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Effect of planting geometry and nitrogen level on growth, yield and nitrogen-use efficiency of scented hybrid rice (*Oryza sativa*)

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season (July–October) of 2000 and 2001 at Indian Agricultural Research Institute, New Delhi, to study the effect of planting geometry and nitrogen levels on growth, yield attributes, yield and nitrogen-use efficiencies of 'PRH 10' scented hybrid rice (*Oryza sativa* L.). Planting geometry did not influence growth, yield attributes, yields and nitrogen-use efficiency. However, each unit increase in N level led to significant increase in growth, yield-attributing characters, and yield of rice. The maximum grain yield (65.5 q/ha) was recorded with highest level of N. The maximum response was observed at 75 kg N/ha and thereafter it decreased with the increase in N level. The nitrogen-use efficiency (NUE), apparent recovery (%), nitrogen efficiency ratio (NER) and physiological efficiency index of absorbed nitrogen (PEIN) were significantly higher at lower level of N and decreased significantly with increasing N levels.

Key words : Rice, Planting geometry, Nitrogen, Yield attributes, Yield, Nitrogen uptake, NUE, Apparent recovery, NER, PEIN

Rice production has to be increased at a much faster rate to feed the burgeoning population, as it is a main cereal crop of India. Of the several possible approaches for increasing rice production hybrid rice technology seems to offer great promise. In India, this technology has just made a humble begining and in 1996 about half a dozen rice hybrids were made available to the farmers and covered about 50,000/ha of land (Siddique, 1996). The Indian Agricultural Research Institute, New Delhi, is also involved in developing rice hybrids and has recently developed scented hybrid 'PRH 10' which has a potential of 7–8 tonnes/ha or even more and is suitable for northern India. Rice variety 'PRH 10' is a first kind of scented hybrid in India which can have a great potential in future to replace the 'Pusa Basmati 1'. For getting higher yield and nitrogen-use efficiency, planting geometry and nitrogen fertilizer are the most important agronomic factors. Some information on these agronomic aspects of 'PRH 10' scented hybrid rice is not available, an attempt was made to assess their effect on growth, yield attributes, yields and nitrogen-use efficiencies.

MATERIALS AND METHODS

The field experiment was conducted during the rainy (*kharif*) season of 2000 and 2001 at the research farm of Indian Agricultural Research Institute, New Delhi. The soil was sandy clay loam, having pH 7.9 (soil:solution ratio 1:2.5), organic carbon 0.45%, total kjeldahl, N 0.045% and 16 and 270 kg/ha available P and K respectively. The treatments comprised 3 planting geometry (20 cm × 15 cm, 25 cm × 12 cm and 30 cm × 10 cm) and 4 nitrogen lelvels (0, 75, 150 and 225 kg N/ha).

The experiment was laid out in split-plot design, keeping the planting geometry in the main plot and the nitrogen levels in subplots, using 4 replications. Seedlings of 25 days of 'PRH 10' scented hybrid rice were transplanted, keeping 1 seedling/hill on 6 and 7 July in 2000 and 2001 under puddled conditions. The nitrogen treatments were imposed in 2 equal splits : half at 10 days after transplanting (DAT) and the rest half at 30 DAT. All plots were given 50 kg P_2O_5/ha, 40 kg K_2O/ha and 5 kg zinc/ha as single superphosphate, muriate of potash and zinc sulphate respectively. Rice crop was harvested in the last week of October in both the years. Dried grain and straw subsamples were analysed for kjeldahls, N. Nitrogen uptake (kg/ha) in grain, straw and total (grain + straw) was estimated as product of N content and plant yield (grain, straw and total). Different estimates on N efficiencies were made by using the following calculations as:

$$\text{Nitrogen-use efficiency (NUE)} = \frac{\text{Grain yield in treated plot (kg/ha)} - \text{grain yield in control plot (kg/ha)}}{\text{Amount of N applied (kg/ha)}}$$

$$\text{Apparent recovery (\%)} = \frac{\text{N uptake in treated plot (kg/ha)} - \text{N uptake in control plot (kg/ha)}}{\text{Amount of N applied (kg/ha)}}$$

Nitrogen-efficiency ratio (NER), the efficiency of nitrogen utilization was calculated:

$$\text{NER} = \frac{\text{Dry-matter yield at harvest (kg/ha)}}{\text{N accumulation in crop at harvest (kg/ha)}}$$

Physiological efficiency index of absorbed nitrogen (PEIN) of the treatments was calculated as ratio of kg grain produced to a kg of nitrogen absorbed in above-ground dry matter at harvest (Isfan, 1990).

$$\text{PEIN} = \frac{\text{Grain yield produced (kg/ha)}}{\text{N absorbed in above dry matter at harvest (kg/ha)}}$$

RESULTS AND DISCUSSION

Yield attributes

The planting geometry did not influence the plant height significantly at the time of harvest and other yield-attributing characters, viz. panicles/hill, panicle length, filled grains/panicle, grain weight/panicle and 1,000-grain weight. This might be due to equal area (i.e. 300 cm^2) was provided in each planting geometry per hill. These results confirm the findings of Chopra and Chopra (2000), who also reported similar results in transplanted rice. Increasing the levels of fertilizer N significantly improved all the yield-attributing characters except 1,000-grain weight (Table 1). This might be due to increased accumulation of photosynthates from source to sink with increased levels of fertilizer nitrogen. Behra (1998) also reported significant increase in plant height, panicles/plant and grain weight/panicle due to nitrogen, 1,000-grain weight remained unaffected due to N. Our findings are in accordance with the results of Chopra and Chopra (2000), who also reported no variation in test weight between the levels, indicating negligible influence of N on grain-filling in medium duration rice.

