EFFECT OF NITROGEN FERTILIZERS ON GROWTH, YIELD AND QUALITY OF HYBRID RICE (ORYZA SATIVA)

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ABSTRACT

A field trial to determine the effect of different nitrogenous (N) fertilizers on growth, yield and quality of hybrid rice variety 'Proagro 6207', comprising of 10 different treatments using randomized complete block design with three replications was conducted at Agricultural Research Station, Bilaspur Chhattisgarh, India. The two years data during 2002 and 2003 revealed that all the growth characters, yield parameters and grain nitrogen (N) increased significantly with an application of sulphur-containing nitrogen fertilizer- Super Net. These results were statistically at par with that of treatment T4, where ammonium sulphate nitrate was applied. In this series of experiment, non-sulphur-containing nitrogen fertilizer, urea gave lowest yield and grain nitrogen (N) content and these reductions were significant in all of the experiments.

KEY WORDS: Benefit: cost ratio, fertilizer, hybrid rice, nitrogen, Oryza sativa, yield.

INTRODUCTION

Rice (Oryza sativa L.) is one of the most important cereal crops of the world, grown in wide range of climatic zones, to nourish the mankind. Introduction of hybrid rice is an important step towards augmentation of rice yield. Hybrid rice yields about 15-20% more than the promising high-yielding commercial varieties. Earlier studies reveal that judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice [14].Given the importance of nitrogen fertilization on the yield in grain from the rice plant, it is necessary to know what the best dose is for each variety as well as its influence on components of yield and other agronomic parameters such as the cycle, plant height, lodging and moisture content of the grain, in order to obtain better knowledge of said productive response. Tanaka et al. (1966) showed that the height of a rice plant is positively correlated to the length of the maturation cycle. A taller plant is more susceptible to lodging and responds less well to nitrogen [25]. Panicles with a low percentage of sterile flowers permit the application of higher doses of nitrogen and produce better yields [26]. Some factors, like early sowing, meet the twin objectives of producing higher yields and improving the grain quality[10, 2]. Other factors, like increased rates of fertilizer nitrogen, may increase the yield but reduce the quality of the grain [2]. An adequate supply of nitrogen to the crop plants during their early growth period is very important for the initiation of leaves and florets primordia [23].

The type of nitrogenous fertilizer may also affect the yield and quality of the grain [4]. Some of these fertilizers, like urea, are substantially cheaper than others, and their use may be justified on economic grounds provided they do not adversely affect the yield or quality of the grain. Gately et al. (1988) [5] reported that calcium ammonium nitrate gave a greater yield and was a more efficient nitrogen source than urea and the grain N content was higher.

The present investigation was undertaken during the rainy seasons of 2002 and 2003 to have a detailed account of the effect of five commercially-available nitrogenous (N) fertilizers on the growth, yield and quality (grain N) of hybrid rice (Oryza sativa L.).

MATERIALS AND METHODS

The field experiment was conducted at Agricultural Research Station, Bilaspur Chhattisgarh, India during the rainy seasons of 2002 and 2003. Physico-chemical properties of the soil were measured by the standard methods of soil chemical analysis [12]. The analysis for respective years of experimentation revealed that the soil had o.52 and 0.58% organic carbon, 180.50 and 198.4 kg/ ha available nitrogen, 23.4 and 23.9 kg/ ha available phosphorus, 213.4 and 217.2 kg/ ha available potassium and Zn, B and Mo 0.50, 0.31, 0.04 and 0.52, 0.35, 0.04 mg kg/soil respectively, 9.1 and 9.3 mg kg/ soil available sulphate-sulphur, and Cd 0.40 and 0.42 mg kg/ soil with pH 7.85 and 7.86. The experiment was laid out in randomized complete block design with three applications of five nitrogen fertilizers [calcium ammonium nitrate (CAN), Urea, Super Net, ammonium sulphate nitrate (ASN) and 20.10.12 NPK compound]. Rice hybrid 'Proagro 6207' was transplanted at spacing of 25cm × 10 cm in five randomized plots and each of the plots was treated with a different nitrogenous fertilizer but each plot was given the same amount (100 kg/ ha) of fertilizer N. Some of these fertilizers also contained substantial quantities of sulphur (Table 1). The P and K fertilizer (0.10.12 NPK compound) was drilled with the seed, at sowing time except in the case of treatment number five which received the same amount of P and K fertilizer and all its nitrogen as 20.10.12 NPK compound. The other four nitrogenous fertilizers were broadcast on the plots immediately after sowing. Plots received identical cultural treatments in terms of ploughing, cultivation, seed rate, sowing method, P and K fertilizers, and disease control. Chemical herbicides were employed against different weeds during the course of study.

