Response of Rice Hybrids to Nitrogen Levels under Lateritic Zone of West Bengal, India

A. K. Bera and K. Pramanik*

Department of ASEPAN, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal (731 236), India

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Correspondence to

**E-mail*: kalipada.pramanik@visva-bharati.ac.in

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Abstract

A pot culture experiment was conducted during *kharif* season of 2009 and 2010 at Agricultural research farm, Visva-Bharati, Sriniketan, Birbhum. The experiment was laid out in CRD with three rice hybrids, viz. PHB-71, 25P25 and KRH-2, and four levels of nitrogen, viz. N_0, N_{50}, N_{100} and N_{150} kg ha^{-1}. Among hybrids, PHB-71 produced significantly higher total chlorophyll content, panicle length, panicle weight, filled grains panicle^{-1}, grain yield hill^{-1} and harvest index as compared to 25P25 and KRH-2 during both years. PHB-71 produced significantly highest grain yield of 43.38 and 46.23 g hill^{-1} in 2009 and 2010, respectively, which showed an increase of 42.08 and 45.23% over rice hybrid 25P25 and KRH-2, respectively. The two years pooled of grain yield hill^{-1} of rice hybrid PHB-71 was significantly higher as compared to others. Variation in nitrogen dose had marked effect on all the yield attributing traits. Application of N @ 150 kg ha^{-1} significantly increased total chlorophyll content, yield contributing parameters and yield as compared with 0, 50, 100 kg N ha^{-1}. Application of 150 kg N ha^{-1} recorded significantly higher grain yield hill^{-1} as compared to lower nitrogen levels. The pooled grain yield of PHB-71 was significantly higher as compared to 25P25 and KRH-2.

1. Introduction

Rice occupies a pivotal place in Indian agriculture and it is the staple food for more than 70% of population and a source of livelihood for about 120-150 million rural households. It accounts for about 43% of the total food grains and 55% of cereal production in the country. At the accelerating current growth rate of 1.8% of population, rice requirement by 2020 is estimated to be around 140 mt. There is no scope for horizontal expansion of cultivable area. Therefore, rice productivity and production have to be increased to meet the future demand. Among the various strategies proposed to improve rice productivity, heterosis through the development of hybrid rice has been exploited in recent times. Rice hybrids yield about 20% increased grain yield over inbred cultivars (Meena et al., 2002). Nitrogen is an important component of rice production technology with high yielding cultivars and its immense role in increasing rice productivity. Nitrogen is an important constituent of many organic compounds and is known to improve the various morphological attributes in rice because of higher synthesis of protoplasmic proteins and nucleic acids. It is also responsible for more leaf area and dry matter production due to higher rate of photosynthesis (Murata, 1959; Baba, 1961). It promotes rapid growth and all parameters contributing to yield.

2. Materials and Methods

A pot culture experiment was conducted during *kharif* season of 2009-2010 and 2010-11 at Agricultural research farm, Visva-Bharati, Sriniketan, Birbhum. The soil was sandy-loam in texture with high percentage of sand and low percentage of clay. The soil was slightly acidic (pH 5.9), low in available nitrogen (136 kg ha^{-1}), phosphorus (11.50 kg ha^{-1}) and medium in potassium (160.5 kg ha^{-1}). The experiment was laid out in complete randomized design with three rice hybrids, viz. PHB71, 25P25 and KRH2, and four levels of nitrogen, viz. 0, 50, 100 and 150 kg ha^{-1}. Seedlings of the three hybrids were raised separately in nursery. In all, twelve treatments were replicated three times. The earthen pots (25 cm diameter) were filled with unsterilized soil (10 kg pot^{-1}) and dose of fertilizers on the basis of soil weight according to treatments. P_2O_5 and K_2O @ 25.6 and 259 mg pot^{-1} were applied in the form of, single super phosphate and murate of potash, respectively. The 14-days old one seedlings of 25P25, KRH2 and PHB71 were transplanted into the pot. The pots were watered immediately after transplanting. The plant height, yield parameters and yield were recorded at harvest (110 days). Half dose of nitrogen (as per treatments) was applied as basal and the remaining half dose of nitrogen was applied as top-dressed in two equal splits at maximum tillering and before flowering stages. Crop was sown in 9th July, 2009 and 5th July, 2010, and transplanted on 24th July 2009 and 19th July, 2010 and harvesting was done on 1st November, 2009 and 26th October, 2010, respectively. Observations were recorded on total chlorophyll content, panicle length, panicle weight, filled grains panicle^{-1}, test weight, grain yield hill^{-1} and harvest index.

