Bangladesh Rice J. 18(1&2): 24-32, 2014

Response of Nitrogen on Yield and Seed Quality of Boro Rice

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ABSTRACT

Nitrogen (N), the most limiting nutrient in Bangladesh, for rice has been studied most rigorously, but its contribution to rice seed production remained relatively unexplored. An experiment was conducted during Boro season (November-April) in 2009-10 at the Bangladesh Rice Research Institute experimental farm, Gazipur, Bangladesh, to evaluate the effect of N fertilizer on seed yield and its quality. The experiment included BRRI dhan28 and BRRI dhan29 and 0, 50, 100, 150, 200 and 250 kg ha^{-1} N rates. Seed yield increased significantly in a quadratic fashion with the increase of N rate both in BRRI dhan28 and BRRI dhan29. Application of N fertilizer increased seed yield by about 3-4 t ha^{-1} compared to control. The highest yield of 5.15 and 6.34 t ha^{-1} was obtained with 150 kg N ha^{-1} in BRRI dhan28 and BRRI dhan29 respectively. However, the predicted economic optimum doses of N appeared as 156 and 158 kg ha^{-1} for BRRI dhan28 and BRRI dhan29 respectively. Nitrogen application to rice seed crop did not impair seed quality in terms of germination, viability, vigour and seed color. The seed N concentration ranged from 0.94 to 1.31% in BRRI dhan28 and 0.85 to 1.07% in BRRI dhan29 among different N rates. The seed phosphorus concentration varied from 0.30 to 0.41% in BRRI dhan28 and 0.28 to 0.36% in BRRI dhan29 among different N rates. The seed K varied from 0.23 to 0.27% and 0.20 to 0.23% in BRRI dhan28 and BRRI dhan29 respectively, among different N rates. The average seed protein of BRRI dhan28 (6.59%) was significantly higher than that of BRRI dhan29 (5.68%). Seed N and protein content slightly increased with the increase of N rate. Nitrogen application did not influence phosphorus and magnesium content in rice seed. However, seed potassium slightly decreased with the N application.

Key words: Rice *(Oryza sativa),* seed yield, seed quality, nitrogen rate

INTRODUCTION

Rice *(Oryza sativa* L.) is the staple food for nearly half of the world's population, mostly live in developing countries. The crop occupies one-third of the world's total area planted to cereals and provides 35-40% of the calories consumed by 2.7 billion people (Fageria and Baligar, 2001). By 2025, it is estimated that it will be necessary to produce about 60% more rice than what is currently produced to meet the food needs of a growing world population (Fageria *et al.*, 2003). In order to grow more food from marginal and good quality lands, sustaining the quality of natural base is a concern. Production of quality seed is one of the few means to achieve the goals. Insufficiency of quality seed is one of the rice production constraints for modern rice varieties in Bangladesh. Government and NGO seed supply systems contribute only 15-20% of total seed demand in the country. Use of quality seed can increase rice yield by 12-15% at a given management practices (Gomosta, 2004). Several authors reported that rice yield can be increased up to 15-20% by using quality seed alone (Bhuiyan *et al.*, 2002; Farooq, 2006). In general, rice seed yield is often lower than the grain yield because of seedling mortality, rouging and low nutrient application. Nutrient management strategy in seed crop may be somewhat different from normal grain crop. Only commercial entrepreneurs grow seed crop and price of seed is always several-fold higher than normal food grain price. Seed yield may be increased through proper nutrient management without sacrificing seed quality.

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Nitrogen is one of the most yield-limiting nutrients in rice production around the world, especially in tropical Asian soils and almost every farmer has to apply N fertilizer to get a desirable yield of rice (Saleque *et al.,* 2004). Judicious use of fertilizers can markedly increase the yield and improve the quality of rice (Chaturvedi, 2005). Given the importance of N fertilization on the yield in grain, it is necessary to know what the best dose is for each variety as well as its influence on yield components and other agronomic parameters such as plant height, lodging and moisture content of the grain, in order to obtain better knowledge of said productive response (Chaturvedi, 2005). However, both excess and insufficient supply of N is harmful to the rice crop and may decrease seed yield. An adequate N supply can increase as much as 60% rice production over control (Mikkelsen *et al.,* 1995).

