-	64.75
December	28.64	27.9	10.94	10.7	1.74	-	0.72	-	76.25
Total :-					112.17	95.60	67.79	58	

well distributed upto 19th August 1974 but thereafter there was a long dry spell upto 22nd September 1974. Moreover heavy rains were received during the period of maturity which had a bad effect on crop.

In general the rainfall was not favourable for the normal growth of paddy crop.

1:4. Experimental design and treatments :

The experimenta was laid out in split plot design, with four replications. The main treatments constituted

five levels of nitrogen and varieties were taken as sub plot treatments.

The details of these treatments alongwith the symbols used are given in Table 4.

Table 4 : Details of treatments.

Treatments		Symbol
A. Main plot treatments - (Levels of nitrogen)		
1. 0 kg N / ha.	...	N_0
2. 50 kg N/ ha.	...	N_1
3. 100 kg N/ ha.	...	N_2
4. 150 kg N/ ha.	...	N_3
5. 200 kg N/ ha.	...	N_4
B. Sub plot treatments - (Varieties)		
1. Jaya	...	V_1
2. Sona	...	V_2
3. Jayanthi	...	V_3
4. Satya	...	V_4
5. Soorya	...	V_5
6. Suhasini	...	V_6
C. Details of layout :		
1. Design	...	Split plot design
2. No.of replications	...	4
3. Total no. of treatments	...	30
4. Total no.of plots	...	120
5. Gross plot size	...	4.00 x 3.00 m
6. Net plot size	...	3.20 x 2.40 m
7. Distance between two rows .		20 cm
8. Distance between two hills		15 cm

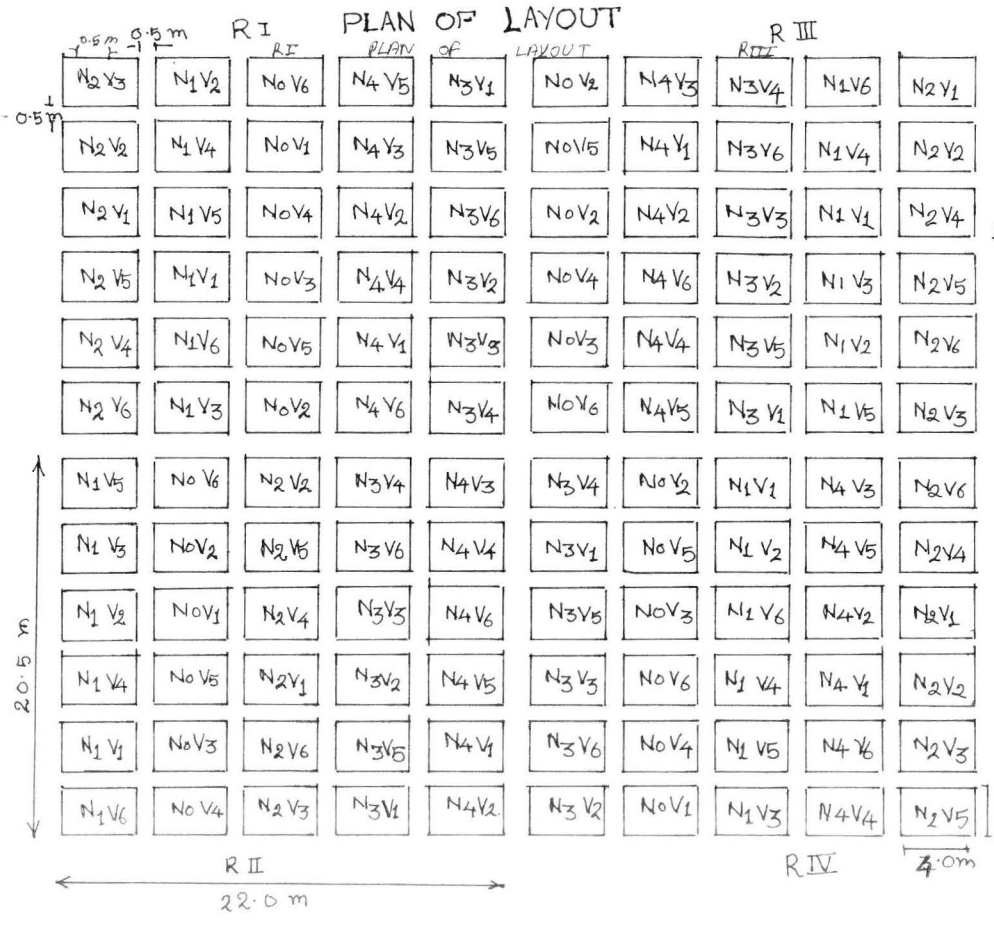


Fig : 1

Design :- Split plot

Gross plot size :- 4·0 x 3·0 m

Net plot size :- 3·20 x 2·40

Main plot treatments
(Levels of nitrogen)

No - 0 kg N/ha
N1 - 50 kg N/ha
N2 - 100 kg N/ha
N3 - 150 kg N/ha
N4 - 200 kg N/ha

Sub plot treatments
(Varieties)

V1 - Jaya V2 - Sona
V3 - Jayanthi V4 - Satya
V5 - Soorya V6 - Suhasini

The plan of layout with necessary details is given in Fig.1.

1:5. Seed material :

The seed of paddy varieties Jaya, Sona, Jayanthi, Satya, Soorya and Suhasini was collected from Agricultural College Farm, Nagpur.

1:6. A brief description of the varieties under study :

Jaya :

It was identified as a variety of F_5 stage from a cross T(N)-1 x T-141. Its duration is about 125 to 130 days which is 7 to 10 days earlier than IR-8. The grain is white, bold and long. It is dwarf, non lodging and gives good response to nitrogen application. It was released by the central variety release committee on December 23, 1968.

Sona :

It has been obtained by crossing CRB.24 x T(N)-1. It is a dwarf photoinsensitive, high yielding variety which matures in about 125 to 130 days and has a yield potential equal to that of Jaya, under good management. In maximization trials yields of 5.5 to 6 tonnes per hectare have been obtained during Kharif and Rabi seasons at many centres. Over and above its high yield potential, its grains are long slender with the length and breadth ratio exceeding 3.5 and a clear translucent texture. Apart from its good appearance its cooking quality is commendable with fair

amylose content. The variety is moderately susceptible to bacterial blight and rice tungro virus.

Jayanthi :

This variety has been developed from the cross type 90 x IR-8. The variety is dwarf, photoinsensitive and is 5 to 7 days late in maturity than Sona. Its yielding potential and grain quality is almost as good as to that of Sona.

Satya, Soorya and Suhasini :

Satya, Soorya and Suhasini are the three hybrids preferred by the Director of Agriculturel Research Institute, Kosbad, District Thana, Sri. Jayantrao Patil. These hybrids and scores of other lines were tested by the Kosbad Institute for two years between 1970 and 1972. The original material running into scores was sent by Sri. M.S. Pawar, the then F.A.O. Rice Geneticist, whose team of workers had bred these in a programme jointly sponsored by the F.A.O. and the Government of Guyana. The female parent of the hybrids is BG-79 which is a selection from a U.P. variety Sutradhan. In Kharif 1972, these hybrids were tested at Kosbad under the field number R., S. and No.10, latter named as Suhasini, Satya and Soorya, respectively. They have given good yields in demonstration plots and mini-kit trials predominantly in the Konkan districts of Thana, Kolaba and Ratnagiri. These

Thew hybrids are dwarf, non lodging and possessing ample seedling vigour. They give a high milling percentage of about 60 per cent. The grain is longish, clear and cooks free.

1:7. Details of cultivation :

1:7:1. Raising of seedlings on nursery beds :

Seed of six varieties was treated separately with one per cent agrosan G.N. at the rate of 2.5 g per kg of seed. The seed was sown in raised nursery beds on 24th June 1974. The beds were irrigated whenever felt necessary. The germination commenced from the third day and was complete by sixth day. Necessary plant protection measures were also taken in the nursery.

1:7:2. Transplanting of seedlings :

Experimental field was ploughed twice and puddled. The gross plot areas were demarked by means of bunds of 30 cm height to be separated from each other. Seedlings of 25 days old were transplanted at the spacing of 20 x 15 cm with two seedlings per hill.

1:7:3. Culturel operations :

The details of cultural operations carried out in the field during the growth period of paddy are presented in Table 5.

Table 5 : Datewise schedule of cultural operations done in the experimental plot.

Field operations	Frequency	Date
I. Pre-transplanting :		
A. Field operations:		
1. Ploughing	2	20.6.74, 10.7.74
2. Stubble picking	1	12.7.74
3. Stubble picking and preparing bunds.	1	14.7.74
4. Puddling and levelling	1	16.7.74
B. Preparation of layout	1	17.7.74
C. Fertilizer application :		
1. Basal dose i.e. ½ N + 75 kg P_2O_5 + 50 kg K_2O	1	16.7.74
2. Second dose of ¼ N at the time of panicle initiation	1	27.8.74
D. Transplanting in the main field	1	18.7.74
II. Post transplanting :		
A.1. Hand weeding	3	4.8.74, 25.8.74, 15.9.74
2. Hoeing	1	28.8.74
B. Crop protection measures :		
Spray of endrin 20% E.C. + Diathane Z-78$^+$ Streptocycline	2	7.9.74, 16.9.74
C. Water management :		
Particular water level was maintained throughout the growing period.		
D. Harvesting :		
Jaya, Sona, Jayanthi, Satya, Soorya, Suhasini	1	8.11.74, 9.11.74, 10.11.74
E. Threshing :		
Jaya, Sona, Jayanthi, Satya, Soorya, Suhasini	1	13.11.74, 14.11.74 16.11.74

1:7:4. Fertilizer application :

The first dose of 3/4 quantity of nitrogen with full dose of phosphate and potash was applied at the time of puddling and the remaining dose of 1/4 nitrogen was applied at the time of panicle initiation.

2. Details of collection of data :

2:1. Sampling technique :

For recording biometric observations five hills were randomly selected from each net plot.

2:2. Growth studies :

Various biometric observations taken during the course of investigation are presented in Table 6.

2:2.1. Height of the plant :

The height of the plant was measured from the base of the plant i.e. ground level to the base of the fully opened terminal leaf upto ear emergence and thereafter upto the base of the panicle.

2:2:2. Tillers per hill :

Total number of tillers including the main culm were periodically counted per hill and recorded.

2:2:3. Number of functional leaves per hill :

Progressive number of functional leaves (fully opened green leaves) per hill were counted and recorded

Table 6 : Details of biometric observations.

Particulars	Frequ--ency	Days from transpla--nting	No.of hills observed per net plot
A. Pre-harvest studies :			
1. Height of the plant(cm)	5	25,40,55,70, 85	5
2. Tillers per hill	5	25,40,55,70, 85	5
3. Number of functional leaves per hill	5	25,40,55,70, 85	5
4. Dry matter of plants per hill (g)	5	25,40,55,70, 85	2 hills upto 2nd observation and 1 hill thereafter
B. Post harvest studies :			
1. Total number of effective panicles per hill	1	At harvest	5
2. Length of panicle(cm)	1	,,	5
3. Number of rachis to the main axis of panicle	1	,,	5
4. Weight of fertile spikelets per hill(g)	1	,,	5
5. Weight of sterile spikelets per hill(g)	1	,,	5
6. No.of fertile spikelets per panicle	1	,,	2
7. No.of sterile spikelets per panicle	1	,,	2
8. Test weight(g)	1	,,	-
9. Hulling percentage	1	,,	-
10. Yield of grain per plot (kg)	1	,,	-
11. Yield of straw per plot (kg)	1	,,	-
C. Chemical studies :			
1. Total nitrogen in the straw and grain	1	,,	Treatmentwise composite samples
2. Total nitrogen in soil	2	Before transplanting and after harvesting.	,,

upto the maximum leaf stage of a plant. Once the leaves have started drying, the remaining half and fully green leaves were counted and recorded upto the last observation.

2:2:4. Dry matter of plants per hill :

For dry matter study, two hills were sampled for the first two observations and one hill each for subsequent dates of observations from each net plot. The hill were selected at random. The above ground portion of plant was detached from roots and used for study each time. The samples were oven dried at 65 to 70°C. The last constant weight was recorded.

2:3. Growth functions :

Studies on growth analysis of plant included the determination of absolute growth rate (AGR) and relative growth rate (RGR). Growth analysis was carried out to study the effects of treatments on the growth and yield of paddy in terms of phisiological determinants.

Absolute Growth Rate (AGR) :

The rate of increase of a growth variable (w) at a time (t) is called absolute growth rate (AGR). This measures as a differential coefficient of (w) with respect to time (t). AGR of growth variable namely total dry matter per plant was worked out by the following formula.

$$AGR = dw / dt$$

where dw = Increase in variable
dt = Time interval in days.

Relative Growth Rate (RGR) :

Blackman (1919) pointed out that increase in dry matter of plant was a process of continuous compound interest wherein the increment in any interval adds to the "Capital" for subsequent growth. This rate of increment is known as relative growth rate and was computed from following formula of Briggs et al. (1920 - 21).

$$RGR = \frac{(\text{Loge } W_2 - \text{Loge } W_1)}{(t_2 - t_1)}$$

where, W_1 and W_2 represent total dry weight at times t_1 and t_2 respectively.

2:4. Post harvest studies :

2:4:1. Total number of effective panicles per hill :

The panicles from the five hills were separated independently and their number was recorded. From this data the average number of panicles per hill was calculated. This data shows the number of effective panicles per hill.

2:4:2. Length of panicle :

The length of all the panicles per hill was measured from the basal whorl i.e. peduncle to the tip of the panicle.From the total of five hills in each plot an average length per panicle was calculated.

2:4:3. Number of rachis to the main axis of panicle :

From the total count of rachis i.e. branches on the main axis of panicle of all the panicles of five observations hills, the average number of rachis per panicle was worked out.

2:4:4. Weight of fertile and sterile spikelets per hill :

The spikelets removed from rachis were separated in two parts, fertile and sterile spikelets. Average weight of both types of the spikelets was calculated from the weight of each type of spikelets of five hills.

2:4:5. Number of fertile and sterile spikelets per panicle :

Number of fertile and sterile spikelets per panicle were calculated by counting all the fertile and sterile spikelets of ears of two randomly selected hills and average was worked out.

2:4:6. Test weight :

A random sample of grain from the total grain produce of the net plot was taken from which 1000 perfect grains were counted and weighed.

2:4:7. Hulling percentage :

A representative sample of 100 g was taken at random from the grain yield of each net plot and its husk was removed. After removing the husk, rice was

weighed and its percentage was recorded.

2:4:8. Yield of grain per net plot :

The grain produced per net plot was sun dried for two days, and weighed in kilogram.

2:4:9. Yield of straw per net plot :

After threshing, the straw was kept for sun drying for 15 days and then the plotwise weight of straw was recorded.

2:4:10. Grain to straw ratio :

It was computed by dividing the grain weight by straw weight for each treatment.

3. Chemical studies :

3:1. Nitrogen estimation :

The plant samples at harvesting were used for chemical studies. The dried samples were ground and preserved in the properly labelled brown paper packets for estimation of total nitrogen. The nitrogen was estimated by the modified Kjeldhal's Method (A.O.A.C. 1955). Composite samples of straw and grain from the four replications were analysed and hence no statistical analysis was done.

Similarly total nitrogen was estimated from the composite soil samples taken before transplanting and after harvesting.

3:2. Quality studies :

Quality of rice was studied by working out the protein percentage in the grain. The nitrogen content in grain was multiplied by 6.25 to find out the protein content.

4. Statistical analysis and interpretation of data :

4:1. General analysis :

The statistical analysis of the data was done by the standard statistical method known as "Analysis of variance". The "Null hypothesis" was tested by 'F' test of significance to know whether observed treatment effects were real or not. From the data in which the treatment effects were significant, the appropriate standard errors (S.E.) and critical difference (C.D.) at 5 per cent level of probability were calculated. Suitable graphical illustrations of the data have been made at appropriate places.

4:2. Correlation studies :

The relationship of paddy grain yield to ancillary characters was investigated by correlation method. The values of 'r' (correlation coefficients) were worked out from the error line of the covariance table as follows.-

$$r = \frac{SP\,(xy)}{\sqrt{S.S.(x) \times S.S.\,(y)}}$$ Where,

r = Coefficient of correlation
x = Independent variable (character)
y = Dependent variable (yield).

4:3. Response curve and economic analysis of the grain yield data :

4:3:1. Response curve :

One of the object of the fertilizer trials is to find out the optimum dose of fertilizer which would increase the production economically. A quadratic equation of the following type was used to study the production relationship between nitrogen and paddy grain yield.

$$Y = a + bx + Cx^2$$

Where,

Y = Paddy grain yield in quintal per hectare

a = A constant(which indicates response in absence of nitrogen).

b = A constant

c = A constant(which measures the curvature of response curve).

x = Coded unit of N i.e. one unit corresponding to 50 kg N.