Five hills in each plot were randomly selected and tagged for recording plant height, tillers/m^2, green leaves/m^2, leaf weight (g/m^2) and leaf-area index at harvest (95 days after transplanting). The observations on dry-matter accumulation were recorded up to 95 days after transplanting (at 30-days interval). The dry samples were weighed and dry-matter yield in tones/ha was computed. The net plots area were harvested and sun-dried for 5 days in the field and the total biomass yield was recorded. After threshing, cleaning and drying the grain and straw, yields were recorded and yield-attributes viz grains/ ear and 1000-grain weight were recorded from plant samples. Straw yield was obtained by substracting grain yield from total biomass yield. The benefit: cost ratio of the hybrid rice was computed. Grain N in plant was analyzed as per standard method, viz Nesseler's reagent colorimetric method [8].

The data were analyzed statistically with Fisher's analysis of variance technique at 5% probability level; treatments were compared using a protected LSD test [22].

RESULTS AND DISCUSSION

The fertilizer treatment had significant effect on the plant growth at different growth stages. Plant height reveals the

Table 1 Nitrogen and sulphur content of the five nitrogen fertilizer treatments

N fertilizer	Content (%)		Application rate (kg/ ha)	
	N	S	N	S
T_1. Calcium ammonium nitrate (CAN)	27.00	0.00	100	Nil
T_2. Urea	40.00	0.00	100	Nil
T_3. Super Net	25.50	8.90	100	34.90
T_4. Ammonium sulphate nitrate (ASN)	30.00	12.20	100	40.60
T_5. 20.10.12 NPK compound	20.00	0.00	100	Nil

overall vegetative growth of the crop in response to various management practices. It was found that application of N fertilizers increased the plant height significantly, but maximum plant height (128.6 cm) was obtained in plots where the Super Net was applied and the lowest plant height (110.2 cm) was recorded for urea (Table 2). The increase in plant height in response to application of N fertilizers is probably due to enhanced availability of nitrogen which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation. These results are supported by the findings of Mandal et al. (1992) [9]. Rupp and Hubner (1995) [17]also reported increased level of leaf N with applied N.

Nitrogen fertilizer application increased significantly tillers/m^2 in rice at harvest (95 days after transplanting) (Table 2). The use of Super Net and ammonium sulphate nitrate (ASN) produced maximum number of tillers/m^2 (17.5 and 17.2, respectively) than all other treatments during 2003. Number of tillers per unit area is the most important component of yield. More the number of tillers, especially fertile tillers, the more will be the yield. More number of tillers /m^2 in experiment might be due to the more availability of nitrogen that played a vital role in cell division. These results are in accordance to the findings of [15]. According to Yoshida et al. (1972) [27], as the amount of nitrogen absorbed by the crop increases, there is an increase in the number of tillers per square meter.

The data on the leaf number and leaf weight are presented in Table 2. The number of green leaves at harvest (95 days after transplanting) was significantly increased with Super Net, being the highest (1517/m^2) during 2002. This result was statistically at par with that of treatment T4. Significantly lowest number of green leaves (1138 and 1147/ m^2) was obtained from urea treatment during 2002 and 2003. A similar pattern was also registered with respect to leaf weight of crop. The increase in leaf count as well as leaf weight due to adequate N nutrition is explainable in terms of possible increase in nutrient mining capacity of plant as a result of better root development and increased translocation of carbohydrates from source to growing points in well-fertilized plots [18].