Neelam and Chopra (2000) found that the highest plant height, number of panicles m^{-2}, seed weight $panicle^{-1}$, grain and straw yields were obtained when the N fertilizer rates increased up to 80 kg ha^{-1}. However, the seed test showed no effect on seed quality due to N levels. The proper use of N fertilizer could improve caryopsis weight of rice by improving the absorbing activity of the root in order to absorb more nutrients from the soil. The increase in amount of N at the booting stage may provide sufficient N to rice plants during the late grain filling stage. This could help lessen threats posed by catabolism of structural protein in stem and leaves, thereby extending the life-span of green leaves by maintenance of high photosynthetic rate (Juan *et al.,* 2006). Yoldas *et al*. (2008) observed that potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), and zinc (Zn) content increased with increases in N rates but, phosphorus (P), copper (Cu), manganese (Mn), boron (B) and sodium (Na) contents were not influenced. The amino acid contents as well as the nutritional value of protein of plant origin are influenced by the plants species and physiological and agro-ecological factors. Fertilization, especially N nutrition, has a very important role on the amino acid contents (Custic *et al.,* 2009). Panicle with a low percentage of sterile flowers permits the application of higher N doses of and produce better yields (Yoshida, 1981). Increasing rates of N fertilizer may increase the yield but reduce the quality of the grain (Conry, 1995; Gately and Kelly, 1987).

Excessive dose of N produces succulent plants and enhances the plants sensitivity to water and temperature stress, susceptible to lodging and pest and disease incidence and in consequence, give poor quality seed of rice (Balasubramaniyan and Palaniappan, 2007). There is an apprehension that the application of nutrient may deteriorate seed quality, although there is little study to develop a nutrient management strategy that combine seed yield increase yet no quality is compensated. Under these circumstances, the present study was undertaken with the objectives to determine the optimum dose of N on yield and seed quality of Boro rice and seed nutrient composition of rice under varying levels of N application.

MATERIALS AND METHODS

A field experiment was conducted during Boro season in 2009-10 at the experimental farm of the Bangladesh Rice Research Institute, Gazipur, Bangladesh (23°59′N latitude, 90°24′E longitude). The farm belongs to agro-ecological zone (AEZ) number 28 known as Madhupur Tract. The soil of the experimental field is Chhiata clay loam, a member of the fine, hyperthermic Vertic Endoaquept (Saleque *et al.,* 2004). The initial soil chemical properties at 0-15 cm soil depth were: pH 6.1, organic matter 2.02%, total N content 0.07%, available P 10.14 mg kg^{-1} (0.5 M $NaHCO_3$ extracted), exchangeable K 0.17 meq/100 g soil (Neutral 1.0 N NH_4OAc extracted), available sulfur (S) 20 mg kg^{-1} [$Ca(H_2PO_4)_2$ extracted], and available Zn 2.8 mg kg^{-1} (0.01N HCl extracted).

The experiment involved two factors, rice variety and N rate. Two rice varieties, BRRI dhan28 and BRRI dhan29 were grown under irrigated conditions during Boro season. The tested N rates were 0, 50, 100, 150, 200 and 250 kg ha^{-1}. Rice was transplanted in the first week of January 2012 with 40-day-old seedlings. Two or three seedlings were transplanted with 20- × 20-cm spacing. The experiment was conducted in a randomized complete block design with three replications. Unit plot size was 5- × 4-m.

All plots were surrounded by soil levees of 30 cm high to avoid N contamination between plots. Nitrogen was applied as urea in three equal splits: 20, 35 and 50 days after transplanting (DAT) for BRRI dhan28 and 20, 35 and 55 DAT for BRRI dhan29. Phosphorus, K, S and Zn were applied as triple super phosphate, muriate of potash, gypsum and zinc sulphate respectively, during final land preparation. After transplanting, intercultural operations like weeding, irrigation and control of pest were done as and when necessary. At maturity the crop was harvested manually at 15 cm above ground level. However, 16 hills from each plot were harvested at the ground level for measuring yield components and straw yield. The grain yield was recorded at 12% moisture content and straw yield as oven dry basis following standard procedures as described by Yoshida *et al.* (1976). Optimum dose of N was determined by differentiating the quadratic N response equation (Colwell, 1994). The grain number panicle^{-1}, 1000-grain weight (TGW) was measured at 12% moisture and sterility (%) was calculated following Yoshida *et al.*, 1972. Rice plants from 5 m^2 area of the middle of each plot were harvested at above ground level and threshed for grain yield determination.