Yield of rice

The planting geometry of rice did not influence significantly the grain and straw yields of rice based on mean of 2 years. There was a significant increase in grain yield of rice with an increase in level of nitrogen (Table 2). The response of grain yield of N was linear up to 225 kg N/ha. Significantly higher yield at the highest level of N was obtained, might be owing to better N uptake leading to greater dry-matter production and its translocation to the sink. Increased panicles/hill, panicle length, filled grains/panicle and grain weight/panicle were mainly responsible for the increased yield at this level of N. The straw yield also significantly increased with increasing level of N during both the years. Vigorous growth (plant height) with increase in N level resulted higher straw yield. These findings confirm the results of Chopra and Chopra (2000).

Nitrogen uptake and efficiencies

There was no significant effect of planting geometry on nitrogen uptake by rice. However, the grain, straw and total N uptake by rice increased significantly with levels of N owing to production of higher amount of biomass. The highest N level recorded the maximum N uptake and significantly higher than the other levels of N (Table 2). Dwivedi and Thakur (2000) also reported similar results. The planting geometry did not show significant influence on the agronomic nitrogen-use efficiency (NUE), apparent N recovery (%), nitrogen-efficiency ratio (NER) and physiological efficiency index of nitrogen (PEIN).

Table 1. Effect of planting geometry and nitrogen level on growth and yield attributes of scented hybrid rice ('PRH 10')

Treatment	Plant height (cm)		Panicles/ hill		Panicle length (cm)		Filled grains/ panicle		Grain weight/ panicle (g)		1,000-seed weight (g)	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Plant geometry (cm × cm)												
20 ×15	75.3	77.7	10.7	11.8	24.8	25.9	98.1	100.8	2.53	2.46	23.68	24.45
25 ×12	74.6	76.8	10.6	11.8	24.6	25.7	99.2	101.5	2.33	2.44	23.32	24.07
30 ×10	74.1	76.3	10.7	11.9	24.6	25.9	98.5	101.2	2.33	2.44	23.39	24.15
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen (kg/ha)												
0	69.3	71.3	7.8	8.8	22.1	23.2	74.5	76.5	1.72	1.82	22.82	23.82
75	72.9	74.9	9.6	10.6	24.6	25.7	91.9	94.2	2.22	2.32	23.62	24.62
150	77.3	79.6	12.2	13.3	25.7	26.9	112.1	115.0	2.60	2.72	23.67	23.67
225	79.2	81.9	13.2	14.8	26.3	27.5	116.0	119.0	2.81	2.94	23.75	24.75
CD (P=0.05)	0.74	0.86	0.52	0.49	0.38	0.33	3.56	3.72	0.09	0.95	NS	NS

Table 2. Effect of planting geometry and nitrogen level on grain yield, straw yield, N uptake and efficiencies of N of scented hybrid rice ('PRH 10')

Treatment	Grain yield (q/ha)*	Straw yield (q/ha)*	N uptake (kg/ha)		NUE (kg grain/kg N)		Apparent N recovery (%)		Nitrogen efficiency ratio		Physiological efficiency index of N	
			2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Planting geometry (cm × cm)												
20×15	53.8	64.7	89.2	89.0	12.4	14.8	24.0	27.8	134.0	134.0	60.8	60.9
25×12	53.5	64.4	88.8	88.6	11.9	14.3	23.5	27.3	134.1	134.0	60.8	60.9
30×10	52.7	63.5	87.3	87.4	11.9	14.8	23.1	27.7	134.2	134.0	60.7	60.9
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Nitrogen (kg/ha)												
0	39.0	46.9	62.6	58.9					141.6	141.5	64.1	64.3
75	50.5	60.8	81.7	83.2	13.1	17.5	25.5	32.4	134.9	134.7	61.0	61.2
150	58.5	70.3	97.7	98.8	12.0	14.0	23.4	26.6	131.1	131.1	59.5	59.6
225	65.6	78.7	111.6	112.5	11.2	12.4	21.8	23.8	128.8	128.8	58.5	58.6
CD (P=0.05)	2.14	2.52	4.05	3.92	1.20	0.83	2.40	2.57	3.34	3.31	1.49	1.50

NUE, Nitrogen-use efficiency; *mean data of 2 years

However, nitrogen levels had significant effect on NUE, apparent N recovery (%), NER and PEIN (Table 2). Agronomic NUE and apparent N recovery declined significantly as N applied to rice is subjected to leaching and denitrification losses (Prasad, 1998). The highest N-efficiency ratio, which indicated the efficiency of N utilization by rice (kg dry-matter produced/kg nitrogen absorbed) and physiological efficiency index of nitrogen (ratio of kg grain produced/kg N absorbed in above-ground plant dry matter at maturity) were observed in the control which were significantly higher than other N levels and decreased significantly with increasing N levels.

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