The data regarding leaf area index is presented in Table 2. Data reveals that Super Net produced maximum leaf area index (2.48) and the minimum leaf area index (1.78) was produced by urea at 95 days after transplanting. It might be due to improved nutrients availability and enhanced growth of plant. These results are in line with the findings of Singh and Ram (1976) [19]. On the other hand Squire et al., (1987) [21] established that the main effect of N fertilizer is to increase the rate of leaf expansion, leading to increased interception of daily solar radiation by the canopy.

Dry matter accumulation increased significantly with N-fertilizer application in rice at all the growth stages of the crop (Table 3). The data presented in Table 3 revealed a statistically significant increase due to nitrogen fertilizer, Super Net and ammonium sulphate nitrate (ASN) throughout the measurement period. Significantly highest dry-matter accumulation (15.51 tonnes/ha) was obtained from Super Net treatment during 2003 at 95 days after transplanting. These results were statistically at par with that of treatment T4, where ammonium sulphate nitrate was applied. It was as expected since vegetative growth resulting from higher photosynthetic activities is well known to be influenced by nitrogen [16]. In general, dry-matter accumulation increased at slow rate up to 30 days after transplanting and thereafter increased at faster rate up to harvest. The higher dry mass of nitrogen treated plants could be connected with the positive effect of nitrogen in some important physiological processes. These differences were statistically significant. Significantly lowest dry-matter accumulation (11.41 tonnes/ha) was obtained from urea treatment during 2003 at 95 days after transplanting.

Table 2 Effect of sulphur-containing and non-containing nitrogenous fertilizers on growth of hybrid rice (Oryza sativa).

Treatments	Plant height (cm)		No of tillers/ m^2		Green leaves/ m^2		Leaf weight (g/ m^2)		Leaf area index	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
T_1. Calcium ammonium nitrate	116.3 c	117.5 b	13.7c	14.9 c	1321c	1328 c	422 b	421c	2.03 c	2.01c
T_2. Urea	111.0 d	110.2 c	12.5 d	13.2 d	1138 d	1147 d	375d	377 d	1.78 d	1.91d
T_3. Super Net	127.0 a	128.6 a	17.1 a	17.5 a	1517a	1515 a	544a	545a	2.48 a	2.45 a
T_4. Ammonium Sulphate Nitrate	125.3 b	126.1 a	16. 9 a	17.2 b	1514 a	1513 a	547 a	548 a	2.31 b	2.32 b
T_5. 20.10.12 NPK compound	115.2 c	115.7 b	14.5 b	14.8 c	1478 b	1470 b	485 b	487b	2.11c	2.22 b
LSD (<0.05)	3.01	2.99	0.3	0.24	34.01	37.21	12.41	10.79	0.09	0.09

Means with the same letters in the same column do not differ significantly at P > 0.05.
LSD: minimum significant difference.

Table 3 Effect of sulphur-containing and non-containing nitrogenous fertilizers on dry- matter accumulation (tonnes/ ha) of hybrid rice.

Treatments	2002			2003		
	30 DAT	60 DAT	At harvest	30 DAT	60 DAT	At harvest
T_1. Calcium ammonium nitrate	4.01c	9.47b	14.02 b	4.14 c	9.44c	14.01b
T_2. Urea	3.01d	7.84 d	11.91d	3.51e	7.48 d	11.41d
T_3. Super Net	5.41a	11.04 a	15.45 a	5.21a	11.04 a	15.51 a
T_4. Ammonium Sulphate Nitrate	4.97 a	10.58 a	15.07 a	4.91b	10.78 b	15.07a
T_5. 20.10.12 NPK compound	3.97c	8.12 c	13.07 c	3.99d	8.62 c	13.31c
LSD (<0.05)	0.24	0.45	0.78	0.25	0.47	0.79

Means with the same letters in the same column do not differ significantly at P > 0.05.
LSD: minimum significant difference.

Application of N fertilizers significantly increased the yield attributes, viz grains/ear, grain weight/ear and 1000-grain weight (Table 4). The number of grains / ear against various applications of N-fertilizers reveal that ammonium sulphate nitrate, produced maximum number of grains per ear (95.2 and 95.9) during 2002 and 2003 respectively. These results were statistically at par with that of treatment T_3 in which Super Net applied giving 94.6 and 95.7 number of grains per ear during the respective year of experimentation. Significantly lowest number of grains/ear i.e. 83.1 was obtained during both the years from urea treatment.

