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Effect of nitrogen scheduling practices on growth characteristics, yield and N uptake of medium duration rice (*Oryza sativa*) varieties

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ABSTRACT

Different nitrogen scheduling practices were evaluated in relation to growth, yield and uptake for four rice varieties under Haryana conditions. It was observed that higher dose of nitrogen applied with farmers' practice did not show any significant yield advantage over recommended and soil test based fertilizer application. The lesser growth and yield in leaf colour chart (LCC) based nitrogen scheduling practice suggests that basal dose may have a distinct advantage and must be applied for better tillering, growth and ultimately yield. However, nitrogen was most efficiently utilized under LCC based fertilizer application and seems to be better option towards enhancing nitrogen recovery as a next generation of technology. Among varieties, HKR 126, PR 106 and PR 114 were statistically at par among themselves but significantly outyielded IR 64. Nitrogen scheduling based on LCC vary for varieties differing in inherent leaf colour and needs further investigation after redefining the LCC values.

Key words: *Rice, nitrogen scheduling practices, varieties, yield, N uptake*

Numerous nitrogen response experiments have shown that the recovery of fertilizer N applied in rice crop ranges from 25-30% and it seldom exceeds 50% because rice is grown in an environment that is conducive to N losses from nitrification-denitrification, ammonia volatilization, run-off and leaching (Stalin *et al*., 1999; Kumar *et. al*., 2001). Nitrogen may also be lost from plant exudates, the flushing action of dew or rain and natural or mechanical lose of plant parts (De Datta, 1981). Therefore, efficient nitrogen management is one of the most important strategies for increasing rice production with maximum energy conservation. Strategies have been planned for better matching of nutrient supply with crop demand from soil and fertilizer through proper timing, rate, placement and source of fertilizer for improving efficiency and stabilizing yield. In this context, a leaf colour chart (LCC) based on chlorophyll content and leaf nitrogen content (Yang *et al*., 2003) might be an alternative along with nitrogen application dictated by soil nutrient status (Riazuddin Ahmed *et al*., 1999). In the quest of achieving higher yields, farmers generally tends to apply N in excess of the crop requirements without any regard to its ill effects on underground water (increased nitrate concentration), disease infestation and environmental pollution problems. Also, faulty method of nitrogen application such as application of greater proportion of total nitrogen while irrigation water is still standing in the field, cultivation of rice in coarse textured soils leading to higher leaching losses and reduced puddling due to high costs of fuel and machinery demands use of higher quantity of nitrogen to achieve acceptable yield levels. Lack of soil test, adoption of exhaustive multiple cropping systems, low to very low soil organic carbon status, absence of organic fertilizers and green manure crops also forces application of higher fertilizer dose to be applied by the farmers. Hence, there is need to fine tune N application time and its dose to make it more judicious, environment friendly and economical. Nitrogen use efficiency can also be improved through selection of more efficient cultivars. The need for developing and identifying superior N efficient genotypes is evident from low recovery of N fertilizers, associated economic and environmental concerns and

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lack of more efficient N management strategies (Brodbent *et al*., 1987). The main objective of this study was to suggest the right scheduling of nitrogen application based on crop requirements at its different physiological stages so as to economise its dose and reduce losses and consequently minimizing soil and water pollution problems and to study the response of different genotypes to different nitrogen scheduling practices.

