

Effect of Magnesium and Boron under Different Nitrogen Levels on Yield and Quality of Hybrid Rice (*Oryza sativa* L.)

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Abstract

A field experiment was conducted during two consecutive *kharif* seasons of 2001 and 2002 to study the effect of magnesium and boron under various nitrogen levels on yield and quality of hybrid rice (Pro Agro 6201). Application of 180 kg N along with 40 kg Mg and 2 kg Boron/ha decreased the grain sterility percentage and increased the yield attributes and recorded maximum grain yield during both the years. Increased N (N 180) and Mg levels (Mg 40) showed an improvement in hulling and milling percent over lower levels. Similarly head rice recovery, Kernel length, protein and amylase content were found to be higher under the same treatment also. Application of 2 kg B/ha also recorded significantly higher head rice recovery, amylase, protein content and kernel length than 1 kg B/ha during both the years of experiments.

Key words : Hybrid rice, Nitrogen, Magnesium, Boron, Sterility Percentage.

A continuous gain in rice grain yield is essential to meet an increasing food demand of 135—145 million tones of rice by 2020 (1). Among various opportunities available for breaking yield barriers, hybrid is a commercially viable option because of its 12—15% higher yield potentiality (2). However hybrid rice has two limitations i.e. high spikelet sterility and poor quality. N supply is essential for effective assimilation and consequent filling of grains. Boron is required for growth of new cell and has effect on the process of flowering germination of pollen grains and grain filling in rice plants (3). It has also strong relationship with magnesium, which plays major role in photosynthesis process in plants and translocation of photosynthates sugar in the form of sugar-borate complexes. Magnesium being the constituent of chlorophyll molecule plays major role in photosynthetic activity. Besides yield, boron and magnesium are also known to affect the quality of rice (4). Therefore, it appears that nitrogen along with magnesium and boron can play an important role to overcome sterility problem of hybrid rice to realize its potential yield and desired quality.

Methods

A field investigation was carried out at the Research Farm, Department of Agronomy, Institute of

Agricultural Sciences, Banaras Hindu University, Varanasi during the two consecutive *kharif* (rainy) seasons of 2001-02, and 2002-03. The soil of the experimental site was sandy loam in texture with pH 7.4. It was medium in available phosphorus (20 kg P₂O₅/ha), potassium (226 kg K₂O/ha), magnesium (5.4 c mol (p+)/kg) and boron (0.47 ppm) and low in available nitrogen (182 kg/ha) and organic carbon content (0.38%). The treatments consisting of three levels of each N (60, 120 and 180 kg/ha), Mg (0, 20 and 40 kg/ha) and B (0, 1 and 2 kg/ha) which were allocated in main, sub and ultimate plots, respectively with three replications. Urea, di-ammonium phosphate, muriate of potash, magnesium sulfate, borax and zinc sulfate were used as source of nutrients. A uniform dose of 75 kg P₂O₅, 60 kg K₂O, 5.25 kg Zn/ha were applied to all the plots as basal application at transplanting. Nitrogen was applied in three splits, half as basal and remaining half in two equal splits coinciding with tillering and panicle initiation stages. The total amounts of magnesium and boron were applied in the ratio of 2/3 as basal and 1/3 as foliar application of 2 and 4% for Mg₂₀ and Mg₄₀ and 0.1 and 0.2% for B₁ and B₂ coinciding at tillering and flowering stages, respectively. Hybrid Pro Agro 6201 was transplanted with 30-day old seedlings at two/hill at a spacing of 20 × 15 cm on July 18 and 14 during 2001 and 2002, respectively. The response of hybrid rice to various

Table 1. Effect of different levels of nitrogen, magnesium and boron on yield attributes and yield of hybrid rice. Y₁ : *kharif* 2001-02 Y₂ : *kharif* 2002-03.