It was found that application of N fertilizers increased the grain weight/ear significantly. Significantly highest grain weight/ear (1.97 and 1.98g) were obtained from ammonium sulphate nitrate treatment during 2002 and 2003 respectively at 95 days after transplanting and significantly lowest grain weight/ear (1.24 g) was recorded for urea treatment. This trend might be due to role of nitrogen in crop maturation, flowering and fruiting including seed formation. These results are in accordance with those of [1].

Table 4 Effect of sulphur-containing and non-containing nitrogenous fertilizers on yield attributes of hybrid rice.

Treatments	No of grains/ear		Grain weight/ear		1000- grain weight (g)	
	2002	2003	2002	2003	2002	2003
T_1. Calcium ammonium nitrate	90.1b	90.4c	1.54 b	1.56 c	15.9 b	16.5 c
T_2. Urea	83.1c	83.1 d	1.31d	1.24 e	14.1 c	15.2 c
T_3. Super Net	94.6 a	95.7 a	1.81a	1.83 a	18.1 a	18.8 a
T_4. Ammonium Sulphate Nitrate	95.2 a	95. 9 a	1.98 a	1.97 a	17.6 b	18.0 a
T_5. 20.10.12 NPK compound	90.7b	91.3 b	1.47 c	1.41c	16.3 b	16.8 c
LSD (≤0.05)	2.11	1.7	0.053	0.041	0.31	0.19

Means with the same letters in the same column do not differ significantly at $P > 0.05$.
LSD: minimum significant difference.

Table 5 Effect of N fertilizers on grain and straw yields and benefit: cost ratio of hybrid rice.

Treatments	Grain yield (tonnes/ ha)			Straw yield (tonnes/ha)			Benefit:cost ratio		
	2002	2003	Pooled	2002	2003	Pooled	2002	2003	Pooled
T_1. Calcium ammonium nitrate	5.31 b	5.73 b	5.52 b	8.20 d	8.14 c	8.17 b	1.69 c	1.92 b	1.80 b
T_2. Urea	4.01 c	4.97 d	4.49 c	5.11e	7.11e	6.11c	1.49 d	1.61 d	1.55 c
T_3. Super Net	6.34 a	6.57 a	6.45 a	9.35 a	8.99 b	9.17 a	1.91 a	2.47 a	2.19 a
T_4. Ammonium Sulphate Nitrate	6.15 a	6.37 a	6.26 a	9.22 b	9.02 a	9.12 a	1.93 a	2.39 a	2.16 a
T_5. 20.10.12 NPK compound	5.02 b	5.11 c	5.06 b	8.55 c	8.00 c	8.27 b	1.89 b	1.90 b	1.89 b
LSD (≤0.05)	0.27	0.45	0.57	0.57	1.57	0.76	0.07	0.08	0.07

Means with the same letters in the same column do not differ significantly at $P > 0.05$.
LSD: minimum significant difference.

It is obvious from the Table 4 that results pertaining to 1000-grains weight in all the treatments differed significantly from one another and the highest 1000-grain weight (18.8 g) was obtained from the plots fertilized by Super Net. Minimum 1000 – grain weight (14.1) was produced by urea treatment during 2003. Application of urea had no significant effect on 1000–grain weight in first year. It appears that the application of nitrogen increased the protein percentage, which in turn increased the grain weight. Kausar et al. (1993) [6] also reported similar result. Grain weight is a genetically controlled trait, which is greatly influenced by environment during the process of grain filling, [6].