4:3:2. Optimum dose of nitrogen :

From the quadratic relationship established between nitrogen as input factor and paddy grain yield, as a output factor, optimum levels of nitrogen fertilization for varying price structures of paddy grains for each variety were calculated by using the following formula.

$$\text{Optimum dose} = \frac{1}{2c}\left\{\frac{q}{p} - b\right\}$$

Where,

q = Cost of 50 kg nitrogen

p = Value of one quintal paddy grains

b and c = Constants

The predicted response and the monetary returns for each variety were calculated at varying price situations.

4:3:3. Maximization of yield :

The maximization of yield of paddy crop under unlimited source was worked out by using the formula.-

$$\frac{dy}{dx} = b + 2cx = 0$$

Where,

b = Constant value

c = Another constant (a measure of curvature of curve)

x = Level of nutrient which would give maximum yield.

IV. EXPERIMENTAL FINDINGS

1. Growth studies :

1:1. Height of plant :

Data pertaining to mean height of plant as affected periodically by various treatments are presented in Table 7.

Table 7 : Mean height of paddy plant in cm as affected periodically by different treatments.

Treatments	Days after transplanting				
	25	40	55	70	85
Levels of nitrogen					
N_0	17.04	20.60	35.62	59.35	62.02
N_1	18.78	23.51	39.69	62.05	65.32
N_2	19.59	25.08	41.12	65.45	68.39
N_3	20.98	25.54	42.22	67.38	69.39
N_4	22.16	26.80	43.28	68.92	72.13
'F' test	Sigt.	Sigt.	Sigt.	Sigt.	Sigt.
S.Em. ±	0.25	0.37	0.93	0.87	0.89
C.D. at 5%	0.77	1.16	2.88	2.68	2.76
Varieties					
V_1	20.01	24.20	38.64	67.46	70.17
V_2	19.02	23.94	39.91	64.40	66.92
V_3	19.67	23.96	38.93	63.33	66.09
V_4	20.16	24.93	42.33	66.04	68.55
V_5	19.70	24.52	41.96	64.23	67.39
V_6	19.71	24.30	40.55	62.32	65.58
'F' test	N.S.	N.S.	N.S.	N.S.	N.S.
S.Em. ±	0.33	0.39	1.31	1.33	1.24
C.D.at 5%	-	-	-	-	-
General Mean	19.71	24.31	40.39	64.63	67.45

Sigt. = Significant; N.S. = Non-Significant

A glance to Table 7 would indicate that the height of plant was found to increase with the increase in age of the crop. It would be seen that slow growth of paddy was found upto 40 days, between 40 and 70 days the mean plant height increased at relatively faster rate. Following 70 days increase in the height was slow. The varieties under investigation being of medium duration type registered maximum height at 85 days from transplanting.

Effect of nitrogen levels :

Nitrogen application was found to affect the height of plant significantly at all the observations. The height was found to increase with increase in the level of nitrogen at all the stages of crop growth i.e. from 25 days onwards upto the last observation at 85 days from transplanting. The difference between the control and all other levels of nitrogen was observed to be significant throughout the period of crop growth.

A 25 days from transplanting differences between each successive level of nitrogen were significant over the previous one. At 40 days, 200 kg N per hectare was significant over other levels of nitrogen, while 150 and 100 kg N per hectare did not differ significantly. At 55 days, 200, 150 and 100 kg N per hectare, and 150, 100 and 50 kg N per hectare did not differ significantly. 200 kg N per hectare was found to be significant over 50 and 0 kg N per hectare. At 70 and 85 days from transplanting 200 and 150 kg N per

hectare and 150 and 100 kg N/ha did not show significant differences, while 200 kg N/ha was found to be significant over 100, 50 and 0 kg N/ha, and 150 kg N/ha was significant over 50 and 0 kg N/ha.

Varieties :

The differences in respect of mean plant height, among the varieties tried were observed to be not significant at all the stages of crop growth.

Interaction :

The interaction effects between various levels of nitrogen and varieties were found to be not significant at all the observations.

1:2. Tiller number per hill :

Data regarding the mean tiller number per hill as affected periodically by different treatments are presented in Table 8.

It is evident from Table 8 that the tiller number per hill increased upto 55 days after transplanting, but decreased thereafter. This decrease might be due to death of late tillers. The crop had produced 86 per cent of tillers upto 25 days and the remaining 14 per cent were produced from 25 to 55 days after transplanting.

Effect of nitrogen levels :

Nitrogen fertilization had a significant effect on

Table 8 : Mean number of tillers per hill as affected periodically by different treatments.

Treatments	Days after transplanting				
	25	40	55	70	85
Levels of nitrogen					
N_0	8.32	7.12	8.85	9.28	8.29
N_1	8.65	9.19	9.90	10.39	9.37
N_2	8.87	9.25	9.99	10.05	9.37
N_3	9.59	11.55	11.95	11.19	11.00
N_4	10.53	11.12	12.52	11.34	11.40
'F' test	Sigt.	Sigt.	Sigt.	N.S.	Sigt.
S.Em. ±	0.33	0.47	0.48	0.79	0.54
C.D. at 5%	1.03	1.45	1.48	-	1.69
Varieties					
V_1	8.82	9.50	10.23	9.51	9.17
V_2	9.10	9.69	10.31	10.15	9.85
V_3	9.72	9.39	10.86	11.33	10.38
V_4	8.74	9.39	10.21	9.70	9.29
V_5	9.66	10.10	11.60	11.70	10.90
V_6	9.12	9.85	10.68	10.32	9.75
'F' test	N.S.	N.S.	N.S.	Sigt.	Sigt.
S.Em. ±	0.31	0.37	0.42	0.42	0.39
C.D.at 5%	-	-	-	1.19	1.09
General Mean	9.19	9.65	10.64	10.45	9.89

N.S. = Non significant, Sigt. = Significant

the number of tillers per hill at all the observations, except at 70 days. The number of tillers per hill at 200 and 150 kg N/ha were of the same order. But both had produced significantly more number of tillers per hill over the control at all the observations.

Varieties :

The varietal differences in respect of number of tillers per hill were significant only at 70 and 85 days after transplanting.

At 70 days Soorya recorded significantly higher number of tillers than that of Suhasini, Sona, Satya and Jaya which were all at par. There was no significant difference between Soorya and Jayanthi so also Jayanthi, Suhasini and Sona were found to be of the same order. At 85 days there was no significant difference between Soorya, Jayanthi and Sona. Soorya recorded significantly more number of tillers per hill over Suhasini, Satya and Jaya, whereas Jayanthi was significant over Jaya.

Interaction :

None of the interaction effects between various levels of nitrogen and varieties under study were found to be significant at any of the observations recorded.

1:3. Number of functional leaves per hill :

Data regarding the mean number of functional leaves per hill as affected periodically by different treatments are presented in Table 9.

Table 9 : Mean number of functional leaves per ... affected periodically by different treatments.

Treatments	Days after transplanting				
	25	40	55	70	85
Levels of nitrogen					
N_0	33.69	39.86	43.30	32.02	24.34
N_1	37.08	48.09	50.54	32.15	24.83
N_2	41.07	49.49	52.55	32.83	26.43
N_3	43.99	57.35	56.69	37.00	29.40
N_4	44.91	61.20	61.68	41.35	30.20
'F' test	Sigt.	Sigt.	Sigt.	Sigt.	N.S.
S.Em. ±	0.99	1.98	2.59	1.31	1.87
C.D. at 5%	3.05	6.11	7.98	4.03	-
Varieties					
V_1	40.50	48.84	50.38	34.70	28.37
V_2	39.08	50.00	53.66	35.53	28.33
V_3	38.71	51.92	54.60	38.36	31.38
V_4	40.62	49.59	49.38	32.83	23.56
V_5	41.66	55.81	57.73	35.48	26.79
V_6	40.31	51.04	51.98	33.56	23.82
'F' test	N.S.	N.S.	Sigt.	N.S.	Sigt.
S.Em. ±	0.90	1.88	1.87	1.33	1.23
C.D.at 5%	-	-	5.19	-	3.40
General Mean	40.15	51.20	52.95	35.07	27.04

N.S. = Non significant, Sigt. = Significant

It is observed from Table 9 that the mean number of functional leaves per hill was found to increase with increase in the age of crop upto 55 days and thereafter it went on decreasing. The mean maximum number of functional leaves per hill recorded were 52.95 at 55 days after transplanting. The increase in leaf production was rapid during 25 to 40 days.

Effect of nitrogen levels :

Nitrogen fertilization significantly increased the number of functional leaves per hill at all the observations of crop except at 85 days. The leaf number per hill was found to increase with increase in the level of nitrogen throughout the period of crop growth.

The highest dose of 200 kg N/ha had produced the maximum number of functional leaves per hill and was at par with 150 kg N/ha, but was significantly superior over all other treatments except the observation recorded at 70 days after transplanting. At 70 days after transplanting 200 kg N/ha was significantly superior over 150 kg N/ha whereas 150 kg N/ha had produced significantly more number of functional leaves per hill than 100, 50 and 0 kg N/ha levels of nitrogen which were at par.

Varieties :

The leaf number per hill was found to differ significantly among the different varieties at 55 and 85 days only. At 55 days Soorya recorded highest number of functional

leaves per hill and was at par with Jayanthi and Sona, but has produced significantly more number of functional leaves than that of Suhasini, Jaya and Satya. At 85 days, i.e. at the last observation Jayanthi recorded highest number of functional leaves and was at par with Jaya and Sona and significantly superior over Soorya, Suhasini and Satya. Varieties Jaya, Sona and Soorya, and varieties Soorya, Suhasini and Satya were of the same order. Jaya was significantly superior over Suhasini and Satya which recorded the lowest number of functional leaves per hill.

Interaction :

The interaction effect between various levels of nitrogen and varieties at all the stages of the crop growth was found to be not significant.

1:4. Dry matter production per hill :

Data regarding the periodical dry matter production per hill in various treatments under study are presented in Table 10.

It would be seen from Table 10 that the dry matter production continued upto 85 days after transplanting. The rate of dry matter accumulation was very slow upto 25 days (6.54 g) followed by moderate increase upto 40 days (15.86 g) and the maximum was at 85 days (51.00 g). The maximum dry matter to the extent of 37 per cent was produced during 40 to 55 days of the crop growth.

Table 10 : Mean dry matter production in gram per hill as affected periodically by different treatments.

Treatments	Days after transplanting				
	25	40	55	70	85
Levels of nitrogen					
N_0	4.87	12.58	29.70	37.29	44.54
N_1	6.00	14.12	32.45	39.52	48.79
N_2	6.25	15.62	35.50	41.10	50.75
N_3	7.08	17.04	36.89	43.45	53.50
N_4	8.50	19.95	39.50	48.47	57.45
'F' test	Sigt.	Sigt.	Sigt.	Sigt.	Sigt.
S.Em. ±	0.72	0.96	1.32	1.87	1.50
C.D. at 5%	2.24	2.96	4.07	5.77	4.63
Varieties					
V_1	6.15	15.80	32.70	41.27	56.65
V_2	6.75	15.80	37.50	43.35	50.70
V_3	5.95	15.55	32.52	40.95	49.40
V_4	6.65	18.15	35.35	39.00	46.65
V_5	7.05	15.70	35.90	45.05	52.20
V_6	6.70	14.20	34.90	42.20	50.45
'F' test	N.S.	N.S.	N.S.	N.S.	N.S.
S.Em. ±	0.49	1.06	1.52	1.81	2.19
C.D.at 5%	-	-	-	-	-
General Mean	6.54	15.86	34.81	41.97	51.00

Sigt. = Significant, N.S. = Non significant

Effect of nitrogen levels :

Dry matter production per hill was affected significantly by nitrogen fertilization at all the stages of crop growth. It was found to increase with each increment in the level of nitrogen throughout the period of crop growth. The nitrogen fertilization at 200 and 150 kg N/ha recorded dry matter per hill of the same magnitude at all the observations. 200 kg N/ha produced significantly more dry matter than 100, 50 and 0 kg N/ha except at 55 days, similarly dry matter produced at 150 kg N/ha was significant over control at all the observations except at 25 days.

Varieties :

The varietal differences in respect of total dry matter produced were found to be not significant at all the stages of growth.

Interaction :

None of the interaction effects between different levels of nitrogen fertilization and varieties were found to be significant.

2. Studies on growth functions :

From the data on mean total dry matter accumulation per hill at different stages of crop growth, the absolute growth rate (AGR) and relative growth rate (RGR) were calculated.

2:1. Absolute growth rate (AGR) :

The data in respect of mean absolute growth rate (AGR) of dry matter in gram per hill per week, as affected periodically by different treatments are presented in Table 11. Data were not statistically analysed. The inferences are based on mean values.

Table 11 : Mean AGR of dry matter in g per hill per week as affected periodically by different treatments.

Treatments	Between days from transplanting			
	26-40	41-55	56-70	71-85
Levels of nitrogen				
N_0	3.592	7.977	3.536	3.378
N_1	3.783	8.541	3.294	4.319
N_2	4.366	9.264	2.609	4.496
N_3	4.641	9.250	3.056	4.683
N_4	5.335	9.110	4.180	4.184
Varieties				
V_1	4.496	7.875	3.993	7.167
V_2	4.217	10.112	2.726	3.425
V_3	4.473	7.908	3.928	3.937
V_4	5.359	8.015	1.700	3.564
V_5	4.030	9.413	4.263	3.331
V_6	3.495	9.646	3.401	3.844
General Mean	4.343	8.830	3.336	4.207

A persual of the data in Table 11 would indicate that the mean AGR showed increasing trend upto 55 days. The mean maximum AGR was recorded during 41 to 55 days.

Effect of nitrogen levels :

Nitrogen fertilization in general increased the AGR throughout the growth season over control, except between 56 to 70 days where AGR at 0 kg N/ha was more than AGR at 50, 100 and 150 kg N/ha. Between 26 to 40 days there was progressive increase in the values of AGR with increasing levels of nitrogen fertilization. From 41 days onwards, no definate trend was observed.

Varieties :

AGR in all the varieties under study was found to increase upto 55 days then it showed a decrease in the next 15 days i.e. between 56 to 70 days, and again it increased from 71 days onwards upto 85 days except in variety Poorya where it gradually decreased from 56 days onwards upto 85 days. Maximum AGR was found between 41 to 55 days in all the varieties under study. Sona has produced the highest AGR during 41 to 55 days, whereas Jaya during 71 to 85 days.

2:2. Relative growth rate (RGR) :

Data pertaining to the RGR in gram per gram per week as affected periodically by the different treatments are presented in Table 12. Data were not statistically analysed. Inferences are based on the mean values.

Table 12 : Mean relative growth rate (RGR) in gm per gm per week as affected periodically by different treatments.

Treatments	Between days from transplanting			
	26-40	41-55	56-70	71-85
Levels of nitrogen				
N_0	0.442	0.400	0.105	0.082
N_1	0.398	0.387	0.091	0.098
N_2	0.426	0.382	0.068	0.098
N_3	0.409	0.360	0.076	0.096
N_4	0.397	0.318	0.095	0.079
Varieties				
V_1	0.439	0.338	0.108	0.147
V_2	0.396	0.402	0.067	0.072
V_3	0.447	0.343	0.107	0.087
V_4	0.467	0.313	0.043	0.083
V_5	0.373	0.385	0.105	0.068
V_6	0.350	0.419	0.088	0.083
General Mean	0.412	0.366	0.087	0.090

A glance to Table 12 would indicate that the highest mean RGR value of 0.412 g / g / week was observed between 26 to 40 days. It subsequently decreased with advancement in the age of the crop upto 70 days and latter between 70 to 85 days it again increased.

Effect of nitrogen levels :

The RGR was maximum in control at all the growth stages except during 71 - 85 days. No definite trend of increase or decrease in the RGR values due to nitrogen levels was observed at all the growth stages.

Varieties :

In the varieties Soorya and Suhasini the RGR values were found to increase upto 55 days and decrease subsequently upto the last observation. Jaya and Satya had higher RGR values between 26 to 40 days, which decreased upto 70 days and increased finally between 71 to 85 days. No definite trend was observed in Sona. In Jayanthi RGR was maximum between 26 to 40 days which decreased throughout the crop growth.

3. Post harvest studies :

Data regarding the number of effective panicles per hill, length of panicle, number of rachis per panicle, weight of fertile spikelets per hill and weight of sterile spikelets per hill as affected by the treatments are presented in Table 13.

3:1. Total number of effective panicles per hill :

A glance to the data presented in Table 13 would show that the total mean number of effective panicles per hill were 9.46.

Table 13 : Mean number of effective panicles per hill, length of panicle, number of rachis per panicle, weight of fertile spikelets per hill and weight of sterile spikelets per hill in different treatments.