2.1. Chlorophyll estimation

Total chlorophyll content was measured adopting the method of Hiscox and Israelstam (1979), using Dimethyl sulfoxide (DMSO).The chlorophyll content was determined by using the formula given by Arnon (1949) and expressed as mg g^{-1}

$$\text{Total Chlorophyll} = [20.2(D645) + 8.02(D663)] \times \frac{V}{1000 \times W}$$

Where, D=Absorbance, V=Final volume of DMSO (ml), W=Weight of fresh leaf (g)

of fresh leaf. Arnon's formula to estimate total chlorophyll is as follows:

3. Results and Discussion

3.1. Total chlorophyll content

The result showed that total chlorophyll content in leaf as affected by rice hybrids (Table 1). Total chlorophyll content was higher in second year as compared to the first year. Rice hybrid PHB71 recorded highest amount of chlorophyll content in leaf as compared to rice hybrids 25P25 and KRH2 in both the years at 20 and 40 DAS. The lowest amount of total chlorophyll content was recorded with 25P25 and it was statistically similar with KRH2 at 20 DAS. Nitrogen showed significant positive effect on total chlorophyll content in leaf. Increasing nitrogen level steadily increased total chlorophyll content in leaf at all the growth stages. The highest total chlorophyll was obtained in crop receiving 150 kg nitrogen ha^{-1}. The lowest total chlorophyll content was recorded in crop at control plot (without nitrogen, N_0 level). Application of 100 kg N (N_{100}) was recorded significantly higher total chlorophyll content as compared to N_{50}. Chlorophyll pigments play an important role in the photosynthetic process leading to biomass production. The study also showed that total chlorophyll content was significantly influenced by nitrogen levels. Ahmad et al. (2003) also concluded that the nitrogen was an important constitute of photosynthetic components of rice and approximately 60% of the nitrogen in a plant leaf with C_3 photosynthesis is invested in photosynthetic components. Zhang et al. (2003) observed a significant and positive correlation between the leaf nitrogen and chlorophyll contents. The results are in conformity with those of Tripathi and Jaishwal (2006), and Bera and Pramanik (2010).

Table 1: Effect of nitrogen levels and rice hybrids on total chlorophyll content (mg g^{-1} of fresh leaf) of hybrid rice

Treatments	20 DAT		40 DAT		60 DAT	
	2009	2010	2009	2010	2009	2010
Rice hybrids						
25P25	3.25	3.41	3.47	3.67	2.48	2.72
KRH-2	3.46	3.46	3.74	4.02	2.57	2.82
PHB-71	3.57	3.75	3.97	4.20	2.71	2.94
SEm±	0.07	0.08	0.07	0.09	0.08	0.09
CD (*p*=0.05)	0.20	0.23	0.20	0.26	NS	NS
Nitrogen (kg ha^{-1})						
N_0	2.97	3.06	3.11	3.28	1.46	1.70
N_{50}	3.25	3.31	3.52	3.73	2.51	2.75
N_{100}	3.52	3.58	3.79	4.06	2.88	3.12
N_{150}	3.97	4.21	4.44	4.78	3.50	3.74
SEm±	0.08	0.09	0.09	0.10	0.11	0.11
CD (*p*=0.05)	0.23	0.26	0.26	0.29	0.32	0.32

3.2. Panicle length

Hybrids showed significant variation in respect of panicle length (Table 2). The longest panicle of 26.71 cm was observed in PHB71. The smallest panicle length (22.05 cm) was obtained from 25P25 rice hybrid during both the years under study. The panicle length of KRH2 hybrid (24.65 cm) was in between the hybrids PHB71 and 25P25. Nitrogen had significant role in increasing the panicle length (Table 2). Panicle length of the three hybrids increased steadily with the increasing rate of N nitrogen fertilizer application during both the years under study. The longest panicle length was recorded in the hybrids receiving 150 kg N ha^{-1} (N_{150}), but it was comparable to those of its immediate lower (N_{100}). Both the above nitrogen treatments produced significantly longer panicle length than those recorded at low nitrogen level (N_0). All the hybrids at low nitrogen (N_0) level produced the smallest panicle length among all other nitrogen treatments in respective years (Table 2). The results are in conformity with the findings of Jiang et al. (1993).