The yield data (Table 5) revealed a positive response to N fertilizer treatment. The pooled data of yield revealed that rice crop responded significantly to sulphur-containing nitrogen fertilizers compared to non sulphur-containing nitrogen fertilizers plots. The Super Net gave maximum grain yield of 6.45 t/ha and significantly lowest grain yield of 4.49 t/ha was obtained from the plots where urea was applied. Urea gave the lowest grain yield in the experiments and these reductions were significant in all of the experiments. Highly significant differences in yield performance were manifested from year to year but the trends remained almost the same. It signifies that hybrid rice variety 'Proagro 6207' is adequately stable concerning its genetic potential for yield of rice. There is a very close relation between the yield and its components, especially with number of filled grains per ear, in accordance with what De Datta [3] described (1986). The improved growth

Table 6 Effect of N fertilizer on grain N (%).

Treatments	Grain N%		
	2002	2003	Pooled
T_1. Calcium ammonium nitrate	1.62 b	1.68 b	1.65 a
T_2. Urea	1.34 c	1.57 d	1.45 d
T_3. Super Net	1.72 a	1.75 a	1.73 a
T_4. Ammonium Sulphate Nitrate	1.65 b	1.68 b	1.66 a
T_5. 20.10.12 NPK compound	1.63 b	1.61c	1.62 b
LSD (<0.05)	0.09	0.07	0.08

Means with the same letters in the same column do not differ significantly at $P > 0.05$.
LSD: minimum significant difference.

attributes, viz plant height and dry-matter production, might be responsible for improved yield attributes. It was found that Application of nitrogen improves various crop parameters like 1000–grain weight [7], more productive tillers [24] and grain yield [20] thus resulting in higher yields. Under some circumstances the reduction in yields from the application of urea may also be attributed to volatilization of ammonia.

Both sulphur-containing nitrogenous (N) fertilizers (super net and ammonium sulphate nitrate) were equally effective and increased straw yield significantly (Table 5). Super Net, gave maximum straw yield of 9.17 t/ha and significantly lowest straw yield (6.11 t/ha) was obtained from urea treatment. More straw yield could be explained as higher capability of hybrid rice to utilize more N through the expression of better growth by accumulating more dry matter. The results confirm the findings of [13]. The improvement in yield owing to the application of N-fertilizers might be brought by the beneficial effect of these on nutrient uptake, physiological growth.

Highest benefit: cost ratio (2.19 based on pooled data) of the crop was recorded when Super Net was applied, however, it was statistically at par with the application of ammonium sulphate nitrate (ASN) treatment (Table 5). Significantly minimum value for benefit cost ratio (1.55 based on pooled data) was obtained from the plots where urea was added.

It is evident from table 6 that nitrogen content in plant is markedly influenced by the application of different N fertilizers. The higher N content of nitrogen treated plants could be connected with the positive effect of nitrogen in some important physiological processes. These differences were statistically significant. Significantly lowest N content was obtained from the plots where urea was added. Gately and Kelly (1987) [4] also reported that the two fertilizers gave different yield responses but that urea gave the lowest grain N irrespective of the rate of application.

The different types of sulphur-containing N fertilizers, had significant effect on growth, yield and quality (grain Nitrogen) of hybrid rice ('Proagro 6207') than the non-sulphur-containing nitrogenous fertilizers (Urea, calcium ammonium nitrate (CAN) and 20.10.12 NPK compound). It might be due to role of sulphur (S) in protein synthesis. Sulphur is an essential component of amino acids which are the building blocks of protein. Sulphur deficient plants accumulate nitrogen as other compounds, (nitrate, ammonium, amides) therefore the quality of protein is reduced in such plants. It is well known that nitrogen nutrition influences the content of photosynthetic pigments, the synthesis of the enzymes taking part in the carbon reduction, the formation of the membrane system of chloroplasts,etc. Thus the increase in growth and yield owing to the application of N-fertilizers may be attributed to the fact that these nutrients being important constituents of nucleotides, proteins, chlorophyll and enzymes, involve in various metabolic processes which have direct impact on vegetative and reproductive phases of plants. These findings confirm those of [11].

CONCLUSION

In present study, treatment two (urea) appeared poorer than the other treatments. Urea gave significant reductions in growth and yields in most of the experiments. It gave the

lowest grain N content in experiments. Thus in this series of experiments, urea had little effect on the quality of the grain. It may be concluded that nitrogen fertilizers, Super Net and ammonium sulphate nitrate were found to be optimum for hybrid rice ('Proagro 6207') production.

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