Treatments	No. of effective panicles per hill	Length of panicle (cm)	No. of rachis per panicle	Weight of fertile spikelets per hill	Weight of sterile spikelets per hill.
Levels of nitrogen					
N_0	8.20	20.36	9.25	19.66	0.99
N_1	8.44	21.06	10.06	22.43	1.30
N_2	9.02	21.52	10.47	24.10	1.61
N_3	10.60	22.73	11.58	30.53	2.34
N_4	11.02	22.31	10.95	29.73	2.75
'F' test	Sigt.	Sigt.	Sigt.	Sigt.	Sigt.
S.Em. ±	0.37	0.22	0.17	1.12	0.30
C.D.at 5%	1.15	0.69	0.54	3.46	0.93
Varieties					
V_1	9.11	22.89	10.85	30.08	2.08
V_2	9.46	21.33	10.17	24.27	1.98
V_3	9.38	21.77	9.82	21.23	1.69
V_4	9.06	21.39	11.12	26.01	1.44
V_5	10.19	21.00	10.12	25.33	1.89
V_6	9.56	21.19	10.70	24.82	1.75
'F' test	N.S.	Sigt.	Sigt.	Sigt.	Sigt.
S.Em. ±	0.28	0.32	0.16	1.27	0.13
C.D.at 5%	-	0.88	0.45	3.54	0.37
General Mean	9.46	21.60	10.46	25.29	1.80

Sigt. = Significant, N.S. = Non significant

Effect of nitrogen levels :

The various levels of nitrogen fertilization differed significantly in respect of number of panicles per hill. The number of panicles per hill were found to increase with increase in the level of nitrogen. Nitrogen at 200 kg /ha had produced the maximum number of effective panicles per hill and it was at par with 150 kg N/ha. Both these levels were significantly superior over all other nitrogen levels which were also at par.

Varieties :

The varietal differences in respect of number of effective panicles per hill were statistically not significant.

Interaction :

The interaction effects between levels of nitrogen fertilization and varieties were found to be not significant.

3:2. Length of panicle :

A reference to Table 13 would show that the mean length of panicle was 21.60 cm.

Effect of nitrogen levels :

The nitrogen fertilization affected the length of panicle significantly. The longest panicle of 22.73 cm was observed at 150 kg N/ha. The length of panicle at 150 and 200 kg N/ha was of the same magnitude, but was significantly

superior over 100 and 50 kg N/ha which were also of the same order. The control plot had significantly shortest panicle length than that of the fertilized plots.

Varieties :

The varieties under study differed significantly in respect of the length of panicle. The length of panicle was maximum in Jaya and was significantly superior than the rest of the varieties which were at par.

Interaction :

The interaction effects in respect of length of panicle between various levels of nitrogen and varieties were found to be non significant.

3:3. Number of rachis per panicle :

A reference to Table 13 would reveal that the paddy crop produced on an average 10.46 number of rachis per panicle.

Effect of nitrogen levels :

It was observed that the number of rachis per panicle was affected significantly, due to the various levels of nitrogen. The maximum number of rachis (11.58) was observed at 150 kg N/ha, which was significantly more than rest of the levels. The differences between 200 and 100 kg N/ha, and 100 and 50 kg N/ha in respect of number of rachis per panicle were not significant. The control plot had significantly

less number of rachis per panicle as compared to various levels of nitrogen.

Varieties :

It was observed that the varieties differed significantly from each other in respect of number of rachis per panicle. The varieties Satya, Jaya and Suhasini were of the same order, but had significantly more number of rachis per panicle than Sona, Soorya and Jayanthi which were at par.

Interaction :

None of the interaction effects between different nitrogen levels and varieties were significant.

3:4. Weight of fertile spikelets per hill :

A glance to Table 13 would indicate that the mean weight of fertile spikelets per hill was observed to be 25.29 g.

Effect of nitrogen levels :

The nitrogen fertilization had affected the weight of fertile spikelets per hill significantly. It was found to increase with increase in the level of nitrogen application upto 150 kg N/ha, Nitrogen at the rate of 150 and 200 kg /ha did not differ significantly however both these levels recorded significantly more weight of fertile spikelets per panicle than all other levels. The weight of fertile

spikelets per hill with 100 and 50 kg N/ha were at par, so also 50 kg N/ha and control did not differ significantly, but weight of fertile spikelets per hill with 100 kg N/ha was found to be significantly higher as compared to the control.

Varieties :

The weight of fertile spikelets per hill was significantly varying among the varieties under study. Highest weight of fertile spikelets per hill was noted in Jaya followed by Satya, Soorya, Suhasini, Sona and Jayanthi. Jaya had recorded significantly higher weight of fertile spikelets per hill as compared to all other varieties under study which were at par except Jayanthi. Satya, Soorya and Suhasini were significantly superior to Jayanthi, but Jayanthi and Sona were of the same magnitude.

Interaction :

The interaction effects in respect of weight of fertile spikelets per hill between various levels of nitrogen and varieties were found to be non significant.

3:5. Weight of sterile spikelets per hill :

It is clear from Table 13 that on an average weight of sterile spikelets per hill recorded was 1.80 g.

Effect of nitrogen levels :

The weight of sterile spikelets per hill differed

significantly due to the effect of various levels of nitrogen fertilization. It was found to increase with each increment in the level of nitrogen. It was of the same order at 200 and 150 kg N/ha, 150 and 100 kg N/ha, and at 100, 50 and 0 kg N/ha. The weight of sterile spikelets per hill was significantly higher at 200 kg N/ha than 100, 50 and 0 kg N/ha so also 150 kg N/ha had significantly increased the weight of sterile spikelets per hill over 50 kg N/ha and the control.

Varieties :

The varieties under study differed significantly in respect of weight of sterile spikelets per hill. The highest weight of sterile spikelets was observed in Jaya which was at par with Sona, Soorya and Suhasini but was significantly superior over Jayanthi and Satya. The lowest weight of sterile spikelets was recorded in Satya which was at par with Suhasini and Jayanthi. The differences between Sona, Soorya, Suhasini and Jayanthi were found to be non significant however Sona and Soorya were significant over Satya in respect of weight of sterile spikelets per hill.

Interaction :

The interaction effects between nitrogen levels and varieties were significant in respect of weight of sterile spikelets per hill. The weight of sterile spikelets per hill obtained in different combinations is given in Table 14.

Table 14 : Weight of sterile spikelets per hill as affected by nitrogen x varieties interaction.

Varieties	Levels of nitrogen				
	N_0	N_1	N_2	N_3	N_4
V_1	1.18	1.65	2.36	1.71	3.49
V_2	0.43	0.91	1.07	3.58	3.67
V_3	0.59	0.75	1.54	2.19	3.40
V_4	0.96	1.47	1.08	2.14	1.56
V_5	1.33	1.93	1.75	2.75	1.70
V_6	1.45	1.11	1.85	1.67	2.66

'F' test = Significant,

S.Em. ± = 0.302

C.D. at 5% = 0.83

It is evident from Table 14 that the weight of sterile spikelets was found to increase with increase in the level of nitrogen in Sona and Jayanthi. In all other varieties no definite trend was found. The variety Sona and Jayanthi has produced highest weight of sterile spikelets per hill at 200 kg N/ha and the lowest weight was given by the same varieties at 0 kg N/ha.

3:6. Number of fertile spikelets per panicle :

A reference to Table 15 would indicate that mean number of fertile spikelets per panicle was 115.04.

Table 15 : Mean number of fertile and sterile spikelets per panicle, percentage of sterile spikelets per panicle(on number basis),test weight and hulling percentage in different treatments.

Treatments	No. of fertile spikelets /panicle	No. of sterile spikelets /panicle	Percentage of sterile spikelets /panicle	Test weight (g)	Hulling percentage
Levels of nitrogen :					
N_0	93.33	18.66	16.28	19.149	71.98
N_1	110.75	24.19	17.67	23.436	72.89
N_2	115.49	35.10	22.80	24.147	73.32
N_3	131.39	44.63	25.55	24.199	74.58
N_4	124.25	56.32	29.83	23.942	73.85
'F' test	Sigt.	Sigt.	Sigt.	Sigt.	Sigt.
S.Em. ±	3.70	2.96	1.20	0.187	0.02
C.D. at 5%	11.42	9.15	3.69	0.576	0.08
Varieties					
V_1	106.76	43.98	27.43	25.576	73.63
V_2	125.97	33.41	19.22	19.134	72.74
V_3	129.65	31.54	18.10	19.370	72.80
V_4	117.88	28.28	18.71	25.637	73.50
V_5	104.96	40.90	26.00	23.806	73.64
V_6	105.03	36.57	25.10	24.325	73.64
'F' test	Sigt.	Sigt.	Sigt.	Sigt.	Sigt.
S.Em. ±	4.54	3.82	1.89	0.224	0.04
C.D. at 5%	12.60	10.61	5.24	0.623	0.11
General Mean	115.04	35.78	22.43	22.975	73.32

Sigt. = Significant

Effect of nitrogen levels :

The number fertile spikelets per panicle was affected. significantly by the various levels of nitrogen fertilization. It was found to increase progressively with increase in the level of nitrogen upto 150 kg N/ha which recorded significantly higher number of fertile spikelets per panicle than 100, 50 and 0 kg N/ha. However the difference between the number of fertile spikelets per panicle at 150 and 200 kg N/ha was not significant. All the levels of nitrogen recorded significantly higher number of fertile spikelets per panicle over the control. The level of nitrogen 200 and 100 kg /ha,and also 100 and 50 kg /ha were at par but 200 kg N/ha has produced significantly more number of fertile spikelets per panicle as compared to 50 kg N/ha.

Varieties :

The varieties differed significantly in respect of number of fertile spikelets per panicle. The highest number of fertile spikelets was observed in Jayanthi. The varieties Jayanthi, Sona and Satya did not differ significantly in their number of fertile spikelets per panicle, so also Satya and Jaya, and Jaya, Suhasini and Soorya did not differ significantly. The varieties Jayanthi and Sona were significantly superior to Jaya, Suhasini and Soorya whereas Satya was significantly superior to Suhasini and Soorya.

Interaction :

The interaction effects between nitrogen levels and

varieties were found to be non significant.

3:7. Number of sterile spikelets per panicle :

It would be clear from Table 15 that on an average 35.78 sterile spikelets per panicle were observed.

Effect of nitrogen levels :

The various levels of nitrogen differed significantly in respect of number of sterile spikelets per panicle. The number of sterile spikelets was found to increase with increase in the level of nitrogen. The difference between 50 and 0 kg N/ha was statistically not significant. The number of sterile spikelets per panicle were however significantly higher in 200, 150 and 100 kg N/ha over 50 and 0 kg N/ha. Above 50 kg N/ha each successive higher level of nitrogen had produced significantly higher number of sterile spikelets per panicle over the preceeding level.

Varieties :

The varieties showed significant difference in respect of number of sterile spikelets per panicle. There were no significant differences in the number of sterile spikelets per panicle of Jaya, Soorya, Suhasini and Sona, and among Soorya, Suhasini, Sona and Jayanthi, and also between Suhasini, Sona, Jayanthi and Satya. The variety Jaya has produced significantly higher number of sterile spikelets per panicle as compared to Satya and Jayanthi,

so also Soorya produced significantly more number of sterile spikelets per panicle as compared to Satya.

Interaction :

The interaction effects between different levels of nitrogen and varieties were found to be non significant.

3:8. Percentage of sterile spikelets per panicle(on number basis)

Data in respect of percentage of sterile spikelets per panicle are presented in Table 15 would indicate that on an average 22.43 per cent sterile spikelets were present per panicle.

Effect of nitrogen levels :

The percentage of sterile spikelets per panicle were affected significantly due to the various levels of nitrogen. The sterility percentage was found to increase with increase in the level of nitrogen. 200 kg N/ha recorded the highest sterility percentage and was significantly higher than that of 100, 50 and 0 kg N/ha, but it was at par with 150 kg /ha level of nitrogen. 100 kg /ha level of nitrogen was significantly superior over 50 kg N/ha and the control, which were of the same magnitude.

Varieties :

The varieties under study differed significantly in respect of sterile spikelets per panicle. The highest sterility percentage was recorded in Jaya which was at par

with Soorya and Suhasini. Jaya, Soorya and Suhasini recorded significantly higher sterility percentage than rest of the varieties viz. Sona, Satya and Jayanthi which were found to be of the same order.

3:9. Test weight :

A reference to Table 15 would indicate that the mean test weight of paddy was 22.975 g .

Effect of nitrogen levels :

Nitrogen fertilization had a significant effect on the test weight of paddy. The test weight was found to increase with increase in the level of nitrogen upto 150 kg N/ha. Application of various levels of nitrogen increased the test weight significantly over the control. The differences between 150, 100 and 200 kg N/ha and between 200 and 150 kg N/ha were observed to be non significant. 150 and 100 kg N/ha recorded significantly higher test weight than 50 and 0 kg level of nitrogen per hectare.

Varieties :

The test weight differed significantly among the varieties under study. The highest test weight was observed in Satya while Sona recorded the lowest test weight. The varieties Satya and Jaya although did not differ significantly had significantly more test weight as compared to all other varieties. Similarly Suhasini and Soorya which did not differ significantly had significantly higher test

weight than Jayanthi and Sona which were at par.

Interaction :

The interaction effects between nitrogen levels and varieties were observed to be significant in respect of test weight. In order to indicate the interaction effects of various combinations, the result obtained have been presented in Table 16.

Table 16 : Test weight(g) as affected by varieties x nitrogen interaction.

Varieties	Levels of nitrogen				
	N_0	N_1	N_2	N_3	N_4
V_1	20.826	26.845	26.376	27.092	26.742
V_2	18.625	18.542	19.495	19.375	19.634
V_3	17.455	19.230	19.723	21.092	19.350
V_4	20.370	26.212	26.541	27.340	27.724
V_5	18.380	24.482	26.947	24.884	24.340
V_6	19.240	25.305	25.802	25.412	25.865

'F' test = Significant

S.Em. ± = 0.502

C.D.at 5% = 1.393

Table 16 would indicate that the test weight of all the varieties except Sona was significantly increased by the various levels of nitrogen over the control. The variety

Satya has recorded highest test weight at 200 kg N/ha which was at par with 150 and 100 kg N/ha. This did not differ significantly with Jaya at all the levels of nitrogen and Soorya at 100 kg N/ha.

3:10. Hulling percentage :

It would be clear from Table 15 that on an average the hulling percentage recorded was 73.32.

Effect of nitrogen levels :

Hulling percentage was significantly affected due to various levels of nitrogen fertilization. Control has recorded the lowest hulling percentage. Upto 150 kg N/ha each successive higher level of nitrogen fertilization was significant over the previous one. However 200 kg N/ha has significantly reduced the hulling percentage than 150 kg N/ha.

Varieties :

Table 15 would reveal that the varieties differed significantly in their hulling percentage. Soorya had produced the highest hulling percentage followed by Suhasini and Jaya which did not differ significantly among themselves but have produced significantly higher hulling percentage over all other varieties i.e. Satya, Jayanthi and Sona. Satya has produced significantly higher hulling percentage than Jayanthi and Sona. The differences between the hulling percentage of Jayanthi and Sona were found to be non significant.

Interaction :

The interaction effects between nitrogen levels and varieties were observed to be significant.

Table 17 : Hulling percentage as affected by nitrogen x varieties interaction.

Varieties	Levels of nitrogen				
	N_0	N_1	N_2	N_3	N_4
V_1	71.85	73.08	73.82	75.15	74.24
V_2	71.95	72.47	72.95	73.25	73.07
V_3	71.97	72.69	72.94	73.33	73.08
V_4	72.07	73.06	73.26	75.02	74.09
V_5	71.72	73.16	73.74	75.38	74.22
V_6	72.35	72.90	73.22	75.32	74.41

'F' test = Significant

S.Em. ± = 0.092

C.D. at 5% = 0.25

It is evident from Table 17 that in general the hulling percentage was found to increase with increase in the level of nitrogen upto 150 kg N/ha in all the varieties, thereafter at 200 kg N/ha it decreased. Soorya had produced significantly higher hulling percentage at 150 kg N/ha over all other combinations of nitrogen levels and varieties except to that of Jaya and Suhasini at the same level.

4. Yield of grain and straw :

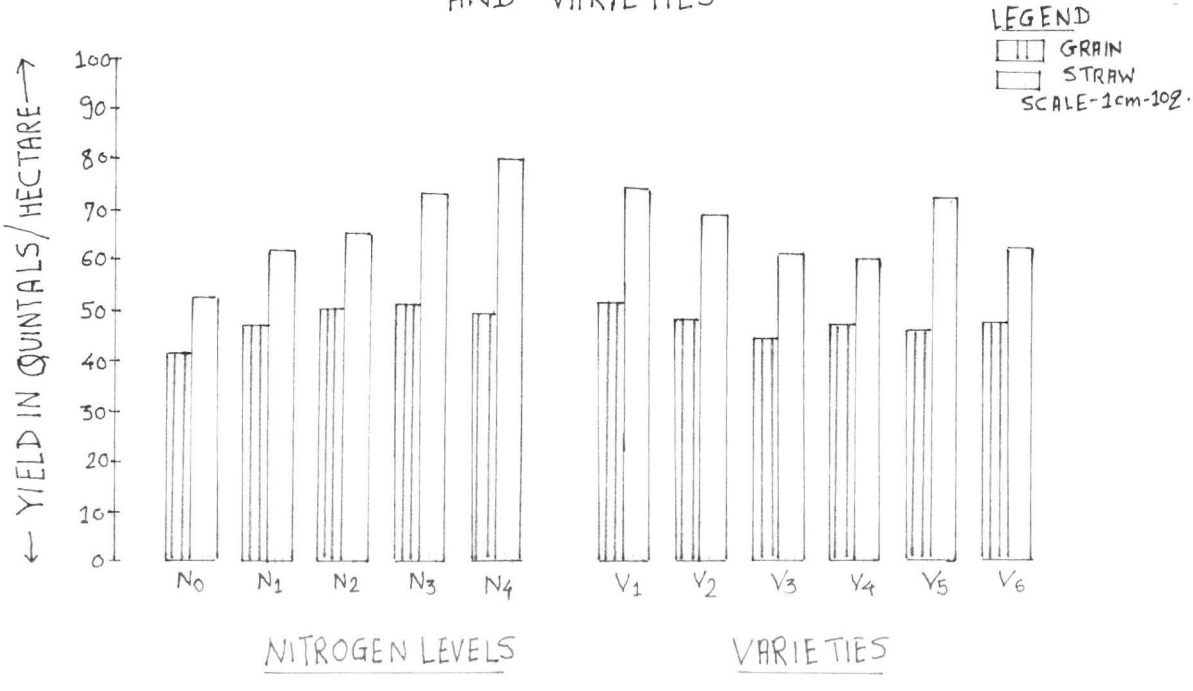
Data regarding the mean yield of paddy grain and straw per plot and per hectare as affected by treatments are presented in Table 18 and graphically shown in Fig.2.