The quality of the freshly harvested rice seeds were assessed by seed germination, seed viability and seedling vigour test. Seedling vigour was tested following two methods: 1) speed of germination and 2) seedling length measurement (Agrawal, 2005). Germination count was made according to ISTA (2006). The N, P, K and Mg concentrations in seed grain were determined according to Yoshida *et al.*, 1976. Seed protein content was calculated by multiplying the N content in seeds by a factor of 5.95 (Juliano, 1972). The seed colour was determined by Munsell Color Chart. Analysis of variance (ANOVA) of the measured parameters was performed and the treatment means were compared using Least Significant Difference (LSD) at the 5% level of probability (Gomez and Gomez, 1984). The yield trends were analyzed by ordinary least squares linear regression as done by Dawe *et al.* (2000). The significance test of the regression analysis was done following Statcal (2012).

RESULTS AND DISCUSSION

Yield contributing characters

The N and variety interactions in relation to yield components were not significant ($P>0.05$) (Table 1). At N-control treatment, BRRI dhan28 produced 205 panicle m^{-2} compared to BRRI dhan29 (167). Receiving 50 kg N ha^{-1}, panicle m^{-2} in BRRI dhan28 and BRRI dhan29 was 219 and 220 respectively. Increasing N rate increased panicle production in both the varieties. At 150 kg N ha^{-1}, BRRI dhan28 and BRRI dhan29 produced 290 and 268 panicle m^{-2} which increased to 292 and 288 respectively with 200 kg N application. Application of 250 kg N ha^{-1} increased panicle m^{-2} abruptly to 314 in BRRI dhan28 and 338 in BRRI dhan29.

The individual effect of N for filled grains panicle^{-1} was not significant ($P>0.05$). In BRRI dhan28, the higher number of grains panicle^{-1} was observed in 50 kg N ha^{-1} followed by 100 and 200 kg N ha^{-1}. The number of grains panicle^{-1} from 150 and 250 kg N ha^{-1} was statistically similar. The lowest number of grains panicle^{-1} was observed in control-N treatment. In BRRI dhan29, the higher number of grains panicle^{-1} was obtained from 150 kg N ha^{-1} followed by 50 kg N ha^{-1} and 200 kg N ha^{-1}. The number of grains panicle^{-1} from 100 kg N ha^{-1} and 250 kg N ha^{-1} was similar. Varietal difference for grains panicle^{-1} was significant ($P<0.01$) (Table 1). Irrespective of N rate, BRRI dhan29 produced significantly higher number of grains in comparison to BRRI dhan28. The increase in number of grains per panicle was 31% in BRRI dhan28 at 50 kg N ha^{-1} and 24% in BRRI dhan29 at 150 kg N ha^{-1} compared to control-N treatment.

TGW ranged from 19.4 to 20.4 g in BRRI dhan28 and from 18.8 to 19.5 g in BRRI dhan29, respectively (Table 1). The application of higher doses of N decreased TGW in both the varieties. BRRI dhan29 had lower TGW than BRRI dhan28 at a given N dose. BRRI dhan28 showed TGW of 20.3 g in N-control plots compared to 19.5 g in BRRI dhan29. Increasing N dose up to 200 kg ha^{-1} had no significant effect on TGW, but the application of 250 kg N ha^{-1} decreased seed weight significantly in both the varieties.

In BRRI dhan28, the sterility ranged from 22-30% and it was 17-25% in BRRI dhan29 (Table 1). Both N application rates and varieties produced significant effect on the sterility percentage. However, interaction effect of N and variety on sterility percentage was not significant. Irrespective of N rates, sterility was higher in BRRI dhan28 than BRRI dhan29. In the N-control plots, BRRI dhan28 and BRRI dhan29 had sterility percentage of 30 and 24 respectively. Receiving 50 kg N ha^{-1}, sterility percentage reduced to 24 and 21 in BRRI dhan28 and BRRI dhan29 respectively. Increasing the N rates to 100 kg ha^{-1}, sterility in BRRI dhan28 increased to 27% and in BRRI dhan29 increased it to 22%. At 150 kg N ha^{-1}, BRRI dhan28 and BRRI dhan29 produced 23 and 17% sterile spikelets respectively. Further increasing the N rates to 200 and 250 kg ha^{-1} did not change the sterility percentage in BRRI dhan28, but in BRRI dhan29 it increased. At the highest N levels, both the varieties had similar sterility percentage. Fageria and Baligar (1999) estimated that the panicle number accounted for 87% of the variation in yield, while spikelet sterility and TGW accounted for 7 and 3% yield variation in rice. Zeng and Shannon (2000) observed that filled grain per panicle and sterility percentage accounted for 71.1 and 38.0% variation respectively, while TGW accounted for only 1.1% variation in the rice yield. The improved growth attributes, such as plant height and dry-matter production, might be responsible for improved yield attributes. It was found that application of N improves various crop parameters like TGW more productive tillers and thus resulting in higher grain yields (Chaturvedi, 2005).

