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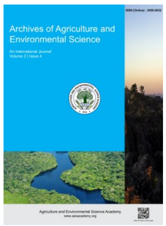

ORIGINAL RESEARCH ARTICLE

CrossMark

Effect of integrated nitrogen application on the yield of two *Boro* rice varieties: BRRI dhan29 and BRRI dhan74

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ABSTRACT

This study aimed to evaluate the effect of integrated nitrogen (N) application on the yield of *Boro* rice. The experiment was composed of two rice varieties: BRRI dhan29 and BRRI dhan74, and eleven N management approaches: control (without N), 100% varietal recommended dose (RD) of N from urea, 75% of RD from urea + 25% of RD from poultry manure (PM), 50% of RD from urea + 50% of RD from PM, 25% of RD from urea + 75% of RD from PM, 75% of RD from urea + 25% of RD from vermicompost (VC), 50% of RD from urea + 50% of RD from VC, 25% of RD from urea + 75% of RD from VC, 75% of RD from urea + 25% of RD from cowdung (CD), 50% of RD from urea + 50% of RD from CD and 25% of RD from urea + 75% of RD from CD. Performance of BRRI dhan74 was better compared to BRRI dhan29 in terms of yield. For both verities, application of 75% of RD from urea + 25% of RD from PM produced the highest grain yield (BRRI dhan74: 3.30 t ha^{-1} and BRRI dhan29: 3.08 t ha^{-1}) and the lowest with control among the N management approaches. Thus, it can be suggested that integrated N application with 75% of varietal RD from urea and 25% from PM in *Boro* rice cultivation will produce appreciable grain yield and also expected to have positive effect on soil health.

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INTRODUCTION

Rice is the main food crop of Bangladesh, accounting for about 75% of agricultural land use (BBS, 2015). There are three rice growing seasons namely *Aus*, *Aman* and *Boro*. The majority of rice growing area is covered by *Boro* rice comprising 58% of the total rice area (BBS, 2015). The yield of *Boro* rice is higher than that of *Aman* and *Aus* rice. Among the top rice growing countries of the world, the position of Bangladesh is forth (BBS, 2015). But there is still a yield gap between potential yield in research field and farmer's field. According to recent study conducted by Bangladesh Rice Research Institute (BRRI), the yield gap in rice production was estimated at 1.74 t ha^{-1}. Yield gap between potential and farmer's yield are substantially high due to the combination of constraints, such as poor management, economic condition of farmers, lack of resources and knowledge. Exploiting the production potential of high yielding rice varieties through agronomic management is one of the major means to minimize the yield gap.

Fertilizers have contributed substantially to the spectacular increase in the yield of rice. Among all nutrient elements, Nitrogen (N) is the most important fertilizer element playing vital role in yield improvement of rice and the element is frequently reported as deficient in agricultural soils of Bangladesh (Islam, 1990). However, growing crop with indiscriminate use of N fertilizers by our farmers has resulted into degradation of lands owing to low yields with poor quality of produce. Moreover, continuous uses of chemical fertilizer cause negative impact on environment. The use of inorganic fertilizer to sustain cropping was found to increase yield only for some few years but on long-term, it has not been effective and lead to soil degradation (Satyanarayana *et al.*, 2002). On the other hand, continuous application of organic fertilizer alone on rice field resulted low yield and low N and K contents at the tillering stage of rice plant (Javier *et al.*, 2004). This implies that the integration of inorganic and organic fertilizers could act as a great way for practicing sustainable agriculture and to achieve food security. The integrated nutrient management system is characterized by reduced input of chemical fertilizers and combined use of chemical fertilizer with organic materials such as animal manures, crop residues, green manure and compost (Husan *et al.*, 2014). Combined use of organic manures and inorganic fertilizers help in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients, enhancing efficiency of applied nutrients and providing favorable soil physical conditions (Gill and Walia, 2014) which may increase up to 50% of the world crop production (Pradhan, 1992). It has been reported that the use of organic fertilizer together with chemical fertilizer, compared to the addition of organic fertilizer alone, had a higher positive effect on microbial biomass and soil health (Dutta *et al.*, 2003). Losses of N from inorganic sources are very rapid from the soil through volatilization and de-nitrification. As a result, in near future, fertilizer N is likely to be even more costly. This situation in turn will pose a serious threat to food security for the vast millions of populations of the country, which again indicates to start using inorganic N fertilizer blended with organic manures to minimize the N loss by increasing N use efficiency by rice plant. Integrated N management increases long term productivity through sustaining soil productivity. Positive effect of integrated N application might help to motivate the growers in this system by reducing total production cost aims for efficient and judicious use of all the major sources of plant nutrients in an integrated manner (Farouque and Takeya, 2007). But still farmers of Bangladesh are not interested in integrated nutrient practices in rice field mainly due to deficiency of material, lack of knowledge about variation of N content in different organic manures, selecting best manures, their specific rate/ratio of integration with chemical fertilizer. In integrated nutrient management, calculation of the exact amount and combination of N from different sources is often critical, which put negative impact on farmer's decision in selecting integrated practice.