MATERIALS AND METHODS

Field experiments were conducted during wet season 2002 at three different sites, *viz*., village Teek, District Kaithal (29º50'48" N, 76º30'58" E), Krishi Vigyan Kendra, Kaithal (29º45'10" N, 76º26'28" E) and village Rampur Thery, District Sirsa (29º31'18" N, 74º47'20" E) in predominantly rice growing areas of Haryana state. The soil of the experimental fields was sandy clay loam in texture, slightly alkaline (pH 8.0-8.6) low (148-175 kg N ha^{-1}) in available nitrogen (Subbiah and Asija, 1956), medium (24.0-28.8 kg P_2O_5 ha^{-1}) in available phosphorus (Olsen *et al.*, 1954) and high (380-500 kg K_2O ha^{-1}) in available potassium (Jackson, 1973) at all the three sites. Sixteen treatment combinations comprising of four nitrogen scheduling practices (Recommendation basis, Soil test basis, Farmers' practice and Leaf Colour Chart basis) and four varieties (IR 64, HKR 126, PR 114 and PR 106) were laid out in randomized block design with three replications at all the sites. For recommended and soil test based fertilizer application, N: P_2O_5: K_2O in the ratio of 150: 60: 60 and 150: 40: 0 kg ha^{-1}, respectively was applied. To test the existing status of fertilizer application (amount and time) among rice growing farmers, a benchmark survey of 160 farmers was conducted in randomly selected four villages, one each in Karnal, Kaithal, Fatehabad and Sirsa districts of Haryana state through farmers' participatory rural appraisal technique with the help of a well structured, interview schedule (Sheoran, 2003). The survey schedule revealed that most farmers used 195 kg N and 57.5 P_2O_5 ha^{-1} and this was taken as the base for farmers' fertilizer application practice. In case of LCC based fertilizer application, LCC readings were taken once every 10 days starting from 14 days after transplanting (DAT) to 54 DAT and a critical value of 4.0 was adjudged as the signal for fertilizer application. For this, 10 youngest fully expanded leaves were chosen for leaf colour measurement. If the mean of all the readings remains d"4.0, then N as urea @ 23 kg ha^{-1} was applied on that day, otherwise the N dose was skipped off. In this practice, 60 kg P_2O_5 as single super phosphate and 60 kg K_2O as murate of potash per hectare was applied as basal dose before transplanting at all the three sites. At 44 DAT, LCC value of e"4.0 was recorded in HKR 126 and PR 106 at all the sites. Therefore, a fertilizer dose of 23 kg N ha^{-1} was omitted in these two varieties. Full dose of P and K was applied at the time of puddling in all the practices, however, nitrogen application was done as per the treatments under study. The details regarding total amount of N applied, number and time of split N application under different nitrogen scheduling practices is given in Table 1. At physiological maturity, the plants from five hills were sampled to determine. Plant height, dry weight, tiller number and yield components like thousand grain weight and total number of spikelets m^{-2} were determined. Nitrogen content in grain and straw samples and total N uptake by grain and straw were calculated. All the parameters related to growth, yield and N-uptake were analyzed (Gomez and Gomez 1984) to evaluate the treatments effects-nitrogen scheduling practices, genotypes and their interaction.

RESULTS AND DISCUSSION

The different nitrogen scheduling practices and varieties influenced the growth characteristics, yield attributing characters, yield and N uptake in a similar manner at all the three locations studied. Therefore, the mean data of different parameters at all the locations have been computed and presented here. The yield data given in Table 4 revealed that application of nitrogen as per farmers' practice (195 kg N ha^{-1}) resulted in highest grain and straw yield and was statistically at par with nitrogen application as dictated by soil test analysis (150 kg N ha^{-1}) and recommendation basis (150 kg N ha^{-1}). However, all these practices proved significantly superior to LCC based N application (92-115 kg N ha^{-1}). The per cent increase in grain yield due to farmer's practice, recommended and soil test based fertilizer application was 17.6, 15.3 and 1.3%, respectively over LCC based nitrogen scheduling practice. This increase in yields under these practices might have occurred from significant improvement in growth (plant height, dry matter accumulation, tiller number) and yield attributes (panicle number, grains

Table 1. Characteristics of rice varieties

Nitrogen scheduling practices	Fertilizer dose (kg ha^{-1})			No. of splits	Time of N application
	N	P_2O_5	K_2O		
Recommendation	150	60	60	3	Basal, 20 & 40 DAT
Soil test	150	40	-	3	Basal, 20 & 40 DAT
Farmer's practice	195	57.5	-	4	Basal, 15, 30 & 45 DAT
Leaf colour chart (LCC)	92*/115**	60	60	5	14, 24, 34, 44 & 55 DAT

*applied to HKR 126 and PR 106, **applied to PR 114 and IR 64, DAT- days after transplanting

Table 2. Effect of nitrogen scheduling practices and varieties on growth characteristics of rice (mean of 3 sites)

Treatments	Plant height at harvest (cm)	Dry matter accumulation at harvest (kg m^{-2})	Number of tillers m^{-2} 60 DAT	Number of tillers m^{-2} At harvest	Yield attributing characters Panicles m^{-2}	Yield attributing characters Grains Panicle^{-1}	Yield attributing characters 1000-grain (g)	Yield (q ha^{-1}) Grain	Yield (q ha^{-1}) Straw	Harvest index (%)
Nitrogen Scheduling Practices										
Recommendation basis	113.27	1.536	444.4	319.0	302.4	95.5	25.57	6.9	8.5	44.79
Soil test basis	112.07	1.505	442.4	318.1	300.0	96.25	25.51	6.8	8.5	44.54
Farmers' practice	115.43	1.553	456.9	329.5	311.7	96.08	26.14	7.1	8.79	44.85
Leaf colour chart basis	103.07	1.338	401.2	292.8	274.2	91.47	24.02	5.8	7.6	43.50
SEm±	1.34	0.019	6.73	5.20	5.34	1.16	0.40	0.12	0.23	1.21
CD (P=0.05)	3.88	0.055	19.40	15.03	15.42	3.36	1.15	0.34	0.67	NS
Varieties										
IR 64	104.23	1.395	422.2	290.9	273.9	99.32	24.46	5.79	7.86	42.35
HKR 126	116.33	1.544	425.7	316.1	297.7	97.63	25.94	7.17	8.38	46.11
PR 114	111.00	1.489	441.9	323.1	305.5	92.22	25.26	6.86	8.73	43.99
PR 106	112.33	1.504	455.1	329.3	311.4	90.14	25.60	6.90	8.39	45.11
SEm±	1.34	0.019	6.73	5.20	5.34	1.16	0.40	0.12	0.23	1.21
CD (P=0.05)	3.88	0.055	19.40	15.03	15.42	3.36	1.15	0.34	0.67	NS