Treatments	Panicle length (cm)		Number of grains/panicle		Sterility (%)		Panicle weight (g)		Test weight (g)		Grain yield (q/ha)		Straw yield (q/ha)	
	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂
Nitrogen (kg/ha)														
N ₆₀	24.7	24.5	144.3	157.1	25.16	29.44	4.05	4.34	19.75	19.96	50.42	56.01	66.76	69.51
N ₁₂₀	26.3	26.7	176.5	189.9	20.82	27.89	5.36	5.54	22.61	23.01	62.14	69.08	73.56	77.56
N ₁₈₀	27.6	27.8	198.7	206.9	20.43	22.24	6.66	6.18	22.89	23.06	69.09	73.41	78.69	80.16
SE ±	0.28	0.27	5.37	4.37	1.02	1.19	0.30	0.13	0.54	0.74	0.79	0.80	2.43	2.58
CD (P=0.05)	0.78	0.75	14.91	12.13	2.83	3.30	0.83	0.36	1.50	2.05	2.19	2.22	6.74	7.16
Magnesium (kg/ha)														
Mg ₀	25.7	25.8	161.1	173.6	23.30	27.29	4.89	4.81	20.50	21.06	56.89	61.85	71.89	74.64
Mg ₂₀	26.3	26.6	173.2	184.9	21.99	26.89	5.46	5.58	22.19	22.47	61.15	67.07	73.49	76.24
Mg ₄₀	26.5	26.6	185.1	195.4	21.12	25.39	5.72	5.67	22.57	22.50	63.62	69.58	73.63	76.35
SE ±	0.24	0.23	4.75	4.14	0.91	1.05	0.21	0.13	0.45	0.41	0.68	0.70	2.21	1.66
CD (P=0.05)	0.52	0.50	10.35	9.02	1.98	2.28	0.45	0.28	0.98	0.89	1.48	1.53	NS	NS
Boron (kg/ha)														
B ₀	25.6	25.9	163.8	175.8	26.35	26.96	4.97	4.83	20.87	21.29	57.06	62.72	75.68	78.43
B ₁	26.4	26.4	173.1	184.9	22.05	26.86	5.40	5.51	21.69	22.07	61.37	66.91	72.12	74.84
B ₂	26.6	26.8	182.5	193.1	18.00	22.75	5.69	5.73	22.69	22.67	63.24	68.88	71.21	73.96
SE ±	0.21	0.21	3.67	3.36	1.01	0.92	0.18	0.12	0.38	0.28	0.49	0.55	1.59	1.43
CD (P=0.05)	0.43	0.43	7.44	6.81	2.05	1.86	0.36	0.24	0.77	0.57	1.00	1.11	3.22	2.91

treatments was measured in terms of quantitative and qualitative expression. Yield and yield attributing components like panicle length, grain number/panicle, sterility percentage and test weight were recorded. Finally grain and straw yield were recorded after crop harvest. Similarly various qualitative aspects of rice grain, related to physical (hulling, milling and head rice recovery), biochemical (protein and amylase content) and cooking (alkali spreading value, kernel length after cooking) were also estimated following standard procedure. Data thus recorded were statistically analyzed through standard procedure of split-split plot design.

Results and Discussion

Effect of Nitrogen

Application of 180 kg N/ha significantly decreased grain sterility percent and increased filled

grains/panicle over 120 kg N (Table 1). The increase in filled grains/panicle due to application of 180 kg N/ha remained 37.72, 31.77 and 12.3, 9.05% higher than 60 and 120 kg N/ha during 2001 and 2002 respectively. Application of 180 kg N/ha also recorded significantly higher panicle length, test weight over 60 and 120 kg N/ha. Marked improvement in yield attributes might be due to adequate availability and translocation of nutrients to the sink and assimilation of carbohydrates in the panicle. Om et al. (5) also reported similar results.

N applied at the rate 180 kg N/ha produced significantly higher grain and straw yield. The increase in grain yield was 37.02 and 31.06% higher by the application of 180 kg N/ha over 60 kg N/ha whereas 11.18 and 6.27% higher than 120 kg N/ha during 2001 and 2002 respectively. Increase in grain yield was found to be associated with increase in yield attributes with adequate N which registered a pronounced re-

Table 2. Effect of nitrogen, magnesium and boron on qualitative characters of hybrid rice. NS : Not significant, Y₁ : *Kharif* 2001-2002 : Y₂ : *Kharif* 2002—2003, CV : Coefficient of variation.

Treatments	Hulling (%)		Milling (%)		Head rice recovery (%)		Protein content (%)	
	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂
Nitrogen (kg/ha)								
N ₆₀	70.67	72.25	64.73	67.07	49.81	51.12	7.54	7.52
N ₁₂₀	73.78	74.02	66.00	67.39	53.20	54.20	8.01	8.14
N ₁₈₀	74.00	74.87	67.52	68.71	55.99	55.50	8.50	8.52
SE ±	3.12	2.29	2.97	2.91	1.64	0.72	0.09	0.04
CD (<i>P</i> =0.05)	NS	NS	NS	NS	4.55	2.00	0.25	0.11
Magnesium (kg/ha)								
Mg ₀	71.11	72.97	65.63	67.38	50.75	51.36	7.84	7.94
Mg ₂₀	72.89	73.87	66.17	67.75	53.79	53.90	8.04	8.04
Mg ₄₀	74.44	74.30	66.45	68.05	54.15	55.56	8.18	8.20
SE ±	1.42	1.01	1.40	1.39	1.31	1.13	0.08	0.04
CD (<i>P</i> =0.05)	3.09	NS	NS	NS	2.85	2.46	0.17	0.09
Boron (kg/ha)								
B ₀	72.11	73.50	65.47	67.12	50.68	50.56	7.90	7.96
B ₁	72.78	73.67	66.04	67.70	53.65	54.86	8.05	8.08
B ₂	73.56	73.97	66.73	68.36	54.37	55.41	8.11	8.13
SE ±	0.73	0.24	0.71	0.74	1.21	1.21	0.07	0.02
CD (<i>P</i> =0.05)	NS	NS	NS	NS	2.45	2.47	0.14	0.04

Table 2. Continued.