3.3. Filled grains panicle^{-1}

Variations exerted significant influence on the filled grains panicle^{-1} (Table 2). Variety PHB71 produced the maximum number of filled grains panicle^{-1} (120.81). The lowest number of filled grains panicles^{-1} was observed from 25P25 (114.95). The hybrid KRH2 produced 117.77 number of filled grains panicle^{-1}. The number of filled grains panicle^{-1} was also significantly affected by different nitrogen levels (Table 2). Nitrogen at 150 kg N ha^{-1} (N_{150}) produced the highest number

Table 2: Influence of nitrogen levels and rice hybrids on panicle length, number of filled grains panicle^{-1}, panicle weight and test weight

Treatments	Panicle length (cm)			Number of filled grains panicle^{-1}			Panicle weight (g) panicle^{-1}			Test weight (g)		
	2009	2010	Pooled	2009	2010	Mean	2009	2010	Pooled	2009	2010	Pooled
Rice hybrids												
25P25	21.06	23.03	22.05	113.1	116.6	114.95	2.62	3.27	2.79	23.47	23.89	23.71
KRH-2	23.17	26.14	24.65	116.0	119.5	117.77	2.75	2.97	2.89	23.46	23.92	23.68
PHB-71	25.25	27.09	26.17	118.5	123.1	120.81	3.18	3.14	3.36	23.49	23.98	23.72
SEm±	0.35	0.16	0.19	0.37	0.31	0.24	0.05	0.03	0.03	0.09	0.06	0.05
CD (p=0.05)	1.03	0.47	0.54	1.09	0.91	0.68	0.15	0.09	0.08	NS	NS	NS
Nitrogen (kg ha^{-1})												
N_0	20.60	22.15	21.38	110.9	113.6	112.28	2.32	2.48	2.44	22.70	23.26	22.99
N_{50}	22.16	24.87	23.52	112.9	117.6	115.23	2.68	3.01	2.88	22.90	23.71	23.31
N_{100}	24.72	26.55	25.64	116.9	122.1	120.48	3.13	3.37	3.28	23.93	24.27	24.11
N_{150}	25.17	28.10	26.63	121.1	125.7	123.36	3.28	3.63	3.47	24.36	24.48	24.42
SEm±	0.41	0.18	0.22	0.42	0.36	0.27	0.06	0.03	0.04	0.11	0.07	0.06
CD (p=0.05)	1.20	0.53	0.63	1.23	1.06	0.77	0.18	0.09	0.11	0.32	0.21	0.18

of filled grains panicle^{-1}. Control (N_0) treatment produced the lowest number of filled grains panicle^{-1} (112.28). The increase in number of filled grains panicle^{-1} with 150 kg N ha^{-1} (N_{150}), 100 kg N ha^{-1} (N_{100}) and 50 kg N ha^{-1} (N_{50}) over control (N_0) was 9.87, 7.30 and 2.63%, respectively. The findings are in agreement with those of Mahajan and Tripathi (1992), Thakur et al. (1994), and Subbaiah et al*,* (2001).

3.4. Panicle weight panicle^{-1}

Hybrids showed significant response on average panicle weight (Table 2). The maximum average panicle weight was recorded with the hybrid PHB71 (3.36 g) and the lowest from 25P25 (2.79g). The average panicle weight of hybrid KRH2 was 2.89 g. The average panicle weight of rice hybrids also varied significantly due to nitrogen fertilizer application (Table 2). The highest average panicle weight (3.47 g) was recorded with application of 150 kg N ha^{-1} (N_{150}). The lowest average panicle weight (2.44 g) was obtained from control plot (N_0). The second (3.28 g) and third highest (2.88 g) of average panicle weight was observed with application of 100 kg N ha^{-1} (N_{100}) and 50 kg N ha^{-1} (N_{50}), respectively.

3.5. Test weight

Hybrids did not show any significant response on 1000-grain weight (Table 2). However, numerically the maximum weight of 1000-grain was recorded with the hybrid PHB71 (23.72 g) and the lowest from KRH2 (23.68 g). Grain weight of rice hybrids also varied significantly due to nitrogen fertilizer application (Table 2). The highest 1000-grain weight (24.42 g) was recorded with application of 150 kg N ha^{-1} (N_{150}). The lowest weight of 1000-grain (22.99 g) was obtained from control treatment (N_0). The second and third best treatment was (N_{100}) and (N_{50}) in respect of test weight (24.11 g and 23.31 g), respectively.