Table 18 : Mean yield of paddy grain and straw in kg/plot as well as in quintals per hectare and grain to straw ratio as affected by different treatments.

Treatments	Grain yield /plot (kg)	Grain yield /ha (q)	Straw yield /plot (kg)	Straw yield /ha (q)	Grain to straw ratio
Levels of nitrogen					
N_0	3.159	41.132	4.047	52.695	0.780
N_1	3.573	46.523	4.726	61.536	0.756
N_2	3.911	50.924	5.011	65.247	0.780
N_3	3.929	51.158	5.672	73.854	0.692
N_4	3.818	49.713	6.201	80.742	0.615
'F' test	Sigt.	Sigt.	Sigt.	Sigt.	-
S.Em. ±	0.068	0.885	0.266	3.463	-
C.D.at 5%	0.210	2.734	0.819	10.664	-
Varieties					
V_1	3.961	51.575	5.706	74.296	0.694
V_2	3.724	48.489	5.337	69.492	0.697
V_3	3.448	44.895	4.686	61.015	0.735
V_4	3.681	47.929	4.667	60.768	0.788
V_5	3.590	46.744	5.567	72.486	0.644
V_6	3.664	47.708	4.828	62.864	0.758
'F' test	Sigt.	Sigt.	Sigt.	Sigt.	-
S.Em. ±	0.082	1.067	0.259	3.372	-
C.D. at 5%	0.228	2.968	0.720	9.375	-
General Mean	3.678	47.890	5.132	66.822	0.716

FIG.- 2

MEAN YIELD OF GRAIN AND STRAW (g/ha) AS AFFECTED BY NITROGEN LEVELS AND VARIETIES



4:1. Yield of grain :

It is clear from Table 18 that paddy crop on an average produced 3.678 kg of grain per plot and on hectare basis the mean grain yield produced was 47.890 quintals.

Effect of nitrogen levels :

The various levels of nitrogen fertilization had a significant influence on the yield of grain. Nitrogen fertilization produced a significant increase in the yield of grain over the control. The grain yield was found to increase with increase in the level of nitrogen upto 150 kg N/ha, thereafter at 200 kg N/ha it declined. Grain yield at 150, 100 and 200 kg N/ha was of the same order but was significantly higher than 50 and 0 kg N/ha.

Varieties :

Significant differences due to varieties were obtained in respect of yield of grain. The variety Jaya gave the maximum grain yield and was significantly superior over rest of the varieties. The grain yield of varieties Sona, Satya, Suhasini and Soorya was found to be at the same level but varieties Sona and Satya gave significantly higher grain yield than of Jayanthi, which gave the lowest yield of grain.

Interaction :

The interaction effects between different levels of nitrogen and varieties were observed to be non significant.

4:2. Yield of straw :

It would be seen from Table 18 that on an average the straw weight per plot was 5.132 kg and on hectare basis it was 66.822 quintals.

Effect of nitrogen levels :

Data in the table would indicate that significant differences in the yield of straw were obtained due to different levels of nitrogen. Yield of straw increased with every additional increment in the level of nitrogen upto the highest level of nitrogen tried i.e. 200 kg N/ha. Straw yield produced at 200 and 150 kg N/ha, 150 and 100 kg N/ha, 100 and 50 kg N/ha, and 50 and 0 kg N/ha were of the same magnitude. Weight of straw produced at 200 kg level of nitrogen was significantly superior over 100, 50 and 0 kg N/ha, whereas 150 kg N/ha was significant over 50 and 0 kg N/ha,while 100 kg N/ha was significant over the control.

Varieties :

A glance to Table 18 would reveal that the varieties differed significantly in respect of yield of straw. Jaya recorded the highest straw yield followed by Soorya and Sona, which were at par however Jaya and Soorya produced significantly higher straw weight than Suhasini, Jayanthi and Satya. The varieties Sona, Suhasini, Jayanthi and Satya did not differ significantly among themselves.

Interaction :

The interaction effects between the levels of nitrogen and the varieties were observed to be non significant.

4:3. Grain to straw ratio :

Data pertaining to mean grain to straw ratio are presented in Table 18. As the statistical analysis was not done, inferences are based on mean values. It is evident from the table that on an average the grain to straw ratio was 0.716.

Effect of nitrogen levels :

It is evident from Table 18 that in general the grain to straw ratio decreased with increase in the level of nitrogen indicating that the plants were running more into straw, except at 100 kg N/ha the increase in the straw was matched by increase in the grain yield keeping the grain to straw ratio at par with that of the control.

Varieties :

The varieties under investigation varied in respect of the grain to straw ratio. Satya recorded the highest grain to straw ratio followed by Suhasini, Jayanthi, Sona, Jaya and Soorya. The values of grain to straw ratio obtained clearly indicate that the proportion of straw exceeded the proportion of grain in all the varieties.

5. Chemical studies :

Chemical studies on rice plant :

In view of the striking response of paddy to nitrogen fertilization, it was thought to have a broad idea of the nitrogen concentration in this crop. Therefore, composite samples of straw and grain from four replications at harvest were analysed. Since composite samples were studied, no statistical analysis has been carried out. The inferences drawn are based on mean values.

5:1. Nitrogen content in the plant parts at harvest :

The data in respect of concentration of nitrogen at harvest in the straw and grain,and protein content in the grain are presented in Table 19.

Table 19 shows that on an average the rice plant at harvest contained 0.625 per cent of nitrogen in the straw and 1.63 per cent of nitrogen in the grain.

5:1:1. Nitrogen content in straw :

Effect of nitrogen levels :

The nitrogen content in the straw was found to increase with increase in the level of nitrogen upto the highest levels of nitrogen fertilization i.e. 200 kg N/ha.

Varieties :

Highest nitrogen content in the straw was found in the variety Jaya and Jayanthi while the lowest was found in the variety Soorya.

Table 19 : Mean nitrogen percentages in the straw, grain and protein content of the grain as affected by different treatments at harvest.

Treatments	Percent nitrogen		Protein percentage in grain
	Straw	Grain	
Levels of nitrogen			
N_0	0.525	1.34	8.37
N_1	0.636	1.63	10.19
N_2	0.638	1.67	10.44
N_3	0.641	1.68	10.50
N_4	0.689	1.83	11.43
Varieties			
V_1	0.630	1.69	10.56
V_2	0.628	1.58	9.87
V_3	0.630	1.55	9.69
V_4	0.619	1.64	10.25
V_5	0.618	1.66	10.37
V_6	0.629	1.67	10.44
General Mean	0.625	1.63	10.19

5:1:2. Nitrogen content in the grain :

Effect of nitrogen levels :

The nitrogen content in the grain was foundto increase with each increment in the nitrogen level.

Varieties :

Jaya recorded the highest nitrogen content in the grain while the lowest was recorded in the variety Jayanthi.

5:2. Quality studies :

5:2:1. Protein content in the grain :

The protein content in the grain at harvest was considered as one of the criteria for quality attributes. It was observed from Table 19, that on an average 10.19 per cent of protein was present in the grain.

Effect of nitrogen levels :

The protein content in the grain was found to increase with increase in the level of nitrogen fertilization. It was lowest being 8.37 per cent in the control while it was highest with the application of 200 kg of nitrogen per hectare being 11.43 per cent.

Varieties :

The variety Jaya recorded the highest protein content i.e. 10.56 per cent and the lowest 9.69 per cent was observed in Jayanthi.

5:3. Studies on soil fertility :

In order to have a broad idea about soil fertility, estimation of total nitrogen was done from the soil samples which were collected before transplanting and after harvesting of paddy crop and the data are presented in Table 20.

Composite samples in both the cases were analysed and hence the data were not statistically analysed. The inferences are based on the mean values.

Table 20 : Mean nitrogen percentage in soil before transplanting and after harvesting of crop as affected by different treatments.

Treatments	Nitrogen percentage before transplanting (initial soil fertility).	Nitrogen percentage after harvesting of crop.
Levels of nitrogen		
N_0	0.142	0.127
N_1	0.133	0.141
N_2	0.138	0.150
N_3	0.132	0.152
N_4	0.140	0.159
Varieties		
V_1	0.134	0.144
V_2	0.139	0.148
V_3	0.141	0.150
V_4	0.131	0.138
V_5	0.133	0.141
V_6	0.145	0.154
General Mean	0.137	0.145

A reference to Table 20 would indicate that on an average initially soil contained 0.137 per cent of nitrogen, but after harvesting it was found to be 0.145 per cent.

5:3:1. Nitrogen percentage before transplanting :

Effect of nitrogen levels :

The soil under experimentation had different nitrogen percentages under different treatments before transplanting. The highest nitrogen estimated was under control followed by 200, 100, 50 and 150 kg N/ha treatments.

Varieties :

It would be clear from Table 20 that the initial fertility was not uniform under different varieties. The variety Suhasini was grown on highest fertility followed by Jayanthi, Sona, Jayan Soorya and Satya.

5:3:2. Nitrogen percentage after harvesting of crop :

On an average, soil contained 0.145 per cent of nitrogen after the harvesting of crop.

Effect of nitrogen levels :

A reference to Table 20 would indicate that the nitrogen percentage in control plots was decreased at the time of harvesting. But the percentage of nitrogen retained in the soil was higher with the application of higher doses of nitrogen.

Varieties :

It would be clear from data presented in Table 20 that the nitrogen percentage of the experimental plots, under different varieties was found to be increased.

6. Correlation studies :

Data regarding correlation coefficients between grain yield and ancillary characters of different varieties are presented in Table 21.

Table 21 : Correlation coefficient between grain yield and ancillary characters of different varieties.

Characters correlated	Values of correlation coefficients of varieties					
	Jaya	Sona	Jayanthi	Satya	Soorya	Suhasini
Grain yield and number of effective panicles / hill.	0.8394*	0.6103*	0.7331*	0.7664*	0.6347*	0.9248*
Grain yield and number of fertile spikelets / panicle.	0.6953*	0.0851	0.8306*	0.9285*	0.1546	0.8790*
Grain yield and test weight	0.7474*	0.7933*	0.0706	0.7843*	0.9781*	0.7378*

* Significant at 5 and 1 per cent level.

It is clear from Table 21 that the yield of paddy grain was significantly correlated with yield contributing

characters such as number of effective panicles per hill, number of fertile spikelets per panicle and test weight in all the varieties under study, except that in Sona and Soorya where number of fertile spikelets per panicle were not significantly correlated with grain yield, whereas grain yield of Jayanthi was not significantly correlated with test weight.

7. Response curve and economics of nitrogen fertilization :

7:1. Response curve :

One of the objects of the fertilizer trial is to find out the optimum dose of a fertilizer that would raise the production economically. The fertilizer response or the yield dose relationship for each of the varieties was therefore studied by fitting the response curves for levels of nitrogen. Since the linear and quadratic components of the treatment S.S. were significant, quadratic type of equation was fitted for yield data. The co-efficients of the fitted production function are given in Table 22.

In the equations, as given in Table 22, 'Y' refers to the expected yield of paddy grain in quintal per hectare and 'X' to the coded units of nitrogen, one unit corresponding to 50 kg N/ha.

Table 22 : Equation for fitting the response curve of grain yield in Polynomial method.

Varieties	Values of coefficients			Response equation
	a	b	c	$Y = a + bX + cX^2$
Jaya	42.978	8.532	-1.410	$Y = 42.978 + 8.532X + (-1.410X^2)$
Sona	41.988	7.397	-1.381	$Y = 41.988 + 7.397X + (-1.381X^2)$
Jayanthi	39.390	7.024	-1.424	$Y = 39.390 + 7.024X + (-1.424X^2)$
Satya	37.022	8.823	-1.123	$Y = 37.022 + 8.823X + (-1.123X^2)$
Soorya	40.316	9.241	-2.009	$Y = 40.316 + 9.241X + (-2.009X^2)$
Suhasini	44.224	2.651	-0.303	$Y = 44.224 + 2.651X + (-0.303X^2)$

7:2. Predicted yields :

Using the above type of equations, the predicted yield of paddy grain for specified nitrogen levels for each variety under study were calculated and presented in Table 23 and depicted in Fig.3.

7:3. Most profitable rate :

Most profitable rate or optimum dose was worked out for each variety under three price levels i.e. Rs. 120/-, 130/- and 140/- per quintal of coarse grain paddy (Jaya), Rs. 150/-, 160/- and 170/- per quintal of medium grain paddy (Satya, Soorya and Suhasini), and Rs. 180/-, 190/- and 200/- per quintal of fine grain paddy (Jayanthi and Sona)

Table 23 : Predicted and observed paddy grain yield in different varieties at various levels of nitrogen fertilization.

Levels of nitrogen (kg/ha)	JAYA		SONA		JAYANTHI		SATYA		SOORYA		SUHASINI	
	A	B	A	B	A	B	A	B	A	B	A	B
0	42.97	44.17	41.98	41.21	39.39	38.89	37.02	38.34	40.31	39.61	44.22	44.59
50	50.10	47.67	48.00	49.03	44.99	45.52	44.72	42.95	47.54	48.58	46.57	45.41
100	54.40	54.54	51.25	52.83	47.74	49.15	50.17	47.58	50.76	51.90	48.31	49.60
150	55.88	58.13	51.75	48.63	47.64	45.24	53.38	58.62	49.95	47.41	49.45	48.90
200	54.54	53.40	49.48	50.78	44.70	45.67	54.34	52.16	45.13	46.22	49.98	50.04
250	50.38	-	44.44	-	38.91	-	53.06	-	36.29	-	49.90	-

A = Predicted yield q / ha.

B = Observed yield q / ha.