DAT= Days after transplanting

panicle^{-1}, 1000-grain weight) over N application based on LCC (Table 3). Consequent upon higher N content and dry matter production, the total uptake was highest in case of nitrogen scheduling according to farmers' practice and lowest in LCC based fertilizer application (Table 4).

Rice varieties differed significantly in respect of growth characteristics, yield attributing characters, yield and N-uptake due to application of nitrogen based on different nitrogen scheduling practices. The mean yield data revealed that HKR 126, PR 106 and PR 114 were statistically at par with each other and significantly out yielded IR 64 at all the locations (Table 4). The mean per cent increase in grain yield due to cultivation of HKR 126, PR 106 and PR 114 was 19.3, 16.1 and 15.7%, respectively over IR 64 at all the sites. However, there was a non-significant effect of varieties on harvest index (HI). Consequent upon higher N concentration in grain and straw, PR 114 resulted in highest total N uptake followed by HKR 126 and PR 106 and lowest was recorded under IR 64 (Table 5).

The study revealed that in farmers' practice, application of N produced only 36.4 kg grain kg^{-1} N applied while the corresponding response for the soil test based and recommended N application was 45.6 and 46.1 kg grain/kg N applied, respectively. However, the N applied on the basis of LCC gave mean response of 56.8 kg grain/kg N applied. This indicates that N was most efficiently utilized under LCC based N application practice followed by N scheduling as dictated by soil test analysis and recommendation basis. This might be due to the fact that in case of LCC based

Table 3. Effect of nitrogen scheduling practices and varieties on N content and uptake in grain and straw and total N uptake of rice (mean of 3 sites)

Treatments	N content (%)		N uptake (kg ha^{-1})		Total N uptake (kg ha^{-1})
	Grain	Straw	Grain	Straw	
Nitrogen Scheduling Practices					
Recommendation basis	1.243	0.902	86.00	76.93	162.93
Soil test basis	1.222	0.885	84.39	75.34	159.73
Farmers' practice	1.299	0.939	91.52	82.10	173.74
Leaf colour chart basis	1.075	0.797	63.00	60.63	123.64
SEm±	0.029	0.019	2.43	2.45	4.35
CD (P=0.05)	0.084	0.056	6.99	7.01	12.48
Varieties					
IR 64	1.167	0.849	67.60	66.81	133.33
HKR 126	1.220	0.889	87.64	74.55	162.19
PR 114	1.244	0.907	85.59	79.19	164.78
PR 106	1.207	0.879	83.36	73.84	157.21
SEm±	0.029	0.019	2.43	2.45	4.35
CD (P=0.05)	0.084	0.056	6.99	7.01	12.48

Table 4. Interaction effect of nitrogen scheduling practices and varieties on grain yield of rice (t ha^{-1})

Varieties	Nitrogen scheduling practices				
	Recommendation basis	Soil test basis	Farmers'practice	Leaf colour chart basis	Mean
IR 64	5.90	5.81	6.05	5.40	5.79
HKR 126	7.41	7.35	7.64	6.29	7.17
PR 114	7.21	7.07	7.30	5.87	6.86
PR 106	7.17	7.11	7.44	5.88	6.90
Mean	6.92	6.83	7.11	5.86	
SEm± = 0.12	CD (P=0.05) = 0.36				

N application, the total quantity of N was applied in 4-5 splits (depending on variety requirement) upto 54 DAT, which might have resulted in better availability and utilization of N for longer duration as compared to other practices where the last dose of N was applied upto 42-45 DAT. Beneficial advantage of split N application in rice have also been reported by Surekha *et al.* (1999). Higher losses at higher N levels might have led to lower utilization of applied N (Velu and Ramanathan, 1988) in case of farmers' practice. Also, the farmers have the tendency to apply fertilizers in standing water which further encourages losses of applied N whereas in case of recommended, soil test and LCC based N scheduling practice, the N application was done when the standing water has infiltered into the soil and later on irrigation was applied 2-3 days after fertilizer application that resulted in reduced N losses. The probable reduction in N losses might have resulted in its enhanced availability to the growing plants and consequently higher N-use efficiency under these practices as compared to farmers' practice. However, the lower growth and yield of LCC based N application might be due to the omission of basal dose and must be applied to achieve the acceptable yield to compare it with other practices.