Therefore, the present study was undertaken to evaluate the differential varietal response on integrated N management practices, to determine the effect of integrated N application on growth and yield of rice and to determine the best combination of integrated N management for *Boro* rice cv. BRRI dhan29 and BRRI dhan74.

MATERIALS AND METHODS

Experimental site and soil

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh (located at 24°75′N latitude and 90°5′E longitude) belonging to the Old Brahmaputra Floodplain agro-ecological zone of Bangladesh (AEZ- 9) during December 2016 to May 2017. The topography of the experimental field was low to medium with moderate drainage facilities having non-calcareous dark gray floodplain soil (UNDP and FAO, 1988). The texture of the soil was loamy in nature with more or less neutral (pH 6.8) in reaction and low in N (0.1%) and exchangeable K (0.14%) contents. Available P and S were 26.0 and 13.9 ppm, respectively and general fertility level was also low. The climate of experimental site was subtropical in nature which is characterized by high temperature, high humidity and heavy precipitation with occasionally gusty wind during *Kharif* season (April to September) and scanty rainfall associated with moderately low temperature during *Rabi* season (October to March).

Experimental design and treatments

The experiment consisted of two factors: A) two varieties and B) eleven N management approaches as follows:

Factor A: variety- BRRI dhan29 and BRRI dhan74

BRRI dhan29 was developed by Bangladesh Rice Research Institute (BRRI) in 1994, by crossing of BG-902 and BR51-45-5. The cultivar of BRRI dhan29 matures in 155-160 days. The grain is medium sized and golden yellow in color. Harvesting time is mid-April to early May and the average yield of the cultivar is 7.5 t ha^{-1}. This cultivar has the resistance against leaf blight and sheath blight. BRRI dhan74 was developed by BRRI through hybridization method in 2014. BRRI dhan74 matures in 145-147 days. The average yield of the cultivar is 7 t ha^{-1}. The special quality of this variety is the protein (8.3%) and amylose (24.2%) contents of the grains.

Factor B: N- management approaches

Control (without N application) (N_1), 100% varietal recommended dose (RD) of N from urea (N_2), 75% N of RD from urea + 25% N of RD from poultry manure (PM) (N_3), 50% N of RD from urea + 50% N of RD from PM (N_4), 25% N of RD from urea + 75% N of RD from PM (N_5), 75% N of RD from urea + 25% N of RD from vermicompost (VC) (N_6), 50% N of RD from urea + 50% N of RD from VC (N_7), 25% N of RD from urea + 75% N of RD from VC (N_8), 75% N of RD from urea + 25% N of RD from cowdung (CD) (N_9), 50% N of RD from urea + 50% N of RD from C (N_{10}) and 25% N of RD from urea + 75% N of RD from C (N_{11}).

[Here, for urea: 100% = 263 kg ha^{-1}; 75% = 197 kg ha^{-1}; 50% = 131 kg ha^{-1}; 25% = 66 kg ha^{-1}; for PM: 75% = 4323 kg ha^{-1}; 50% = 2882 kg ha^{-1}; 25% = 1440 kg ha^{-1}; for VC: 75% = 6052 kg ha^{-1}; 50% = 4035 kg ha^{-1}; 25% = 2017 kg ha^{-1} and CD: 75% = 7566 kg ha^{-1}; 50% = 5044 kg ha^{-1}; 25% = 2521 kg ha^{-1}]

The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. The size of each unit plot was 5 m^2 (2.5 m × 2 m). The space between block to block and plot to plot was 1m and 0.5 m, respectively.