Fig-3

PREDICTED AND OBSERVED GRAIN YIELDS IN q/ha OF DIFFERENT VARIETIES AS AFFECTED BY LEVELS OF NITROGEN

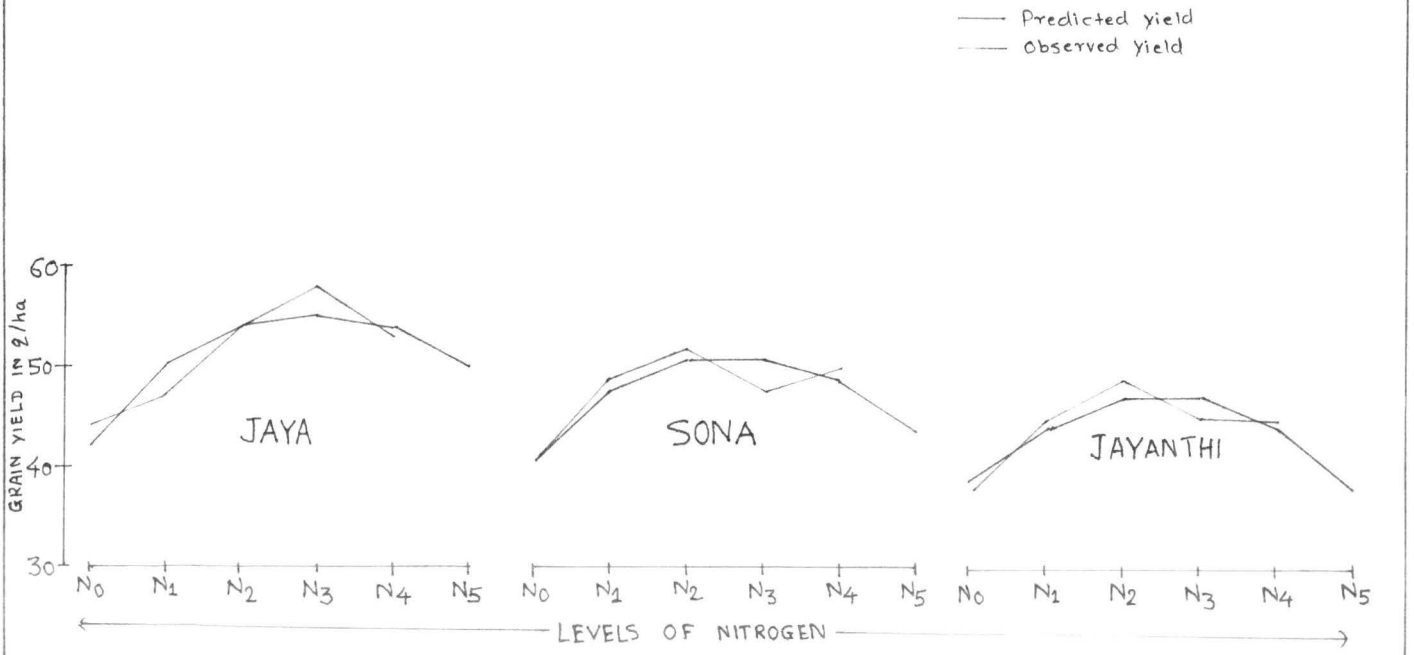
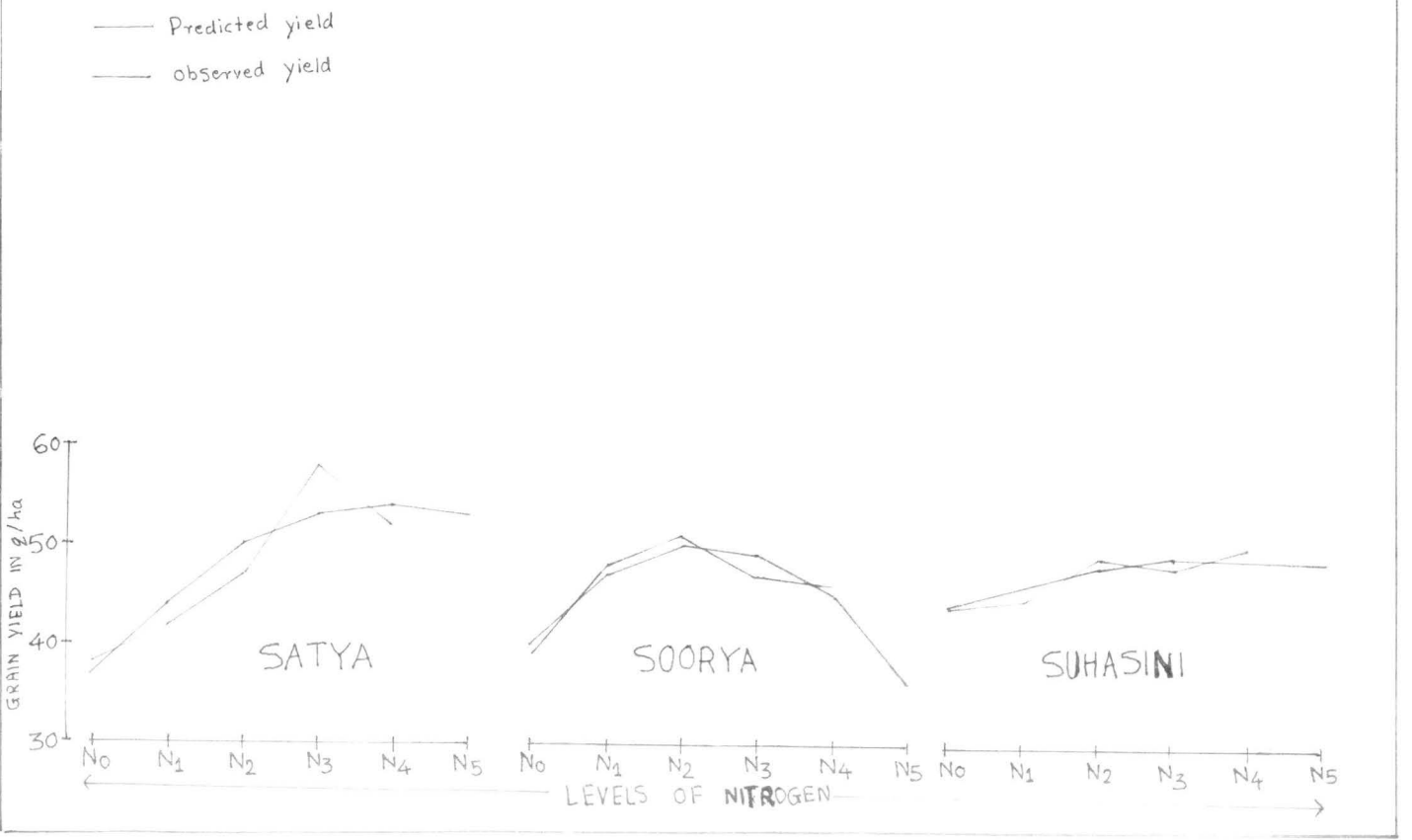


Fig-3 (..contd..)


Predicted yield
observed yield
60
50
40
30
GRAIN YIELD IN g/ha
SATYA
SOORYA
SUHASINI
No N1 N2 N3 N4 N5
No N1 N2 N3 N4 N5
No N1 N2 N3 N4 N5
LEVELS OF NITROGEN

at fixed cost of Rs. 230/- per unit of nitrogen i.e. 50 kg /ha.

Optimum level of nitrogen for variety Jaya, Sona, Jayanthi, Satya, Soorya and Suhasini was 119.900, 112.000, 102.050, 164.400, 97.100 and 100.150 kg N/ha respectively at prevailing price level. Optimum levels of nitrogen at different price levels alongwith profit economics are presented in Table 24, which indicates that the variety Soorya had given maximum profit per rupee investment.

7:4. Maximization of yield :

The maximum obtainable predicted yield under the conditions of unlimited resources was worked out by fitting the quadratic equations. It was found to be 55.85, 51.89, 48.05, 54.35, 50.94 and 48.77 q./ha in Jaya, Sona, Jayanthi, Satya, Soorya and Suhasini at 151.25, 133.90, 123.30, 196.40, 114.95 and 218.70 kg N/ha respectively.

Table 24 : Predicted optimum levels of nitrogen, grain yield and net return from nitrogen fertilization as affected by varying prices of produce in different varieties.

Particulars	JAYA			SONA			JAYANTHI			SATYA			GOURYA			SUHASINI		
	120	130	140	180	190	200	180	190	200	150	160	170	150	160	170	150	160	170
Optimum level of nitrogen /hectare	117.300	119.900	122.150	110.750	112.000	113.050	100.850	102.050	103.100	162.250	164.400	166.300	95.900	97.100	98.150	92.200	100.150	107.150
Cost of nutrient (Rs.)	539.58	551.54	561.89	509.45	515.20	520.03	463.91	469.43	474.26	746.35	756.24	764.98	441.14	446.66	451.49	424.12	460.69	492.89
Predicted yields quintal /hectare	55.235	55.330	55.407	51.597	51.629	51.653	47.765	47.795	47.820	53.827	53.893	53.945	50.651	50.687	50.716	48.082	48.318	48.514
Predicted response quintal /hectare	12.257	12.352	12.429	9.609	9.641	9.665	8.375	8.405	8.430	16.805	16.871	16.923	10.335	10.371	10.400	3.858	4.094	4.290
Cost of predicted response (Rs.)	1470.84	1605.76	1740.06	1729.62	1831.79	1933.00	1507.50	1596.95	1686.00	2520.75	2699.36	2876.91	1550.25	1659.36	1768.00	578.70	655.04	729.30
Net return from nitrogen fertilization (Rs.)	931.26	1054.22	1178.17	1220.17	1316.59	1412.97	1043.59	1127.52	1211.74	1774.40	1943.12	2111.93	1109.11	1212.70	1316.51	154.58	194.35	236.41
Profit / rupee investment	1.72	1.91	2.09	2.39	2.55	2.71	2.24	2.40	2.55	2.37	2.56	2.76	2.51	2.71	2.91	0.36	0.42	0.47

V. DISCUSSION

The results of the investigation reported in the previous chapter are discussed in the following pages.

Soil, season and crop development :

It will be seen from Table 1, that the soil in the experimental plots was sandy loam in texture, high in total nitrogen with adequate total phosphorus and total potash. The soil was slightly alkaline in reaction. The rainfall during the period of the experimentation was in general, unfavourable for the normal growth of paddy.

In the present investigation Jaya, Sona, Jayanthi, Satya, Soorya and Suhasini, the promising dwarf varieties of paddy, responsive to high nitrogen fertilization were grown by transplanting under irrigated conditions. The present recommended dose of nitrogen in Maharashtra State for dwarf high yielding varieties is 100 kg nitrogen per hectare. In order to evaluate, whether the said varieties could assimilate higher doses of nitrogen above the recommended nitrogen dose under Nagpur conditions, the highest dose of 200 kg N/ha was tried. In order not to allow the crop to be affected adversely from phosphate deficiency, the phosphate dose used was 75 kg P_2O_5 per hectare. It has been reported that single application of nitrogen made at the time of transplanting often fails to supply nitrogen at latter stages of growth due to loss

of nitrogen from soil. Patnaik and Abichandani (1957) on introgen utilization of paddy showed that 50 to 60 per cent of fertilizer nitrogen was absorbed when given as a single application but with split doses 2/3rd basal and 1/3rd top dressed, the amount of nitrogen absorbed was about 75 per cent. As such fertilizing the crop with 3/4th as basal and 1/4th as top dressed at the time of panicle initiation stage was taken up. It is an established fact that when the fertilizer phosphate is applied, large portion of it gets fixed up and is not available to the crop in the quantities needed for development and growth of the crop. Therefore, in order to provide longer duration for availability of steady supply of phosphate, it is recommended, in general, that phosphatic fertilizers should be added to the soil at the time of planting. In order not to allow the crop to suffer due to potash deficiency, in the present investigation potash alongwith phosphate was worked up uniformly into the soil at the time of puddling.

In order to get a broad outline of the growth pattern of paddy crop an extract of relevant information about the mean plant height, tiller number per hill, number of functional leaves per hill and total dry matter production per hill in different varieties at various growth phases of crop are presented in Table 25,26,27 and 28, and depicted in Fig.4.

Height of plant :

A glance at Table 25 would indicate that the growth measured in terms of mean plant height showed a rapid increase

Table 25 : Mean height of plant in cm in different varieties, at various growth stages.

Days from trans-planting	JAYA		SONA		JAYANTHI		SATYA		SOORYA		SUHASINI		Average height of plant (cm)	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
25	20.01	28.51	19.02	28.42	19.67	29.76	20.16	29.40	19.70	29.23	19.71	30.05	19.71	29.22
40	24.20	34.48	23.94	35.77	23.96	36.25	24.93	36.36	24.52	36.38	24.30	37.05	24.31	36.04
55	38.64	55.06	39.91	59.63	38.93	58.90	42.33	61.75	41.96	62.26	40.55	61.83	40.39	59.88
70	67.46	96.13	64.40	96.23	63.33	95.82	66.04	96.33	64.23	95.31	62.32	95.02	64.63	95.81
85	70.17	100.00	66.92	100.00	66.09	100.00	68.55	100.00	67.39	100.00	65.58	100.00	67.45	100.00

Table 26 : Mean number of tillers per hill in different varieties,at various growth stages.

	A	B	A	B	A	B	A	B	A	B	A	B	Average no.of tillers/hill. A	B
25	8.82	86.21	9.10	88.26	9.72	85.78	8.74	85.60	9.66	82.56	9.12	85.39	9.19	86.37
40	9.50	92.86	9.69	93.98	9.39	82.87	9.37	91.77	10.10	86.32	9.85	92.22	9.65	90.69
55	10.23	100.00	10.31	100.00	10.86	95.85	10.21	100.00	11.60	99.14	10.68	100.00	10.64	100.00
70	9.51	92.96	10.15	98.44	11.33	100.00	9.70	95.00	11.70	100.00	10.32	96.62	10.45	98.21
85	9.17	89.63	9885	95.53	10.38	91.61	9.29	90.98	10.90	93.16	9.75	91.29	9.89	92.95

A = Absolute, B = Percentage of total

Table 27 : Mean number of functional leaves per hill in different varieties, at various growth stages.

Days from trans-planting	JAYA		SONA		JAYANTHI		SATYA		SOORYA		SUHASINI		Average no.of functional leaves per hill	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
25	40.50	80.38	39.08	72.82	38.71	70.89	40.62	81.91	41.66	72.16	40.31	77.54	40.15	75.82
40	48.84	96.94	50.00	93.17	51.92	95.09	49.59	100.00	55.81	96.67	51.04	98.19	51.20	96.69
55	50.38	100.00	53.66	100.00	54.60	100.00	49.38	99.57	57.73	100.00	51.98	100.00	52.95	100.00
70	34.70	68.87	35.53	66.21	38.36	70.25	32.83	66.20	35.48	61.45	33.56	64.56	35.07	66.23
85	28.37	56.31	28.33	52.79	31.38	57.47	23.56	47.50	26.79	46.40	23.82	45.82	27.04	51.06

Table 28 : Mean total dry matter production per hill in different varieties, at various growth stages.

	A	B	A	B	A	B	A	B	A	B	A	B	Average dry matter production / hill. A	B
25	6.15	10.85	6.75	13.31	5.95	12.04	6.65	14.25	7.05	13.50	6.70	13.28	6.54	12.82
40	15.80	27.89	15.80	31.16	15.55	31.47	18.15	38.90	15.70	30.07	14.20	28.14	15.86	31.09
55	32.70	57.72	37.50	73.96	32.52	65.82	35.35	75.77	35.90	68.77	34.90	69.17	34.18	68.25
70	41.27	72.85	43.35	85.50	40.95	82.89	39.00	83.60	45.05	86.30	42.20	83.64	41.97	82.29
85	56.65	100.00	50.70	100.00	49.40	100.00	46.65	100.00	52.20	100.00	50.45	100.00	51.00	100.00

A = Absolute, B = Percentage of total

Fig-4

PERCENTAGE OF MEAN HEIGHT, NUMBER OF TILLERS, FUNCTIONAL LEAVES, AND TOTAL DRY MATTER/HILL IN DIFFERENT VARIETIES, AT VARIOUS GROWTH STAGES

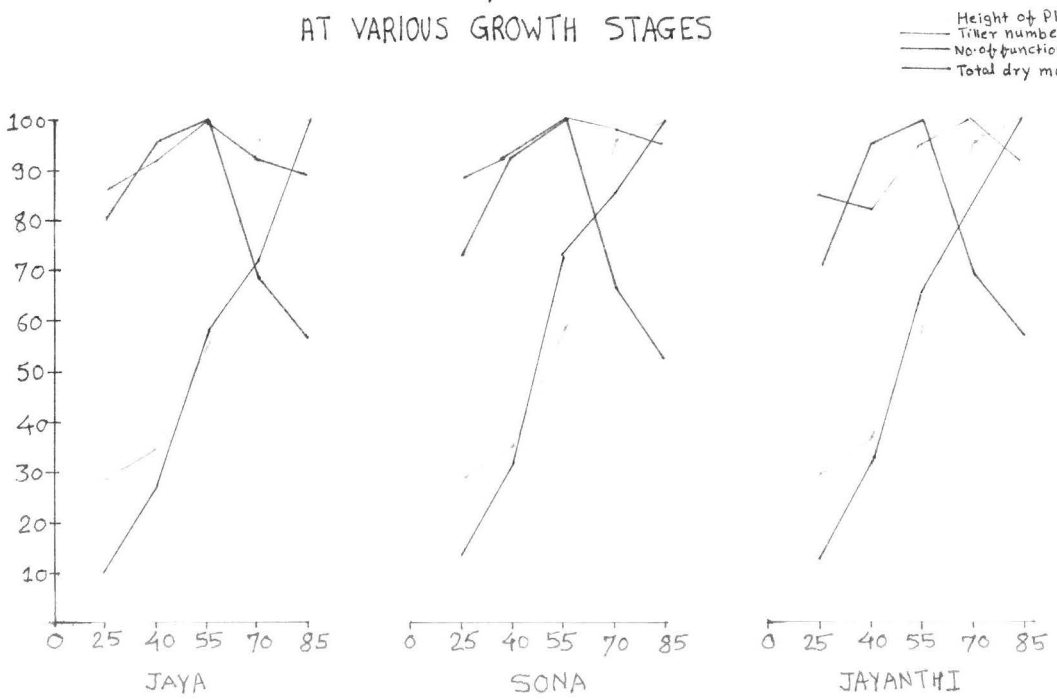
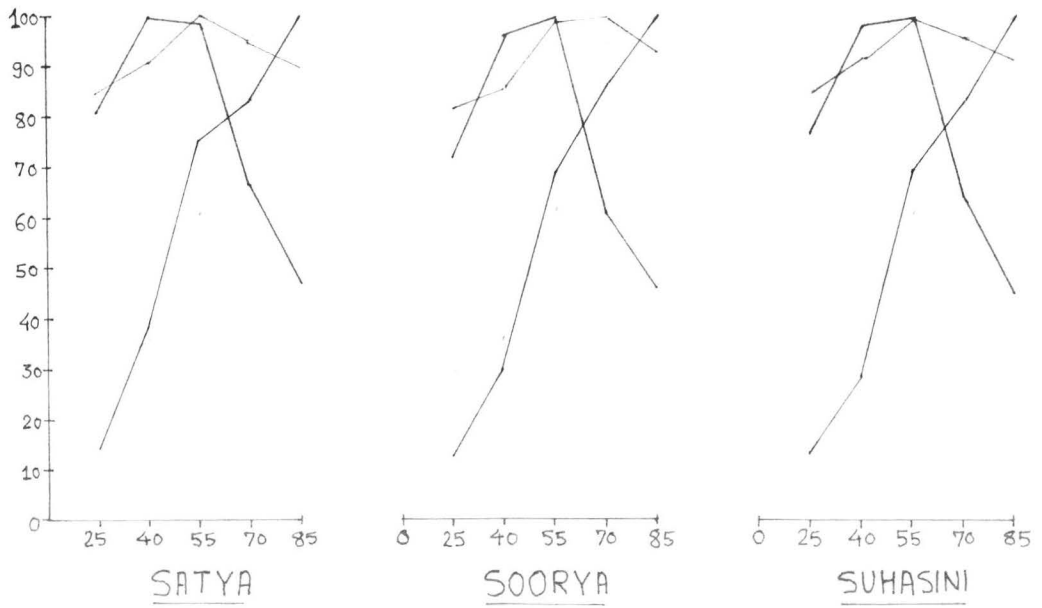


Fig-4 (--- contd. -)


100
90
80
70
60
50
40
30
20
10
0
25 40 55 70 85
SATYA
0 25 40 55 70 85
SOORYA
0 25 40 55 70 85
SUHASINI

in height upto 25 days from transplanting, when it accounted average height 29.22 per cent of the total height. During 25 to 40 days the increase in height was fairly slow when only 6.82 per cent increase in the average height was recorded. All the varieties reached a maximum height of 95.02 to 96.33 per cent by 70 days after transplanting. From 55 days onwards the increase in height was accelerated due to the elongation of internodes. At 70 days from transplanting the paddy varieties attained a average height of 95.81 per cent of the total height. The growth rate of paddy in terms of height declined after 70 days i.e. during flowering stage when there was a marginal increase in average height of 4.19 per cent of the total height. Adair (1936) found that during first six weeks increase in height was rapid and then it was slowed for about two weeks followed by rapid increase again till blooming under high fertility conditions.