3.6. Grain yield

The rice hybrids exhibited significant variation in grain yield hill^{-1} (Table 3). The hybrid variety PHB71 produced the highest grain yield (44.80 g hill^{-1}). The hybrid variety 25P25 produced the lowest grain yield (31.78 g hill^{-1}). The yield increase by PHB71 and KRH2 was 13.02 g hill^{-1} and 8.56 g hill^{-1} which was 40.97 and 26.94%, respectively over 25P25. The impact of nitrogen application on grain yield (g hill^{-1}) was significant (Table 3). Grain yield (g hill^{-1}) increased linear with the increment of the fertilizer doses of N up to 150 kg N ha^{-1} (N_{150}). Application of 150 kg N ha^{-1} (N_{150}) produced the highest grain yield (58.75 g hill^{-1}) and it was statistically with N_{100}, N_{50} and N_0 treatments. Plants grow without N fertilizer had the lowest grain yield (21.28 g hill^{-1}). The increase in yield by use of 150 kg N, 100 kg N and 50 kg N ha^{-1} was 176.08%, 104.70% and 51.79% over the control (without nitrogen), respectively. Higher yield under 150 kg N ha^{-1} may be due to more filled grains panicle^{-1} and larger grains. Higher nitrogen level, in fact, increased the photosynthetic efficiency of crop leading to greater sink. Om et al. (1997), Behera (1998), and Channabasappa et al. (1998) also reported that N increases the sink capacity.

3.7. Straw yield

Significant differences in straw yield hill^{-1} were observed between two hybrids (Table 3). The hybrid PHB71 produced the highest straw yield hill^{-1} (61.87 g) and the lowest (44.98 g)

Table 3: Influence of nitrogen levels and rice hybrids on grain yield, straw yield and harvest index

Treatments	Grain yield (g hill^{-1})			Straw yield (g hill$^{-1)}$			Harvest index (%)		
	2009	2010	Pooled	2009	2010	Pooled	2009	2010	Pooled
				Rice hybrids					
25P25	30.53	33.02	31.78	43.64	46.32	44.98	40.90	41.42	41.16
KRH-2	38.83	41.86	40.34	54.47	58.06	56.26	41.50	41.78	41.64
PHB-71	43.38	46.23	44.80	60.22	63.50	61.85	41.72	42.02	41.87
SEm±	0.56	0.58	0.39	0.85	0.85	0.58	0.10	0.06	0.06
CD (p=0.05)	1.64	1.70	1.11	2.49	2.49	1.65	0.29	0.18	0.17
				Nitrogen (kg ha^{-1})					
N_0	20.40	22.17	21.28	29.93	31.68	30.81	40.45	41.12	40.79
N_{50}	30.91	33.70	32.30	43.79	47.16	45.48	41.36	41.65	41.50
N_{100}	42.21	44.91	43.56	58.82	62.12	60.47	41.74	41.94	41.84
N_{150}	56.81	60.70	58.75	78.56	82.90	80.73	41.95	42.26	42.11
SEm±	0.65	0.67	0.46	0.98	0.98	0.68	0.12	0.07	0.07
CD (p=0.05)	1.91	1.96	1.31	2.87	2.87	1.93	0.35	0.21	0.20

from the hybrid 25P25. The hybrid KRH2 produced 56.26 g hill^{-1} that was in between the hybrids PHB71 and 25P25. The increase in straw yield with PHB71 and KRH2 was 37.55% and 25.08% more over the hybrid 25P25. Xie et al. (2007) reported that biomass production varied with variety which rendering different straw yield. Significant difference on straw yield of hybrid rice was observed when different doses of nitrogen fertilizers application (Table 3). The highest straw yield hill^{-1} (80.73 g) was obtained from 150 kg N ha^{-1} (N_{150}) application. The lowest straw yield hill^{-1} (30.81 g) was obtained from the control plot (without nitrogen, N_0). The second best dose of nitrogen was N_{100} in respect of straw yield (60.47 g hill^{-1}). The increase in straw yield hill^{-1} with 150 kg N, 100 kg N and 50 kg N ha^{-1} application was 162%, 96.27% and 47.61% higher over the crop receiving no nitrogen. The results are conformity with those of Bhowmick and Nayak (2000), Datta and Mistry (1958), and Nakashita et al. (2003).

3.8. *Harvest index*

The difference in harvest index due to variety was also significant (Table 3). The maximum harvest index was obtained from PHB71 (41.87%) and the lowest harvest index was obtained from 25P25 (41.16%). There was also significant effect of nitrogen on the harvest index of hybrid rice (Table 3). Harvest index increased linear with the increment of the fertilizer doses of N up to 150 kg N ha^{-1} (N_{150}). The maximum harvest index was obtained from the treatment of 150 kg N ha^{-1} (42.11%) and the lowest from control plot (40.79%). Om et al. (1997), Behera 1998, and Channabasappa et al. (1998) also reported similar type of results. Pramanik et al. (2013) also reported the role of fertilizer and yield.

4. Conclusion

Based on these findings, it can be concluded that rice hybrid PHB71 as well as 150 kg N ha^{-1} can be recommended to increase hybrid rice productivity.

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