Crop husbandry

The experimental land was opened with a power tiller and then puddled thoroughly by ploughing. Weeds and stubble of the previous crop were collected and removed from the field. Both organic and inorganic fertilizers were applied according to the treatments. Urea was applied into three equal splits. The first split of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and other organic manure (PM, VC and CD) were at the time of final land preparation as per treatment. The second split of urea was top dressed at 30 days after transplanting (DAT) and third split of urea was top dressed at 60 DAT (Panicle initiation stage). Organic manures were analyzed (micro Kjeldahl method) in the laboratory for N content and found 2.1%, 1.5% and 1.2% N in PM, VC and CD, respectively. Thirty-five days old seedlings were then transplanted in rows in the main field at the rate of three seedlings hill^{-1} with 25 cm × 15 cm spacing. Intercultural operations- gap filling, weeding, irrigation and drainage have been done as when necessary. The crop was harvested at full maturity. The harvested crop of each plot was separately bundled, properly tagged and the fresh weights of grain straw were recorded plot wise. The grains were cleaned and sun dried to a moisture content of 14%.

Data collection and statistical analysis

Five random hills of each plot were selected to record plant height, total tillers hill^{-1}, effective tillers hll^{-1}, number of sterile spikelet panicle^{-1} and grains panicle^{-1}; and 1000-grain weight, grain + straw yields, biological yield and harvest index of each plot were recorded from the whole plot at harvest. The recorded data on yield and yield contributing characters were statistically analyzed using "Analysis of Variance" technique following two factors RCBD computer package MSTAT. The mean differences among treatments means were tested by Duncan's New Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Varietal effect on yield and yield contributing characters

All the yield and yield contributing characters except number of sterile spikelet panicle^{-1} were significantly influenced by the variety (Table 1 and Figure 1). Performance of BRRI dhan74 was better compared to BRRI dhan29 in terms of all parameters. BRRI dhan74 produced the taller plant (89.00 cm) than the BRRI dhan29 (81.10 cm) (Table 1). Higher (10.12) number of total tillers hill^{-1}, effective tillers hill^{-1} (9.09) and grains panicle^{-1} (97.74) was produced by BRRI dhan74 than BRRI dhan29 (number of total tillers hill^{-1}: 9.70, effective tillers hill^{-1}: 8.65 and grains panicle^{-1}: 94.33). The varietal differences might be due to heredity or varietal character (Hossain *et al.*, 2003; Kabir *et al.*, 2004; Kamal *et al.*, 1999). Numerically BRRI dhan29 gave the higher (6.32) number of sterile spikelet panicle^{-1} than BRRI dhan74 (6.01). Weight of 1000 grains (g) was 34.10 g in BRRI dhan74 and 24.28 g in BRRI dhan29. BRRI dhan74 gave higher grain (2.75t ha^{-1}), straw (4.30 t ha^{-1}) and biological (7.05 t ha^{-1}) yields compared to BRRI dhan29 (2.65 t ha^{-1}, 3.53 and 6.18 t ha^{-1} of grain, straw and biological yields, respectively) (Figure 1). Similar results were also reported by Hossain *et al.* (2003) and Kabir *et al.* (2004). Harvest index was higher in BRRI dhan29 (42.86%) than BRRI dhan74 (39.28%).

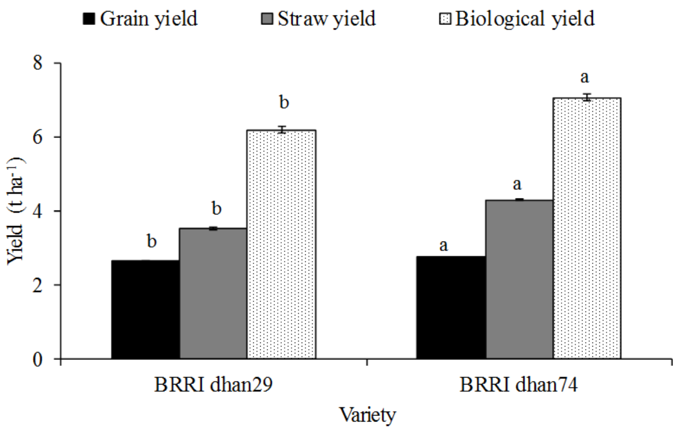

Figure 1. *Effect of variety on grain, straw and biological yields of BRRI dhan29 and BRRI dhan74. Error bars in the figure represent the standard error of three replications. Column with same letter do not differ significantly whereas figures with dissimilar letter differ significantly (p <0.01).*