Tiller number per hill :

Data presented in Table 26 would reveal that the varieties under study produced on an average 86.37 per cent of tiller per hill within the first 25 days of the transplanting. The varieties Jaya, Sona, Satya and Suhasini attained the maximum number of tillers per hill at 55 days from transplanting, and Jayanthi and Soorya at 70 days from transplanting. Jayanthi of all other varieties has only showed 2.91 per cent mortality of tillers between 25 to 40 days.

The reduction of 7.05 per cent of tillers at 85 days as compared to the total maximum number of tillers recorded at 55 days might be due to the death of late tillers. Similar results were reported by Ramiah and Narsimhan (1936) and Ramteke (1971).

Number of functional leaves per hill :

Scrutiny of the data presented in Table 27 would show that the number of functional leaves per hill progressively increased upto 55 days in all the varieties under study except in Satya where it showed an increase upto 40 days from transplanting and thereafter there was a decline, as the leaf production ceased after panicle initiation and existing lower leaves started drying. Similar growth behaviour in respect of number of functional leaves in dwarf medium duration varieties was observed by Ramteke (1971) under Nagpur conditions.

Dry matter production per hill :

A glance to Table 28 would reveal that the pattern of growth measured in terms of dry matter production per hill was very slow upto 25 days in all the varieties under study. The dry matter increased steadily during the next 15 days i.e. between 25 to 40 days. The increase in the rate of dry matter production per hill was rapid during 40 to 55 days in all the varieties except Jaya. Slow rate of dry matter production was observed in Satya during 55 to 70 days, while Jaya showed a rapid increase in dry matter from 70 to 85 days than all other varieties.

Growth functions :

Data regarding the growth functions studied is presented in Table 11 and 12. It would reveal that the AGR showed slow increase in dry matter upto 40 days. Thereafter the rate was accelerated during 41 to 55 days. It dropped subsequently during 56 to 70 days and again increased between 71 to 85 days. The maximum AGR of 8.830 g per week per hill was recorded during 41 to 55 days. Thereafter the AGR values dropped considerably. The probable reason for sharp decline in AGR after 55 days may be that even though there was a considerable increase in height during 56 to 70 days; the reduction in tiller number per hill and drying of leaves might have affected the AGR values considerably. Data on RGR indicated that it was maximum during 26 to 40 days followed by 41 to 55 days and thereafter there was a decline in the values of RGR. This indicates that the varieties have passed through the active vegetative growth period between 26 to 55 days. Raut (1970) found that the vegetative growth period of dwarf high yielding varieties was between 36 to 45 days from transplanting.

Effect of nitrogen fertilization :

Nitrogen fertilization not only favoured a stimulative vegetative growth but also enhanced the crop yield in all the six varieties of paddy under study. The five graded levels of nitrogen produced differential effects on growth and the developmental characters of paddy plant. With a

view to study the effects of various levels of nitrogen on the growth, yield contributory characters, yield and quality of paddy an extract of relevant data are presented in Table 29.

A. Effects on growth :

Growth studies have shown that the height of plant, number of tillers, number of functional leaves and total dry matter per hill were all enhanced significantly by nitrogen fertilization. These characters in general, were found to increase with increase in the level of nitrogen upto the highest level of nitrogen i.e. 200 kg N/ha tried. Studies in respect of height obtained in the nitrogen treatments brought out, that a rapid growth in height of plant was noticed upto 25 days from transplanting followed by a slow increase in height upto 40 days. From 40 days onwards upto 70 days the rate of increase in height was accelerated and further it again decreased upto the last observation i.e. at 85 days from transplanting. The magnitude of increase in height of plant varied with the dose of nitrogen applied. Growth was slow in plants receiving no nitrogen. In all the treatments it tended towards linearity till the plants attained their full height. The maximum height of 72.13 cm was observed with 200 kg N/ha and that in control it was only 62.02 cm. Increase in height with increasing nitrogen doses were reported by Joshi (1967), Urkande (1968), Kalyanikutty et al. (1969), Singh (1971), Michael Raj et al. (1974) and Natrajan et al. (1974).

Table 69 : An extract of relevant information on the effects of nitrogen on the growth, yield contributory characters, yield and quality of paddy, nitrogen contents in plants at harvest and soil before transplanting and after harvesting.

Particulars		N_0	N_1	N_2	N_3	N_4
Mean height of plant at 85 days (cm).	...	62.02	65.32	68.39	69.39	72.13
Mean total number of tillers per hill at 85 days.	...	8.29	9.37	9.37	11.00	11.40
Mean maximum number of functional leaves per hill.	...	43.30	50.54	52.55	56.69	61.68
Mean total dry matter per hill at 85 days (g).	...	44.54	48.79	50.75	53.50	57.45
Mean number of effective panicles per hill.	...	8.20	8.44	9.02	10.60	11.02
Mean length of panicle (cm).	...	20.36	21.06	21.52	22.73	22.31
Mean rachis number per panicle.	...	9.25	10.06	10.47	11.58	10.95
Mean weight of fertile spikelets per hill (g).	...	19.66	22.43	24.10	30.53	29.73
Mean weight of sterile spikelets per hill (g).	...	0.99	1.30	1.61	2.34	2.75
Mean number of fertile spikelets per panicle.	...	93.33	110.75	115.49	131.39	124.25
Mean number of sterile spikelets per panicle.	...	18.66	24.19	35.10	44.63	56.32
Percentage of sterile spikelets per panicle (on number basis).	...	16.28	17.67	22.80	25.55	29.83
Mean test weight (g)	...	19.149	23.436	24.147	24.199	23.942
Mean hulling percentage.	...	71.98	72.89	73.32	74.58	73.85
Mean grain yield (q / ha).	...	41.132	46.523	50.924	51.158	49.713
Mean straw yield (q/ha).	...	52.695	61.536	65.247	73.854	80.742
Mean grain to straw ratio.	...	0.780	0.756	0.780	0.692	0.615
Mean nitrogen content in the straw at harvest.	...	0.525	0.636	0.638	0.641	0.689
Mean nitrogen content in the grain at harvest.	...	1.34	1.63	1.67	1.68	1.83
Mean protein content in grain.	...	8.37	10.19	10.44	10.50	11.43
Mean nitrogen percentage in soil before transplanting.	...	0.142	0.133	0.138	0.132	0.140
Mean nitrogen percentage in soil after harvesting.	...	0.127	0.141	0.150	0.152	0.159

As regards to the number of tillers per hill in the present investigation it was found to increase with increase in the level of nitrogen. The maximum tiller number was observed at 70 days with 0, 50 and 100 kg N/ha, and at 55 days with 150 and 200 kg N/ha. Subsequently, death of late formed tillers was noticed which may be due to the cut off of nutrient supply by the mother shoot. Increase in the total number of tillers per hill with increase in the level of nitrogen was reported by Joshi (1967), Ramanujam and Sakharam Rao (1971), Raut (1973) and Mahant (1974).

The number of functional leaves per hill were found to increase with increase in the level of nitrogen. At 55 days maximum number of functional leaves per hill were recorded, thereafter there was a decline in the number of functional leaves due to the drying of the leaves in all the treatments. The maximum number of functional leaves per hill were 43.30, 50.54, 52.55, 56.69 and 61.68 with 0, 50, 100, 150 and 200 kg N/ha at 55 days. Joshi (1967) and Raut (1973) observed that nitrogen fertilization enhanced the number of functional leaves.

The effect of nitrogen fertilization on plant height, tiller number per hill and number of functional leaves per hill was mostly reflected in the total dry matter production per hill. The total dry matter production per hill pronouncely increased with the higher levels of nitrogen fertilization. The rate of dry matter production was maximum between

40 to 55 days. The total dry matter per hill was 48.79, 50.75, 53.50 and 57.45 g with 50, 100, 150, and 200 kg N/ha respectively at the last observation, while in control it was 30.29 g only. Sinha (1970) reported increase in the dry matter production of paddy with higher doses of nitrogen.

B. Effects on yield contributory characters :

The beneficial effects of nitrogen fertilization on vegetative growth ultimately reflected in enhancing the yield contributory characters markedly.

A glance at Table 29 would indicate that the number of effective panicles per hill were found to be increased with nitrogen fertilization upto the highest level i.e. 200 kg N/ha. tried. The number of effective panicles observed at 200 and 150 kg N/ha i.e. 11.02 and 10.60 respectively were of the same order, but were significantly more than those produced at other levels which were at par. Control treatment has recorded lowest number of effective panicles per hill. Increase in the effective panicles per hill with increase in the levels of nitrogen was reported by Koregave (1967), Joshi (1967) and Singh (1971).

The length of panicle as well as number of rachis per panicle were found to increase with increase in the level of nitrogen upto 150 kg N/ha, thereafter at 200 kg N/ha a decline in these characters was noticed. The length of panicle with 150 kg N/ha was 22.73 cm and the number of

rachis per panicle were 11.58. The increase in the length of panicle with increase in the level of nitrogen was also reported by Panchabhai (1958), Koregave (1967), Urkande (1968), Kalyanikutty et al. (1969), Ramteke(1971), Singh (1971), Michael Raj et al. (1974) and Natrajan et al. (1974). Joshi (1967) found increase in rachis number and earhead length with nitrogen.

Nitrogen fertilization had a remarkable effect on weight of fertile spikelets per hill, which was found to be elevated by nitrogen application upto 150 kg N/ha and declined further at 200 kg N/ha. Similar trend was observed in case of number of fertile spikelets per panicle. The weight of fertile spikelets per hill increased from 19.67 g in control 30.53 g with 150 kg N/ha and number of fertile spikelets per panicle increased from 93.33 in control to 131.39 with 150 kg N/ha. Maximum weight of fertile spikelets per hill at 150 kg N/ha may be due to the highest number of fertile spikelets per panicle. Increase in grain number with increased levels of nitrogen has been reported by Panchabhai (1958), Koregave (1967), Urkande (1967), Ranganathan et al. (1970) and Singh (1971).

The weight of sterile spikelets per hill was higher with the higher level of nitrogen fertilization, indicating that more number of sterile spikelets per panicle were produced at higher levels of nitrogen. Similar findings were reported by Yamada (1959) and Tanaka (1965). The number of sterile spikelets per panicle increased from

18.66 in the non fertilized plots to 56.32 with 200 kg N/ha. The sterility percentage on number basis was lowest 16.28 per cent in the control and highest 29.83 per cent with 200 kg N/ha. Chanda (1958) reported that grain number increased upto certain level of nitrogen, and at higher levels of nitrogen increased sterility was found. Increase in sterile grains and sterility percentage with increased level of nitrogen is reported by Yamada et al. (1957).

A keen observation will show that as the number of fertile and sterile spikelets increased per panicle, the weight of fertile and sterile spikelets per hill also increased and vice-versa. The increase in sterility percentage on number basis indicates that with increase in the level of added nitrogen the number of sterile spikelets increased per panicle due to high rate of increase in the total number of spikelets than that of production of the carbo-hydrates which must have resulted in more number of empty spikelets as reported by Yamada et al. (1957). The cumulative effect of these characters must have further reflected in paddy varieties giving quadratic response in respect of grain yield.

Nitrogen fertilization showed a favourable effect on test weight i.e. 1000 grain weight. Application of nitrogen significantly increased the test weight over control. The test weight was significantly increased by applying 150 and 100 kg N/ha over 50 and 0 kg N/ha. These results indicate that weight of individual grain had played a

significant role in increasing the yield over control by nitrogen fertilization. Increase in test weight by application of nitrogen is supported by Koregave (1967), Joshi (1967)& Ranganathan et al. (1970). Majumdar and Dilipkumar (1971) reported that test weight of grain recorded significant decrease with increasing doses of nitrogen. Natrajan et al. (1974) found that test weight was not significantly influenced by nitrogen fertilization.

The hulling percentages of grain were also affected significantly by the nitrogen fertilization. It was lowest in control (71.98 per cent) and highest with 150 kg N/ha (74.58 per cent). It was found to decrease at 200 kg N/ha. The hulling percentage in control indicates the low proportion of rice and high proportion of husk as compared to percentages of rice and husk in fertilized plots. Hulling percentage relates indirectly with the test weight which was significantly increased by nitrogen fertilization over the control plots. These findings are in confirmity with the work of Ramteke (1971).

C. Effect on yield on paddy :

The favourable effects of nitrogen fertilization on vegetative and yield contributory characters were finally reflected on the grain and straw yield. The total yield of grain were 41.132, 46.523, 50.924, 51.158 and 49.713 q/ha with 0, 50, 100, 150 and 200 kg N/ha respectively with the corresponding straw yield of 52.695, 61.536, 65.247, 73.854

and 80.742 q/ha respectively. The increases in absolute figures of grain yield with 50, 100, 150 and 200 kg N/ha over control were 5.391, 9.792, 10.026 and 8.581 q/ha respectively. With the corresponding increases in straw 8.841, 12.552, 21.159 and 28.047 q/ha respectively. All these results of increments showed that yield of grain was found to increase upto 150 kg N/ha and at 200 kg N/ha it declined, where as straw increased progressively with nitrogen fertilization upto 200 kg N/ha. It can be expressed in other words that the grain yield responses obtained with each incremental level of nitrogen were not proportionate and linearly additive. This has ultimately resulted in the quadratic response. Increase in the grain and straw yield of paddy due to increase in the levels of nitrogen has been reported by many workers. Rajgopalan et al. (1974) reported increase in yield upto 120 kg N/ha and the response was found to be quadratic. Rethinam (1974) reported quadratic form of response and maximum grain yield was found to be at 160 kg N/ha.

The diminishing increments in yield of grain and straw resulted in the decrease of grain to straw ratio. The grain to straw ratio with 0 kg N/ha was 0.780 and was found to decrease with increase in the level of nitrogen, except with 100 kg N/ha. The increase in the straw was matched by increase in the grain yield keeping the ratio at a par with that of control. The decrease in the grain to straw ratio with higher levels of nitrogen indicates

that proportion of grain got reduced as compared to straw at higher levels of nitrogen. These results and in agreement with those reported by Panchabhai (1958), Rao (1962), Joshi (1967), Koregave (1967), Raut (1970) and Mahant (1974).

D. Chemical studies :

Chemical studies showed that the concentration of nitrogen in the straw and grain were enhanced by nitrogen fertilization. The nitrogen percentage of straw in control was increased from 0.525 per cent to 0.689 per cent with 200 kg N/ha, whereas the percentage of nitrogen in grain increased from 1.34 per cent in control plots to 1.83 per cent in 200 kg N/ha. Thus, the grains were richer in nitrogen content than the straw. This may be due to the translocation of nitrogen from vegetative parts towards the generative portion of the plant, leaving the straw poorer in nitrogen. Quality studies were made by working out the protein content in the grains. These data have also shown that the nitrogen fertilization had very pronounced effect in increasing the protein content of grains. The percentage of protein was found to increase with each increment in the dose of nitrogen applied. These studies have clearly indicated that nitrogen fertilization not only enhanced the growth and yield contributory charactersbut also enhanced the concentration of nitrogen in plant tissues, which ultimately resulted in enhancing the grain yield and

improved the quality of grain. Increase in nitrogen content of grain and straw with increased nitrogen levels is reported by Joshi (1967), Urkande (1968) and Raut (1970). Increase in protein content of grain with increased levels of nitrogen application is reported by Swaminathan (1964), Sadayappan and Kolandaiswamy (1974), and Krishnaswamy et al. (1974). Muthuswamy et al. (1973) and Subramaniam et al. (1974) contrary to the above findings stated that nitrogen level had no effect on the protein content of grain.