HKR 126, PR 106 and PR 114 performed relatively similar in case of growth characteristics (plant height, dry matter production and number of tillers), yield attributing characters (panicles m^{-2}, grains panicle^{-1}, test weight), grain and straw yields and total N uptake but all these varieties were significantly superior to IR 64 at all the locations. This might be ascribed to genetic potential of cultivars, which resulted in taller plants, more number of tillers, higher dry matter production and yield attributing characters and finally higher grain yield

(Bhattacharya and Singh, 1992). The data further indicate that the mean response regarding grain yield per unit N applied was 48.9, 47.0 and 45.0 for HKR 126, PR 106 and PR 114, respectively. However, it was only 37.9 kg grain kg^{-1} N applied in case of IR 64. Genotypic variation in the efficiency of N utilization has also been reported by Broadbent *et al.* (1987) and Singh *et al.* (1998). The results of the present work suggests that genotypic variation for harvest index is consistent under different nitrogen scheduling practices and genotypes with high HI would be desirable.

Thus, it can be concluded that over-exploitation of nitrogen in farmer's practice did not bring out any significant yield advantage over recommended dose and soil test based N application. The LCC reading of e"4.0 used to match nitrogen top dressing with crop/plant demand resulted in lower growth and yield, clearly suggesting the distinctive advantage of basal N application and must be applied to achieve a yield target comparable with other nitrogen scheduling practices. Nitrogen was most efficiently utilized under LCC based nitrogen scheduling practice and it seems to be better prospective towards increasing N-use efficiency in rice cropping systems as a next generation of technology provided basal N application is applied. However, the use of LCC to compare varieties differing in inherent leaf colour for nitrogen scheduling in rice may not be a reliable tool as the nitrogen application by this method is influenced by the varieties and needs further investigation after redefining the LCC values for different varieties depending on their leaf colour. The study also indicates that genotypes with high HI are likely to perform well and may be used as selection criteria. The cultivars with high uptake efficiency had higher N contents than cultivars with low uptake efficiency from N application and could be used for environmental friendly farming systems.

REFERENCES

Bhattacharya HC and Singh KN 1992. Response of direct seeded rice (Oryza sativa) to levels and time of nitrogen application. Indian Journal of Agronomy 37(4): 681-685

Broadbent FE, De Datta SK and Laureles EV 1987. Measurement of nitrogen utilization efficiency in rice genotypes. Agron J 79: 786-791

Gomez KA and Gomez AA1984. Statistical procedures for Agricultural Research. 2nd ed., John Wiley and Sons, New York.

Jackson ML 1973. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Kumar RM, Subbiah SV, Padmaja K, Balasubramaniam V 2001. Nitrogen management through soil and plant analysis development and leaf colour chart in different groups of rice varieties grown on vertisols of Deccan plateau. Indian Journal of Agronomy 46(1): 81-88.

Olsen SR, Cole CV, Watanable FS and Dean LA 1954. Estimation of available phosphorus in soil extract with sodium bicarbonate. USDA circular No. 939, Washington DC.

Riazuddin Ahmed S, Chandrasekhar Reddy K and Shan Mohammad 1999. Soil test -yield goal approach as an aid to balanced fertilization to rice in intensive cropping systems. Oryza 36(3): 223-227

Sheoran P 2003. Nitrogen management and its impact assessment at farmers' fields in rice in rice-wheat cropping system. Ph.D. Dissertation, CCSHAU, Hisar, Haryana, India.

Singh U, Ladha JK, Castillo EG, Punzalan G, Tirol-Padre A and Duqueza 1998. Genotypic variation in nitrogen use efficiency in medium and long duration rice. Field Crops Research 58: 35-53

Stalin P, Thiyagarajan TM and Rangarajan R 1999. Nitrogen application strategy and use efficiency in rice. Oryza 36(4): 322-326

Subbiah RV and Asija CL 1956. A rapid procedure for estimation of available N in soils. Current Science 25: 172-194

Surekha K, Narayana Reddy M and Mahender Kumar R. 1999. Yield attributes and yield of rice hybrids as influenced by nitrogen sources and its split application. Indian Journal of Agronomy 44(1): 80-88

Velu V and Ramanathan KM 1988. Leaching losses of nitrogen in clay loam soils of Cauvery decay. Oryza 25: 374-379

Yang W, Peng S, Huang J, Sanico AL, Buresh RJ and Witt C 2003. Using leaf colour charts to estimate leaf nitrogen status of rice. Agronomy Journal 95: 212-217