Table 1. Effect of N application on different yield parameters of BRRI dhan28 and BRRI dhan29

N rate (kg ha^{-1})	Panicle m^{-2}	Grains panicle^{-1}	1000 grain wt (g)	Sterility (%)
		BRRI dhan28		
0	205	87	20.3	30
50	209	114	20.1	22
100	258	100	20.1	27
150	290	94	20.4	23
200	292	101	19.9	24
250	338	99	19.4	24
Avg.	265	99	20	25
		BRRI dhan29		
0	167	107	19.5	24
50	220	119	19.4	21
100	255	111	19.3	22
150	268	133	19.3	17
200	288	118	19.2	25
250	314	116	18.8	24
Avg.	252	117	19	22
LSD$_{0.05}$ for N	36.01	NS	0.44	3.59
LSD$_{0.05}$ for V	NS	9.47	0.25	2.07
LSD$_{0.05}$ for N×V	NS	NS	NS	NS
CV (%)	13.6	14.9	2.2	14.9

NS=not significant at the 0.05 probability levels

Seed yield

Nitrogen and variety demonstrated significant interaction effect on the seed yield ($P<0.05$). Seed yield increased with N fertilization and showed significant ($P<0.01$) quadratic response both in BRRI dhan28 and BRRI dhan29 rice (Fig. 1). The quadratic regression equation ($Y = 2881.29 + 41.23x - 0.13x^2$, $R^2 = 0.99$) for BRRI dhan29 and $Y = 2606.18 + 31.72x - 0.10x^2$, $R^2 = 0.98$) for BRRI dhan28 explained 99% of yield variation in BRRI dhan29 and 98% in BRRI dhan28 by N application. Varietal effect showed highly significant ($P<0.01$) and BRRI dhan29 achieved significantly greater yield compared to BRRI dhan28 (Fig. 1). BRRI dhan28 and BRRI dhan29 produced 2,486 and 2,908 kg ha^{-1} respectively, in the control plots, which increased to 4,130 and 4,534 kg ha^{-1} respectively, with 50 kg N ha^{-1}. Increasing N dose to 100 kg ha^{-1}, BRRI dhan28 increased yield to 4,864 kg ha^{-1}, while BRRI dhan29 produced 5,186 kg ha^{-1}. Difference in grain yield between BRRI dhan28 and BRRI dhan29 was larger at 100 and 150 kg N ha^{-1} compared to other doses. Differentiating the quadratic equation of yield response with respect to applied N doses, the optimum N rate was 164 kg ha^{-1} both for BRRI dhan28 and BRRI dhan29. However, the economic optimum dose was 156 and 158 kg ha^{-1} for BRRI dhan28 and BRRI dhan29 respectively. Singh *et al.* (1998) also reported that maximum grain yield of 20 lowland rice genotypes was obtained at 150–200 kg N ha^{-1} at IRRI, Philippines. In fertilizer experiments, 90% of the maximum yield is often considered as an economical rate (Fageria *et al.,* 2003). The 90% of the maximum grain yield was obtained at 136 kg N ha^{-1} and 90% of the maximum shoot dry matter yield was achieved at 120 kg N ha^{-1} (Fageria *et al.,* 2008). Similarly, Dobermann et al. (2000) obtained maximum average grain yield in the dry season at IRRI, Philippines with 120 to 150 kg N ha^{-1}. Singh *et al.* (2007) observed 120 kg N ha^{-1} as an optimum dose for a yield level of 7.45 and 6.80 t ha^{-1} in Indo-Gangetic plain of Ludhiana, India.