Studies regarding the soil nitrogen content before transplanting and after harvesting of crop were made. The soil nitrogen content before transplanting was varying from 0.132 to 0.142 per cent. On an average, it was 0.137 per cent. Studies of soil nitrogen content after harvesting have brought out that the plots fertilized with higher doses were, inspite of heavy cropping, richer in the left over of the soil nitrogen, whereas soil under control plots was deplected in nitrogen content. From the initial status of 0.132 per cent nitrogen in the soil before transplanting on an average, 0.145 per cent nitrogen was recorded after harvest. The increase in nitrogen content after harvest appears to be quite high. The probable reason might be due to continuous application of heavy doses of nitrogen to paddy crop grown in the earlier seasons and high native fertility. The other reason may be that the varieties under study are not in a position to take up such as large amount

of nitrogen which must have resulted in left over of high quantities of nitrogen. Raut (1970) and Ramteke (1971) in their studies reported that fertilized plots with higher doses of nitrogen, inspite of heavy cropping were richer in the left over of nitrogen while soil in control plots was found to be depleted in nitrogen content.

Varietal differences :

In order to study the probable varietal features responsible for differences in grain yield, an extract of relevant data on some of the important plant characters are presented in Table 30.

A. Effects on growth :

It would be seen from Table 30 that the varieties under study showed no significant differences in respect of height and total dry matter per hill. The maximum number of tillers per hill were recorded by variety Soorya, which was significantly superior over Suhasini, Satya and Jaya. Soorya was found to be at par with Jayanthi and Sona. Jayanthi was significantly superior over Jaya. Jaya recorded lowest number of tillers per hill. The maximum number of functional leaves were recorded in Soorya followed by Jayanthi and Sona at 55 days of the crop growth but the differences were found to be non significant. Satya had produced maximum number of functional leaves at 40 days.

Table 30 : An extract of relevant information on the growth, yield contributory characters, yield and quality of paddy, nitrogen content in plants at harvest and soil before transplanting and after harvesting as affected by varieties.

Particulars	V_1 V_1	V_2	V_3	V_4	V_5	V_6
Mean height of plant at 85 days (cm).	70.17	66.92	66.09	68.55	67.39	65.58
Mean total number of tillers per hill at 85 days.	9.17	9.85	10.38	9.29	10.90	9.75
Mean maximum number of functional leaves per hill.	50.38	53.66	54.60	49.38	57.73	51.98
Mean total dry matter per hill at 85 days (g).	56.65	50.70	49.40	46.65	52.20	50.45
Mean number of effective panicles per hill.	9.11	9.46	9.38	9.06	10.19	9.56
Mean length of panicle (cm).	22.89	21.33	21.77	21.39	21.00	21.19
Mean rachis number per panicle.	10.85	10.17	9.82	11.12	10.12	10.70
Mean weight of fertile spikelets per hill (g).	30.08	24.27	21.23	26.01	25.33	24.82
Mean weight of sterile spikelets per hill (g).	2.08	1.93	1.69	1.44	1.89	1.75
Mean number of fertile spikelets per panicle.	106.76	125.97	129.65	117.88	104.96	105.03
Mean number of sterile spikelets per panicle.	43.98	33.41	31.54	26.28	40.90	36.57
Percentage of sterile spikelets per panicle (on number basis).	27.43	19.22	18.10	18.71	26.00	25.10
Mean test weight (g).	25.576	19.134	19.370	25.637	23.806	24.325
Mean hulling percentage.	73.63	72.74	72.80	73.50	73.64	73.64
Mean grain yield (q/ha).	51.575	48.489	44.895	47.929	46.744	47.708
Mean straw yield (q/ha).	74.296	69.492	61.015	60.768	72.486	62.864
Mean grain to straw ratio.	0.694	0.697	0.733	0.788	0.644	0.758
Mean nitrogen content in the straw at harvest.	0.630	0.628	0.630	0.619	0.618	0.629
Mean nitrogen content in the grain at harvest.	1.69	1.58	1.55	1.64	1.66	1.67
Mean protein content in grain.	10.56	9.87	10.25	10.25	10.37	10.44
Mean nitrogen percentage in soil before transplanting.	0.134	0.139	0.141	0.131	0.133	0.145
Mean nitrogen percentage in soil after harvesting.	0.144	0.148	0.150	0.138	0.141	0.154

B. Effects on yield contributory characters :

Scrutiny of yield contributory characters would reveal that the varieties differ significantly in respect to almost all the characters studied except the number of effective panicles per hill. Variety Jaya recorded significantly longest panicle length than all other varieties which were of the same order. Highest number of rachis per panicle were found in the variety Satya followed by Jaya and Suhasini which were at par but were significantly more than Sona, Soorya and Jayanthi which were also at par. Variety Jaya gave significantly highest weight of fertile spikelets per hill, while the variety Jayanthi gave the minimum weight of fertile spikelets per hill. These important yield contributory characters might have reflected in the highest yield of Jaya and the lowest yield of Jayanthi. The weight of sterile spikelets per hill was found to be highest in Jaya and was significantly more as compared to Jayanthi and Satya.

The highest number of fertile spikelets per panicle were found in the fine grain variety Jayanthi followed by Sona and both have produced significantly more number of fertile spikelets per panicle as compared to all other varieties except Satya. Variety Jaya recorded the highest number of sterile spikelets per panicle followed by Soorya, Suhasini, Sona, Jayanthi and Satya. The percentage of sterile spikelets per panicle on number basis was significantly

more in Jaya, Soorya and Suhasini than Sona, Satya and Jayanthi. In general the grain filling was not proper in coarse and medium grain varieties as compared to fine grain varieties which might have resulted in higher percentage of sterile spikelets.

In respect of grain type the variety Jaya is coarse, Satya, Soorya and Suhasini are medium while Sona and Jayanthi are fine grain varieties. The test weight of these varieties was found to differ significantly. The coarse variety Jaya had significantly more test weight as compared to medium and fine ones except Satya a medium grain variety recorded higher test weight than Jaya, but they were at par. The test weight of fine grain varieties Sona and Jayanthi was also found to be significantly less as compared to all other coarse and medium grain varieties. Ramiah (1952) observed that generally coarse varieties give the larger yield as compared to fine ones. This indicates that weight of individual grain played a significant role in grain yield differences exhibited by the varieties under study.

The varieties differ significantly in respect of hulling percentage. The differences in percentages observed in Soorya, Suhasini and Jaya though were not significant they were significantly higher than the percentages recorded in Satya, Jayanthi and Sona.

C. Effects on yield :

The differential behaviour in respect of several

characters studied were ultimately reflected into the significant differences in the grain and straw yields. The highest grain and straw yields were obtained in Jaya, which had given significantly more grain yield as compared to all other varieties. The other varieties namely Soona, Satya, Suhasini and Soorya were at par with the yield in descending order. Sona and Satya gave significantly higher grain yield as compared to Jayanthi whereas the grain yield of Suhasini, Soorya and Jayanthi were of the same order. Jaya produced the maximum straw yield followed by Soorya, Sona, Suhasini, Jayanthi and Satya. The respective per hectare straw yields were 74.296, 72.486, 69.492, 62.864, 61.015 and 60.768 quintals.

The chief cause of higher grain and straw yield in Jaya may be attributed to the highest dry matter production and superior yield contributory characters such as more weight of fertile spikelets per hill and test weight. Bhapkar and Jadhao (1969) and Shastry (1969) reported superiority of Jaya in grain yield as compared to other high yielding dwarf varieties in trials conducted under AICRIP. These results are in agreement with the results obtained by Kanwar and Mahapatra (1971).

The grain to straw ratio was highest in the variety Satya followed by Suhasini, Jayanthi, Sona, Jaya and Soorya. It would be seen from the data presented in Table 30 that in all the varieties the proportion of straw was greater than that of the grain. In the present investigation Satya

had greater efficiency of giving higher grain yield than all other varieties.

D. Chemical studies :

Nitrogen percentages in the straw at harvest were 0.630, 0.628, 0.630, 0.619, 0.618 and 0.629 in Jaya, Sona, Jayanthi, Satya, Soorya and Suhasini with the corresponding nitrogen percentages of 1.69, 1.58, 1.55, 1.64, 1.66 and 1.67 in grains respectively. This indicates that the nitrogen percentage in straw was lower than the percentage in grain in all the varieties. This might be due to the translocation of nitrogen from vegetative parts to the reproductive portions of the plants. Quality studies of grains in terms of protein varied in the same proportion of nitrogen content of the grain in the corresponding varieties. The protein content of grain in Jaya was the highest followed by Suhasini, Soorya, Satya, Sona and Jayanthi.

The initial nitrogen status of the soil though was high, uniformity in nitrogen content was not observed. It would be seen from the data presented in Table 30 that the nitrogen concentrations after harvest in soil under all the varieties were found to be increasad over the initial percentages in soil indicating left over of nitrogen in soil by these varieties.

Nitrogen x variety interaction :

Out of the several interactions studied in this

investigation, only nitrogen x variety interaction was found to be significant in very few characters viz. weight of sterile spikelets per hill, test weight and hulling percentage.

The weight of sterile spikelets was found to increase with increase in the level of nitrogen in Sona and Jayanthi. In all other varieties no definite trend was observed. Sona and Jayanthi produced the highest weight of sterile spikelets per hill at 200 kg N/ha and the lowest weight was given by the same in the control plots. Ramteke (1971) also found significantly nitrogen x variety interaction in respect of weight of sterile spikelets per hill, where it increased with increase in the level of nitrogen.

The test weight of all the varieties except Sona was significantly increased by the various levels of nitrogen over the control. Satya recorded highest test weight at 200 kg N/ha, which was at par with 150 and 100 kg N/ha. This did not show significant differences with Jaya at all the levels of nitrogen and Soorya at 100 kg N/ha.

Hulling percentage was found to increase with increase in the level of nitrogen upto 150 kg N/ha in all the varieties. Soorya gave significantly higher hulling percentage with 150 kg N/ha than all other combinations except to that of Jaya and Suhasini at the same level.

Correlation studies :

Correlation studies revealed that the yield of paddy was significantly correlated with the yield contributory

characters such as number of effective panicles per hill, number of fertile spikelets per panicle and the test weight in all the varieties under study, except the number of fertile spikelets per panicle in Sona and Soorya, and the test weight in Jayanthi. The positive correlation between grain yield and the yield contributory characters studied in the present investigation have been reported by Sadanathan (1958), Bains et al. (1969), Raut (1970) and Palaniswamy (1974).

Yield response data :

Significant quadratic response to nitrogen application was observed in all the varieties under study. The predicted yield in absence of nitrogen fertilization could be taken as the measure of native soil fertility. It was observed from data presented in Table 23, that the yield had started falling down after reaching 55.88 q/ha at 150 kg N/ha in Jaya, 51.75 q/ha at 150 kg N/ha in Sona, 47.74 q/ha at 100 kg N/ha in Jayanthi, 54.34 q/ha at 200 kg N/ha in Satya, 49.95 q/ha at 150 kg N/ha in Soorya and 49.98 q/ha at 200 kg N/ha in Suhasini. A critical study of the table will show that the increase in grain yield with the increased levels of nitrogen fertilization in all the varieties under study was in decreasing order. This decreasing response of yield has indicated that it is tending towards the law of diminishing returns. Raut (1970) observed quadratic response in Jaya. Rajgopalan et al. (1974) observed a quadratic response in Jayanthi and Sona.

Economics of nitrogen fertilization :

The crop responded well to nitrogen fertilization. Hence most important and realistic economic problem that arises is to calculate the most profitable rate (MPR) of nitrogen fertilization. Nutrient costs change to a very little extent during the crop season. On the contrary, the selling rate of the produce is subjected to a greater variation depending on the acerage under a crop, market demand, nearness or other-wise to the market, nature of produce and such other factors. The selling rate may vary from a very low uneconomic rate to a highly remunerative one, not only from year to year but even during the same season for different periods. Hence consideration of optimum dose of nitrogen fertilization under as wide a range of selling rates as possible has a great practical utility. Such data have been presented in Table 24.

It was observed from the data that the optimum doses of nitrogen for Jaya, Sona, Jayanthi, Satya, Soorya and Suhasini were 119.900, 112.000, 102.050, 164.400, 97.100 and 100.150 kg N/ha respectively, with the corresponding monetary returns of Rs. 1,054.22, 1,316.59, 1,127.52, 1,943.12, 1,212.70 and 194.35 per hectare respectively. Soorya had given maximum profit per rupee investment. The optimum doses of the varieties under study have been calculated only by taking into consideration the cost of fertilizer. But other items such as cultural expenses,

plant protection measures etc. which consume lot of expenditure are also required to be taken into account at the time of computing economic optimum dressings.

Finally, it may be stated that the results obtained in the present investigation are based on only one year's trial. In order to bring out sound recommendations, these studies need to be repeated for two to three years more.

VI. SUMMARY

The field experiment was laid out in split-plot design with four replications on Agricultural College Farm, Nagpur at Telangkhedi Block, during Kharif 1974 to study the yield potential of six promising paddy (Oryza sativa L.) varieties under different nitrogen levels. The main plot treatments consisted of five levels of nitrogen viz. 0, 50, 100, 150 and 200 kg N/ha and the sub plot treatments consisted of six varieties of paddy viz. Jaya, Sona, Jayanthi, Satya, Soorya and Suhasini. The experimental site was high in total nitrogen with adequate total phosphorus and total potash. The rainfall, during the period of the experimentation was in general, unfavourable for the normal growth of paddy.

Periodical observations were recorded on important growth and yield contributory characters to evaluate the treatment effects. Studies on the nitrogen content in the straw and grain, and quality of grain based on protein content as influenced by the treatments were studied. Emphasis was also given to the economic analysis of the yield data, resulting upon different factors under study. Some of the important findings of this investigation are summarised below.-

I. Effects of nitrogen fertilization :

A. Growth studies :

Nitrogen fertilization had significantly increased the mean plant height, number of tillers, functional leaves

and total dry matter production per hill. These characters, in general were found to increase with increase in the level of nitrogen. AGR of dry matter production in g per hill per week was found to increase with increase in the level of nitrogen between 26 to 40 days but no definite trend was observed during subsequent observations. RGR was found to be higher in control plot at all the observations except, between 71 to 85 days.

B. Yield contributory characters :

A favourable effect of nitrogen was also noticed on the yield contributory characters. The number of effective panicles and weight of sterile spikelets per hill were found to increase with increase in the level of nitrogen upto the highest dose of 200 kg N/ha, which was at par with 150 kg N/ha. Application of 200 kg N/ha was found to be significant over other levels in respect of the above characters. An increase upto 150 kg N/ha was recorded in respect of the length of panicle, number of rachis per panicle and mean weight of fertile spikelets per hill. The length of panicle and weight of fertile spikelets per hill were of the same magnitude with 150 and 200 kg N/ha which were significantly superior over other levels of nitrogen. 150 kg N/ha recorded significant increase in number of rachis per panicle over all other levels of nitrogen.

The highest number of fertile spikelets were recorded with 150 kg N/ha which was at par with 200 kg N/ha and significant over 100, 50 and 0 kg N/ha. The number of sterile

spikelets per panicle as well as percentage of sterile spikelets per panicle (on number basis) were found to be increased with 200 kg N/ha. 200 kg N/ha recorded significantly highest number of sterile spikelets per panicle than all other levels of nitrogen, while it was at par with 150 kg N/ha in respect of percentage of sterile spikelets per panicle and significant over other nitrogen levels.

The test weight was influenced favourably by nitrogen fertilization. Nitrogen fertilization significantly increased the test weight over control. It was of the same order at 150, 100 and 200 kg N/ha.

The hulling percentage of grain was enhanced by the nitrogen application. Application of 150 kg N/ha was found to record significantly more hulling percentage over all other levels of nitrogen.

C. Yield :

Nitrogen fertilization significantly increased the grain and straw yield. The grain yield was found to increase upto 150 kg of nitrogen per hectare, while the straw yield was increased upto 200 kg N/ha. The per hectare grain yield with 0, 50, 100, 150 and 200 kg N/ha was 41.132, 46.523, 50.924, 51.158, and 49.713 quintals respectively. The corresponding straw yield was 52.695, 61.536, 65.247, 73.854 and 80.742 quintals respectively. Grain yield at 150, 100 and 200 kg N/ha was of same order.

The grain to straw ratio was found to decrease with higher levels of nitrogen.

D. Chemical studies :

Chemical studies revealed that concentration of nitrogen in straw and grain increased with increasing levels of nitrogen. The grains were richer in nitrogen than the straw. The beneficial effects of nitrogen application were also noticed in the improvement of quality of the grain. The nitrogen fertilization enhanced the protein content of the grain.

Studies regarding soil nitrogen content at harvest brought out that the plots fertilized with higher doses of nitrogen, inspite of heavy cropping were richer in the left over of the soil nitrogen, while soil in control was found to be depleted in nitrogen content.