Treatments	Anylose content (%)		Alkali spreading value		Kernel length after cooking (mm)	
	Y ₁	Y ₂	Y ₁	Y ₂	Y ₁	Y ₂
Nitrogen (kg/ha)						
N ₆₀	21.13	22.67	2.37	2.11	10.18	10.33
N ₁₂₀	23.27	23.45	2.37	2.26	10.73	10.78
N ₁₈₀	23.35	23.97	2.80	2.30	10.85	10.84
SE ±	0.42	0.20	0.14	0.08	0.06	0.05
CD (<i>P</i> =0.05)	1.17	0.55	NS	NS	0.17	0.14
Magnesium (kg/ha)						
Mg ₀	22.21	22.87	2.22	2.15	10.44	10.44
Mg ₂₀	23.28	32.23	2.26	2.22	10.65	10.75
Mg ₄₀	23.23	23.98	2.33	2.30	10.67	10.76
SE ±	0.17	0.14	0.17	0.16	0.06	0.05
CD (<i>P</i> =0.05)	0.37	0.30	NS	NS	0.13	0.11
Boron (kg/ha)						
B ₀	22.15	22.68	2.22	2.19	10.65	10.72
B ₁	22.73	23.94	2.34	2.26	10.58	10.65
B ₂	23.08	23.72	2.26	2.22	10.53	10.59
SE ±	0.13	0.11	0.14	0.13	0.05	0.06
CD (<i>P</i> =0.05)	0.26	0.22	NS	NS	0.10	0.12

duction in grain sterility percentage. These results were in conformity with the findings of Rao et al. (6).

Increased N levels (N 180) showed in improvement in hulling and milling percent over low levels (Table 2). Accordingly, application of 180 kg N/ha recorded significantly higher head rice recovery and amylase content over 60 kg N/ha but remained at par with 120 kg N/ha. Increasing rates of N also increased the protein content of hybrid rice over rest of the N levels, while alkali spreading value remained unaffected. Incorporation of 180 kg N/ha significantly increased kernel length (cooked) and showed an increase in volume expansion of hybrid rice over 120 kg N/ha.

Effect of Magnesium

Significantly higher panicle length, test weight and reduced sterility percent were recorded by the incorporation of 40 kg Mg/ha over control, though it remained at par with 20 kg Mg/ha. Under adequate Mg availability greater synthesis of protein is expected in grain with subsequent reduction in unfertile grains which increased the number of grains/panicle. Percentage increase in grain number by the application of 40 kg Mg/ha was 14.92, 12.57 and 6.87, 5.68 over control and 20 kg Mg/ha during 2001 and 2002 respectively. Vijaylakshmi and Mathan (7) also observed a similar significant effect of Mg on different yield attributes of rice.

Grain yield increased significantly at each successive increase in Mg levels. Application of 40 kg Mg/ha produced maximum grain yield. These results are in accordance to Pandey et al. (8). Increasing Mg levels although increased straw yield but could not prove significant mainly because hybrid rice had higher photosynthetic activity and their grain : straw ratio often remained higher (9).

Application of 40 kg Mg/ha recorded significantly higher head rice recovery and increased protein and amylase content and volume expansion of grain over control and 20 kg Mg/ha (Table 2). Similarly increasing levels of Mg also showed some improvement in hulling, milling percentage and on alkali-spreading value as compared to low levels but remained insignificant. Increasing Mg application (Mg 40) increased kernel length after cooking over 20 kg Mg/ha. Lin et al. (10) observed increased grain protein and amylase

content in plant tissues, starch content and improvement in milling quality of rice due to Mg.

Effect of Boron

Increased boron supply (B_2) significantly increased panicle length and reduced grain sterility percentage over control and remained equally effective with 1 kg B/ha. The percentage increase in grain number/panicle due to 2 kg B/ha was 11.44 and 9.24 over control and 5.45 and 4.41 over 1 kg B/ha during 2001 and 2002 respectively (Table 1). The maximum test weight was recorded due to application of 2 kg B/ha which proved significantly superior to control and 1 kg B/ha. Boron showed marked stimulating effect on protein synthesis and increased panicle length with effective translocation of carbohydrates which consequently decreased the sterility percentage and increased the number of grains/panicle (11). Increased yield attributes due to boron application was also reported by Mondal and Ray (12).

The maximum grain yield was recorded by the application of 2 kg B/ha which proved significantly superior to 1 kg B/ha and control. Both the boron levels i.e. 1 kg and 2 kg B/ha increased the grain yield by 7.55 and 10.83 and 6.68 and 9.82% over control during 2001 and 2002 respectively. Contrary to this reduction in straw yield was noted due to 2 kg B/ha over control alone. Increase in grain yield due to increasing B supply was positively correlated with grain number. Studies on boron nutrition have indicated that boron required for seed and grain production is little higher than that for vegetative growth.

Hulling, milling and alkali spreading value showed marked improvement with increasing rates of boron (Table 2). Application of 2 kg B/ha recorded significantly higher percent of head rice recovery, amylase and protein content along with higher kernel length after cooking and volume expansion over control. Increased amylase content under increased supply of B is expected due to their close association with the formation of organic compounds such as amylase, protein and sugars (13, 14). Similar findings were also obtained by Madan et al. (15) and they reported positive correlation of cooking quality of rice with amylase content.

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