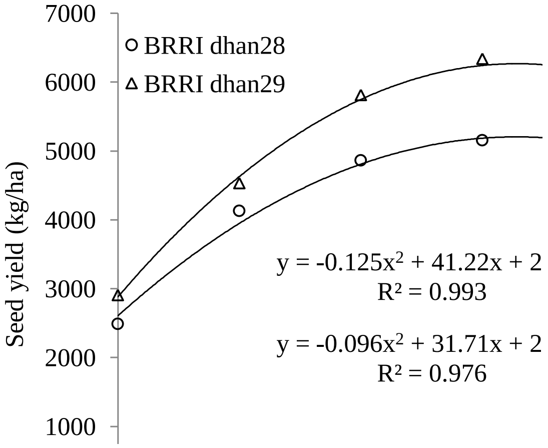

Fig 1. Seed yield of two rice varieties at different rates of nitrogen application.

Seed germination

Nitrogen and variety interactions on seed germination were insignificant ($p>0.05$). The individual effect of N on seed germination was significant ($P<0.01$). In BRRI dhan28, the N rate, 50, 200 and 250 kg ha^{-1} produced the higher germination (%) followed by control-N treatment (Table 2). The 100 kg N ha^{-1} produced significantly lower germination in comparison to 50, 200 and 250 kg N ha^{-1}.

The lowest germination was obtained from 150 kg N ha^{-1}. The 100 kg N ha^{-1} and control-N treatment gave statistically similar germination. The 50 and 150 kg N ha^{-1} gave similar germination. The individual effect of variety on seed germination was significant ($P<0.05$). Under control-N treatment, BRRI dhan28 and BRRI dhan29 gave similar germination percentage. At 100 and 150 kg N ha^{-1}, BRRI dhan28 and BRRI dhan29 gave similar germination. A similar scenario was observed at 200 and 250 kg N ha^{-1}. But at 50 kg N ha^{-1}, BRRI dhan28 gave significantly higher germination compared to BRRI dhan29 (Table 2).

Seedling vigour

Nitrogen and variety interactions demonstrated insignificant effect on seedling vigour. The individual effect of N on speed of seed germination ($p<0.05$) was significant with different levels of N. In BRRI dhan28, the highest speed of germination was obtained from the rate of 200 kg N ha^{-1} followed by 50 kg N ha^{-1} and 250 kg N ha^{-1} (Table 2). The control-N treatment, 100 kg N ha^{-1} and 150 kg N ha^{-1} also gave similar speed of germination. The lowest speed of germination was observed in 150 kg N ha^{-1}. In BRRI dhan29, the highest speed of germination was obtained from 250 kg N ha^{-1} followed by 200 kg N ha^{-1}, 100 kg N ha^{-1} and control-N treatment. The 100 kg N ha^{-1} and 150 kg N ha^{-1} gave similar speed of germination. The lowest speed of germination was observed in 50 kg N ha^{-1}. In BRRI dhan28, 50 kg N ha^{-1} performed better speed of germination along with 200 kg N ha^{-1} and 250 kg N ha-1 whereas in BRRI dhan29, it gave reverse performance. The individual effect of N on vigour index showed insignificant effect with different levels of N (Table 2). The individual effect of variety on speed of germination ($p<0.05$) was significant. At 0, 100, 150 and 250 kg N ha^{-1}, BRRI dhan28 and BRRI dhan29 gave similar speed of germination. At 50 and 200 kg N ha^{-1}, BRRI dhan28 gave significantly higher speed of germination in comparison to BRRI dhan29. The individual effect of variety on vigour index ($p<0.01$) was also significant. BRRI dhan28 gave significantly higher vigour index in comparison to BRRI dhan29 at all N rates (Table 2). These results are partially in agreement with the findings of Khan *et al*. (2002). They reported that germination percentages, vigour index and growth characters did not vary due to N application. Vigour testing is important because it often gives a better prediction of field performance and is a more sensitive indicator of seed quality than the standard germination test (Younis *et al.*, 1990). The highest vigour status occurs at physiological maturity after which deterioration processes begin. Deterioration involves loss of membrane integrity, slower respiration, and more leakage of electrolytes and decreased enzyme activity, all of which may be reflected in lower germination percentage.