II. Effects of varieties :

A. Growth characters :

The varieties did not differ significantly in respect of height and total dry matter production per hill, whereas significant differences were observed in respect of total number of tillers and functional leaves per hill. Soorya gave significantly higher number of tillers than Suhasini, Satya and Jaya, whereas Jayanthi was significant over Jaya. The maximum number of functional leaves were recorded in Soorya followed by Jayanthi and Sona at 55 days of crop growth.

B. Yield contributory characters :

The varieties under study recorded significantl differences in respect of all the yield contributory characters except the number of effective panicles per hill. Jaya recorded significantly longest panicle length and highest weight of fertile spikelets per hill than all other varieties. The number of rachis per panicle were significantly higher in Satya, Jaya and Suhasini, which were at par, but were significantly superior to Sona, Soorya and Jayanthi which were of the same order. Jaya recorded significantly more weight of sterile spikelets per panicle than Jayanthi and Satya, while Sona and Soorya were significant over Satya.

The fine grain varieties Jayanthi and Sona recorded significantly highest number of fertile spikelets than Jaya, Suhasini and Soorya. Number of sterile spikelets and percentage of sterile spikelets per panicle (on number basis) were found to be maximum in Jaya.

The varieties under study showed significant differences in respect of the test weight. Highest test weight was recorded in Satya which was at par with Jaya. The lowest test weight was recorded in the fine grain varieties Jayanthi and Sona which were of the same magnitude.

The hulling percentages recorded in Soorya, Suhasini and Jaya were of the same order, but were significantly higher than all other varieties. The fine grain varieties Jayanthi and Sona recorded significantly lowest hulling percentages.

C. Yield :

Significant differences were observed in the grain and straw yields of the different varieties. The highest grain and straw yields were obtained in Jaya, which had given significantly more grain yield as compared to all other varieties. The per hectare grain yield in Jaya, Sona, Jayanthi, Satya, Soorya and Suhasini was 51.575, 48.489, 44.895, 47.929, 46.744 and 47.708 quintals respectively, with corresponding straw yield of 74.296, 69.492, 61.015, 60.768, 72.486 and 62.864 quintals respectively.

Grain to straw ratio was maximum in Satya and minimum in Soorya.

D. Chemical studies :

Chemical studies revealed that the varieties recorded higher nitrogen content in the grain than in the straw. The highest nitrogen and protein content in the grain was found in Jaya followed by Suhasini, Soorya, Satya, Sona and Jayanthi.

Nitrogen x varieties interaction :

Out of the several characters studied, nitrogen x varieties interaction was found to be significant in very few characters namely, weight of sterile spikelets per hill, test weight and hulling percentage. The weight of sterile spikelets was found to increase with increase in the level of nitrogen in Sona and Jayanthi. In all other varieties

no definite trend was observed. The test weight of all the varieties except Sona was significantly increased by the various levels of nitrogen over the control. The variety Satya has recorded highest test weight at 200 kg N /ha. Hulling percentage was found to increase with increase in the level of nitrogen upto 150 kg per hectare in all the varieties. Soorya has given highest hulling percentage at 150 kg N/ha.

Correlation studies :

The yield of paddy was significantly correlated with the yield contributory characters such as number of effective panicles per hill, number of fertile spikelets per panicle and the test weight in all the varieties, except the test weight in Jayanthi and number of fertile spikelets per panicle in Sona and Soorya.

Yield response data and economics of nitrogen fertilization :

Significant quadratic response to nitrogen fertilization was observed in all the varieties under study. The optimum levels of nitrogen for Jaya, Sona, Jayanthi, Satya, Soorya and Suhasini were 119.900, 112.000, 102.050, 164.400, 97.100 and 100.150 kg / ha respectively, with the corresponding net returns from nitrogen fertilization of Rs. 1,054.22, 1,316.59, 1127.52, 1943.12, 1212.70 and 194.35 respectively under Nagpur conditions, at the prevailing rates of paddy and nitrogen. Soorya had given maximum net

profit per rupee investment. The maximum yields of 55.85, 51.89, 48.05, 54.35, 50.94 and 48.77 quintals /ha were obtained in Jaya, Sona, Jayanthi, Satya, Soorya and Suhasini at 151.25, 133.90, 123.30, 196.40, 114.95 and 218.70 kg N/ha respectively.

*****

LITERATURE CITED

of rice (Oryza sativa L.) to different levels of soil fertility. Thesis submitted to I.A.R.I., New Delhi, for Associateship.

Dayanand, Singh, K.N. and Bains, S.S. 1972. Relative responses of different varieties of rice to graded levels of nitrogen on saline soil with high water table. Indian J. Agron. 17 (3): 156-157.

Gupta, S.K. and Padalia, C.R. 1971. A note on correlation studies of yield attributing characters in different high yielding varieties of rice. Oryza (1971) 8(1): 103-106.

* Ishizuka, Y. 1965. Nutrient uptake at different stages of growth. Paper No.13 of the Mineral nutrition of rice plant. Jahns Hopkins Baltimore, Maryland: 199-217.

Jackson, M.L. 1958. Soil chemical analysis. Prentice Hall Inc., Englewood, Cliffs, N.J.

Joshi, K.S. 1967. Influence of nitrogen applied at different growth phases and phosphate at planting on growth, uptake of N and P_2O_5 , yield and quality of paddy Var. T(N)-1. Thesis submitted to Nagpur University for M.Sc.(Agri.) (Unpublished).

Joshi and Bhapkar 1969. Quoted from thesis by Raut, S.D. (1970), submitted to P.K.V., Akola for M.Sc.(Agri.).

Kalyanikutty, T., Narayanan, T.R. and Srinivasan, V. 1969. High yielding varieties of rice in Tamilnadu. Their response to nitrogen and spacing. Madras Agric. J. 56 (5): 209-213.

_____ and Morachan, Y.B. 1974. Influence of NPK on the growth, yield and composition of rice varieties differing in inherent yield potentials. Madras Agric. J. 61 (8): 239-244.

Koregave, B.A. 1967. The study of maximum yielding capacity of paddy under irrigated conditions. Thesis submitted to Nagpur University for Ph.D.

Krishnaswamy, R., Kothandaraman, G.V., Jeyaraj, G. and Krishnamoorthy, K.K. 1974. Yield and quality of IR-8 rice (Oryza sativa L.) as influenced by fertilization. Madras Agric. J. 61 (8): 262-267.

Kulandavivelu, R. and Kallappan, R. 1971. The response of ADT-27 rice to nitrogen and spacing. Madras Agric.J. 58 (8): 703-704.

Lakhdive, B.A. 1968. Yields and nitrogen uptake by rice as affected by rates and sources of nitrogen, nitrification inhibitor treatment and variety. Thesis submitted to I.A.R.I., New Delhi for Ph.D.

Lenka, D. and Behera, P.C. 1967. Response of four Taiwan and two local varieties of paddy to high levels of nitrogen. Indian J. Agron. 12 (4): 353-357.

_____ and Misra, B. 1973. Path-coefficient analysis of yield in rice varieties. Indian J.Agric.Sci. 43(4): 376-379.

Lindt, J.H. 1953. Rice fertilization. Rice J. 56(7):31-32.

Mahant, J.N. 1974. To study the performance of rice varieties under lowland and upland conditions. Dissertation submitted to P.K.V.,Akola for M.Sc.(Agri.).

Mahapatra, I.C. and Panda, S.C. 1969. Plant density and fertilizer needs of rice varieties. Advances in upland rice Agron. I.C.A.R., New Delhi, Dec. 1969: 6-7.

_____ and Bapat, S.R. 1971. Response of rice to fertilizers on farmers fields in A.P. Indian Fmg. 21 (2):34-40.

Majumdar and Dilipkumar 1971. Effect of sowing time and fertilizers on yield attributes and yield of rice. Indian J. Agron. 16 (1): 6-10.

Michael Raj, S., Morachan, Y.B., Subramanian, S. and Subbiah, K.K. 1974. Effect of plant density and rate of nitrogen application on IR-20 rice. Madras Agric. J. 61 (8): 289-292.

Mishra, K.N., Nanda, J.S. and Chaudhary, R.C. 1973. Correlation, path-coefficient and selection indices in dwarf rice. Indian J.Agric. Sci. 43 (3):306-311.

Munegowda, M.K. and Mahadevappa, M.M. 1971. A note on the performance of high yielding varieties of paddy in Shimoga District. Mysore J.Agric. Sci. 5(3):354-356.

Muthuswamy, P., Raj,D. and Krishnamoorthy, K.K. 1973. Effect of forms and levels of fertilizers nitrogen on the quality of certain high yielding varieties. Madras Agric. J. 60 (1): 12-16.

Natrajan, C.T., Ganapathy, S. and Teetharappan, T.S. 1974. Response of rice var. Jaya (L) for nitrogen. Madras Agric. J. 61 (9): 653-654.

Palaniswamy, K.M. 1974. Correlation studies in rice under different densities and fertilizer levels. Madras Agric. J. 61 (9): 663-665.

Panchabhai, K.R. 1958. Study of response of some indica and japonica types of rice to the various N and P levels in the boro crop season. Thesis submitted to I.A.R.I., New Delhi for Associateship.

Panchaksharaiah, S., Mahadevappa, M. and Chandrasekharappa,D. 1972. Response of paddy varieties to progressive nitrogen application. Mysore J.Agric. Sci. 6 (4): 393-398.

Patnaik, S. and Abichandani, C.T. 1957. Studies on nutrition of rice plant at C.R.R.I., Cuttack. Rice News Letter 5: 28.

Pillai, G.R., Nair, R.R., Pisharody, P.N. and Gopalakrishnan,R. 1972. Effect of spacing, number of seedlings per hill and nitrogen on growth and yield of Annapurna rice (Oryza sativa L.). Agric.Res. J.,Kerla 10 (2): 86-92.

Piper, C.S. 1950. Soil and plant analysis. 1st ed. :59. Univ. of Adelaide.

Rajgopalan, K., Venkatesan, G., Chandran,V.R. and Robinson,J.C. 1974. Variety- Nitrogen interaction in some of the newly evolved high yielding rice varieties. Madras Agric. J. 61 (9): 659-662.

Ramanujam, T. and Sakharam Rao, J. 1971. Influence of N supply on growth factors of rice. Madras Agric.J. 58 (3): 239-244.

* Ramiah, K. and Narsimhan, M. 1936. Developmental studies in rice. Madras Agric. J. 24 (2): 50-66.

_____ 1951. Rice Research in India. Hosali Press, Banglore. India.

Ramteke, J.R. 1971. Influence of levels of N and P on growth, yield and quality of three varieties of paddy. Thesis submitted to P.K.V., Akola for M.Sc. (Agri.).

Ranganathan, T.B., Palaniswamy, K.M. and Srinivasan, V. 1970. Studies on the performance and response of some exotic rice varieties to two levels of manuring at Coimbatore. Madras Agric. J. 57 (1): 18-21.

Rangiah, P.K. 1973. Nitrogen response and yield potential of some high yielding rice varieties. Madras Agric. J. 60 (2): 100-103.

Rao, M.V. 1969. Response of high yielding varieties and cultures to nitrogen. C.R.R.I. Tech.Report.(1969): 26-28.

Raut, S.D. 1970. Response of five new varieties of paddy (Oryza sativa L.) to nitrogen fertilization under irrigated conditions. Thesis submitted to P.K.V., Akola, for M.Sc.(Agri.).

Raut, P.N. 1973. To study the performance of rice varieties under lowland and upland conditions. Dissertation submitted to P.K.V., Akola for M.Sc.(Agri.).

Ray Chaudhari, C.P. 1952. Chemical fertilizers and soil productivity. Indian J.Agric.Sci. 22 : 223-224.

Ray Chaudhari, B. 1968. Response of paddy to fertilizer application. Fertil. News 13 (2): 29-31.

Rethinam, P. 1974. A study of functional relationship for rice (Padma) response to nitrogen. Madras Agric.J. 61 (8): 249-252.

Sadanathan, N. 1958. Effects of split application of nitrogenous fertilizers on the yield and other agronomic characters of rice. Thesis submitted to the I.A.R.I., New Delhi for Associateship.

Sadayappan,S. and Kolandaiswamy,S. 1974. Influence of added nitrogen and its time of application on grain protein, phosphorus, and potash. Madras Agric. J. 61 (9): 646-647.

Saini, S.S. 1971. Jaya the new high yielding dwarf rice variety does better than IR-8 in the Punjab. Indian Farming. 21 (2): 43-44.

Sarathe, M.L., Sharma, K.K. and Shrivastava, M.N. 1969. Study of yield attributes and heretability in some varieties of rice. Indian J.Agric. Sci. 39 (9):925-929.

Sastry, N.S., Rao, M.J.B. and Rawlo, S. 1967. The relationship between grain yield and associated characters in some short statured and high yielding rice varieties. Int. Rice Commn. Newsl. 16 (4): 20-42.

Sethi, R.L., Ramiah, K. and Abraham,T.P. 1952. Manuring of rice in India. I.C.A.R. Bull. 38 : 122.

Sharma, S.E. and De,R. 1969. Effect of method of irrigation and rate,and method of nitrogen application on yield of rice. Advances in upland rice Agron. I.A.R.I., New Delhi: 9.

Shastry, S.V.S. 1969. New high yielding varieties of rice, Jaya and Padma. Indian Farming. 18 (11): 5-13.

_____ 1970. Quoted from the thesis by Raut,S.D.(1970).

Singh, R.S. 1971. Response of three types of rice to various levels of nitrogen and spacings. Indian J. Agric. Res. 5 (3): 185-189.

Singh, M. and Varma, S.C. 1971. Effect of different rates of nitrogen and phosphorus application on the yield and yield attributing characters of T(N)-1 rice. Indian J.Agron. 16 (3): 257-260.

Singh, B.P. and Malik, H.S. 1972. Influence of nitrogen application on yield and net returns of high yielding varieties of rice. Madras Agric. J. 59 (1):19-22.

Singlachar, M.A. 1973. Nitrogen response in medium duration rice varieties. Mysore J.Agric.Sci. 7 (2): 316-317.

Sinha, T.D. 1970. Optimum levels of nitrogen for IR-8 paddy. J. Tirhut Coll.Agri. 4: 53.

Sircar, S.M. and Sen, N.K. 1941. Studies in the physiology of rice. I. Effects of phosphorus deficiency on growth and nitrogen metabolism in rice leaves. Indian J. Agric. Sci. 11 (2): 193-204.

Subramanian, A., Palaniappan,S.P. and Morachan,Y.B. 1974. Effect of graded doses of nitrogen and the method of planting on the protein content of rice (IR-8) grain. Madras Agric. J. 61 (9): 657-658.

Sumbali, G.L. and Gupta, D.K. 1972. Response of paddy (IR-8 and Jaya) to nitrogen. Indian J.Agron. 17 (4): 279-283.

Swaminathan, M.S. 1964. Nutritive content of rice. Proc. of Nutri.Society of India. Abstr. 1: 44-47.

Tanaka, A., Patnaik,S. and Abichandani,C.T. 1958. Studies on the nutrition of rice plant. I. Influence of nitrogen levels on growth and nutrient uptake of rice plant. Proc. Indian Acad.Sci. 47 : 140-154.

_____, 1959. Studies on the nutrition of rice plant. III. Partial efficiency of nitrogen absorbed by rice plant at different stages of growth in relation to yield of rice. Proc. Indian Acad.Sci. Sect. B. 49 (4): 207-216.

Tanaka, A.1964. Plant characters related to nitrogen response in rice. The mineral nutrition of rice plant. Proc. of symposium at the I.R.R.I. Inc. Johns.,Hopkins, Press, Baltimore : 419-435.

_____ 1965. Plant characters related to nitrogen response. Paper No.24. Johns Hopkins, Mary-Land.

_____, and Kawano, K. 1966. Effect of mutual shadding on dry matter production in tropical rice plant. Pl. Soil 24 : 128-144.

Urkande, V.M. 1968. To study the growth, yield, uptake of nitrogen and quality of paddy variety R-15 Chinoor as affected by different nitrogen and their times of application. Thesis submitted to Nagpur University for M.Sc. (Agri.).

Veeraraja Urs, Y.S. and Mahadevappa, M.M. 1972. Effect of spacing and fertilizers application on growth and yield of Jaya, IR-8 and IR-5 varieties of paddy. Mysore J. Agric. Sci. 6 (4): 399-404.

Verma, V.N. and Srivastava, K.N. 1972. Response of IR-8 rice to different levels and split application of nitrogen. Indian J.Agron. 17 (1): 5-8.

* Yamada, N., Ota, Y. and Kushibuchi, K. 1957. Studies on ripening of rice. I. Role of nitrogen in the process of ripening of rice. Proc. Crop Sci. Soc. Japan. 26 (2): 115.

Yamada, N. 1959. The nature and fertilizer response in japonica and indica rice varieties. I.R.C. 8 (4):14-19.

Yogeswara Rao, Y. and Padmanabham, M. 1971. Performance of new varieties of rice in West Godavari district (A.P.). Indian J. Agron. 16 (3): 360-362.

---

* Originals not seen.