Table 2. Effect of different nitrogen rates on seed quality of BRRI dhan28 and BRRI dhan29

N rate (kg ha^{-1})	Germination (%)	Speed of germination	Vigour index
		BRRI dhan28	
0	98	18.89	824.14
50	99	19.25	854.07
100	96	18.76	789.88
150	93	18.17	892.3
200	99	19.26	875.94
250	99	19.12	809.11
Avg.	97	18.91	840.91
		BRRI dhan29	
0	97	18.81	644.81
50	92	17.72	711.15
100	95	18.52	692.86
150	93	18.13	551.63
200	98	18.81	717.23
250	98	19.04	744.53
Avg.	96	18.51	677.04
$LSD_{0.05}$ for N	2.83	0.59	NS
$LSD_{0.05}$ for V	1.64	0.34	63.36
$LSD_{0.05}$ for N × V	NS	NS	NS
CV(%)	4.2	4.5	20.6

NS=not significant at the 0.05 probability levels.

Seed colour

Different rates of N did not affect seed colours according to Munsell colour chart. The seed colour was 10YR with value 7 and chroma 6-8.

Seed nutrient content

The N and variety interactions in relation to seed N concentration were not significant ($P>0.05$). The individual effect of N in relation to seed N concentration was highly significant ($P<0.01$) (Table 3). In BRRI dhan28, the seed N concentration varied from 0.94 to 1.31% among different N rates. The highest seed N content was obtained from 250 kg N ha^{-1} followed by 200 kg N ha^{-1} application. The seed N content with the rate of 150 kg N ha^{-1} was observed significantly lower in comparison to 200 kg N ha^{-1} and 250 kg N ha^{-1}. Application of N at 100 and 150 kg ha^{-1} performed similar seed N concentration. The seed N content with the application of 100 kg N ha^{-1} performed significantly higher in comparison to the application 50 kg N ha^{-1}. The lowest seed N concentration (0.94%) was observed in control-N plots. The seed N content from control-N and 50 kg N ha^{-1} performed similar concentration. However, with the increase of N rate increased seed N concentration progressively. In BRRI dhan29, the seed N concentration varied from 0.85 to 1.07% among different N rates. The higher seed N content was obtained from the rate of 200 kg N ha^{-1} and 250 kg N ha^{-1} (1.07%). The seed N content with 150 kg N ha^{-1} performed significantly lower in comparison to 200 kg N ha-1. The seed N content with 100 kg

N ha^{-1} and 150 kg N ha^{-1} gave similar concentration. Application of 100 kg N ha^{-1} produced significantly higher seed N concentration in comparison to the application of 50 kg N ha^{-1}. The lowest seed N content was observed in control-N plots. However, this value was similar to 50 kg N ha^{-1}. The application of N in BRRI dhan29 increased seed N concentration progressively similar to that obtained in BRRI dhan28. The individual effect of variety on seed N concentration was highly significant ($P<0.01$). Average over the N doses, including control, BRRI dhan28 produced significantly higher seed N concentration (1.11%) compared to BRRI dhan29 (0.95%). The N and variety interactions and the individual effects of N and variety in relation to seed P concentrations were insignificant ($P>0.05$) (Table 3). The individual effect of variety in relation to seed P concentration was insignificant ($P>0.05$). BRRI dhan28 and BRRI dhan29 produced similar seed P concentration. The effects of N rate in relation to seed K concentration was highly significant ($P<0.01$). In BRRI dhan28, the seed K varied from 0.23 to 0.27% among different N rates. The higher seed K (0.27%) was obtained from control-N rates and 50 kg N ha^{-1} rates followed by the 100 kg N ha^{-1} (0.26%). The seed K concentration from the rate of 100 kg N ha^{-1}, 150 kg N ha^{-1} and 200 kg N ha^{-1} was similar (Table 3). The lowest seed K was observed in 250 kg N ha^{-1} (0.23%). However, the K concentration declined gradually with the increase of N rates and apparently it was the reverse scenario of seed N concentration. The N × V interactions and the individual effect of N in relation to seed Mg concentration were not significant ($P>0.05$). The individual effect of variety in relation to seed Mg concentration was significant ($P<0.05$). BRRI dhan28 produced significantly higher seed Mg % compared to BRRI dhan29 irrespective of N rate (Table 3). The N and variety interactions in relation to seed protein content were insignificant ($P>0.05$). But the main effect of N rate in relation to seed protein content was highly significant ($P<0.01$). The seed protein % varied from 5.62 to 7.77% among different N rates. The highest seed protein (7.77%) was obtained from 250 kg N ha^{-1} followed by 200 kg N ha^{-1} (7.71%). With the application of 150 kg N ha^{-1}, the seed protein content was observed significantly lower in comparison to the rate of 200 kg N ha^{-1} (7.71%) and 250 kg N ha^{-1} (7.77%). The seed protein content had similar concentration with the application 100 kg N ha^{-1} and 150 kg N ha^{-1}. But seed protein at 100 kg N ha^{-1} was significantly higher (6.20%) incomparison to 50 kg N ha^{-1} (5.70%). The lowest seed protein (5.62%) was observed in the control-N plots. However, with the application of 50 kg N ha^{-1} and control-N plots performed similar seed protein concentration. It was observed that increasing N rates increased seed protein concentration progressively (Table 3). The seed protein in rice grain with the application of 150 kg N ha^{-1} was significantly lower compared to 200 kg N ha^{-1}. Application of 100 kg N ha^{-1} and 150 kg N ha-1 produced similar seed protein. On the other hand, application of 100 kg N ha^{-1} gave significantly higher seed protein compared to 50 kg N ha^{-1}. The lowest seed protein was obtained from control-N plots (5.07%), however, this value was similar to application of 50 kg N ha^{-1}. The individual effect of variety in relation to seed protein was highly significant ($P<0.01$). The average seed protein of BRRI dhan28 (6.59%) was significantly higher in comparison to BRRI dhan29 (5.68%) irrespective of N rate (Table 3). Hossain *et al.* (2009) reported fertilizers had significant influence on protein percentage in brown rice of BRRI dhan28. They obtained the highest protein (7.78%) in rice with the recommended chemical fertilizer (NPKSZn) dose and the lowest (6.80%) was in the control. Blunenthal *et al.* (2008) observed that N often affects amino acid composition of protein and in turn its nutritional quality in rice crop. Uppal and Bali (1997) reported that protein content increased significantly with the increased dose of nitrogen in rice. Sikdar *et al.* (2008) reported significant varietal difference in N content, N uptake, protein and aroma of rice grain. Varietal differences in rice on N content and consequently protein percentage have been reported frequently (Mannan 2005; Saleque *et al.,* 2005). Total soluble protein of freshly harvested rice seed influenced significantly by planting time, N level and mode of N application. Total soluble protein ranged from 5.12 to 9.27 mg g^{-1} which is in agreement with the findings of Sinclair and De Wit (1975) who found 8 to 16% proteins in cereal seed.

Table 3. Nutrient contents of seeds of two rice varieties

N rate (kg ha^{-1})	N%	P%	K%	Mg%	Protein%
			BRRI dhan28		
0	0.94	0.34	0.27	0.087	5.62
50	0.96	0.41	0.27	0.088	5.70
100	1.04	0.33	0.26	0.088	6.20
150	1.10	0.36	0.25	0.088	6.55
200	1.30	0.30	0.24	0.090	7.71
250	1.31	0.31	0.23	0.087	7.77
Avg.	1.11	0.34	0.25	0.088	6.59
			BRRI dhan29		
0	0.85	0.32	0.23	0.087	5.07
50	0.87	0.33	0.23	0.085	5.20
100	0.96	0.36	0.22	0.086	5.70
150	0.90	0.30	0.22	0.087	5.38
200	1.07	0.28	0.20	0.085	6.36
250	1.07	0.30	0.19	0.087	6.38
Avg.	0.95	0.32	0.22	0.086	5.68
LSD$_{0.05}$ for N	0.07	NS	0.02	NS	0.42
LSD$_{0.05}$ for V	0.04	NS	0.01	0.002	0.24
LSD$_{0.05}$ for N × V	NS	NS	NS	NS	NS
CV (%)	6.70	17	7.20	3.10	6.70

NS=not significant at the 0.05 probability levels.

CONCLUSIONS

BRRI dhan29 produced about 1 t ha^{-1} more seed than the BRRI dhan28, the N requirement for both the varieties was 164 kg ha^{-1}. Nitrogen application to rice seed crop did not impair seed quality in terms of germination, viability, vigour and seed colour. However, a slight difference in N, P, K and Mg contents due to N management resulted in little variation in the seed qualities of the tested varieties. Popular belief in the deterioration of seed quality due to the application of chemical fertilizer seems to have little acceptability.

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