Effect of nitrogen management approaches on yield and yield contributing characters

All the yield and yield contributing characters except harvest index were significantly influenced by N management approaches (Table 2). The tallest (88.07 cm) plant was observed from applying 25% N of RD from urea + 75% N of RD from VC (N_8) which was statistically identical to N_7 (50% N of RD from urea + 50% of RD from VC). The shortest (81.27 cm) plant height was found from control (N_1). The highest number of total tiller hill^{-1} (10.97) was found in case of N_3, *i.e.*, 75% N of RD from urea + 25% N of RD from PM and the lowest (9.17) was observed in control. Usman *et al.* (2003) also reported maximum number of tillers hill^{-1} from the combined application of urea and PM (50 kg N ha^{-1}+ 20 t ha^{-1}PM). Maximum number (10.30) of effective tillers hill^{-1}was obtained from the application of 75% N of RD from Urea + 25% N of RD from PM (N_3) and the lowest (7.70) was found in control. The highest no. of grain panicle^{-1}, 1000 grain weight (30.35 g), grain yield (3.19 t ha^{-1}), straw yield (5.02 t ha^{-1}), biological yield (8.21 t ha^{-1}) was observed in 75% N of RD from Urea + 25% N of RD from PM (N_3). The result agreed with Dwivedi *et al.* (2000) who reported higher grain yield of rice from integrated application of organic and inorganic fertilizers than sole application of inorganic fertilizer. Similar results were also reported by Sarkar *et al.* (2007), Islam *et al.* (2007) and Sarkar *et al.* (2016).

Table 1. Effect of variety on yield and yield contributing characters of transplanted *Boro* rice .

Variety	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of grains Panicle^{-1}	No. of sterile spikelet Panicle^{-1}	1000 grain weight (g)	Harvest index (%)
BRRI dhan29	89.00 a	9.70 b	8.65 b	94.33 b	6.32	24.28 b	42.86 a
BRRI dhan74	81.10 b	10.12 a	9.09 a	97.74 a	6.01	34.10 a	39.28 b
Standard error	0.588	0.078	0.044	0.527	0.143	0.161	0.233
Level of significance	**	**	**	**	NS	**	**
CV (%)	3.97	4.54	2.84	3.15	13.33	3.17	3.27

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). **=Significant at probability level (*p*) 0.01, NS = Non-significant and CV=coefficient of variation.

Table 2. Effect of nitrogen (N) management approaches on yield and yield contributing characters of transplanted *Boro* rice.

N management approaches	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of grains Panicle^{-1}	No. of sterile spikelet Panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N_1	81.37c	9.17d	7.70e	87.67e	7.22a	27.90e	2.40h	3.32g	5.72i	42.00
N_2	84.97abc	10.07bc	9.23c	99.31ab	5.88bc	29.75abc	2.85c	4.06c	6.91bc	41.22
N_3	86.03ab	10.97a	10.30a	101.10a	5.26c	30.35a	3.19a	5.02a	8.21a	39.96
N_4	82.10bc	9.73cd	8.57d	95.48bcd	6.27abc	29.05b-e	2.61f	3.81de	6.42efg	40.61
N_5	84.90abc	9.59cd	8.43d	94.91cd	6.31abc	28.85b-e	2.52g	3.71ef	6.23fg	40.32
N_6	86.10ab	10.57ab	9.90b	101.00a	5.67bc	29.95ab	2.91b	4.24b	7.16b	41.23
N_7	86.90a	9.96c	8.97c	97.10bc	6.11bc	29.25a-d	2.75d	3.98cd	6.73cde	41.10
N_8	88.07a	9.80c	8.63d	96.08bc	6.15abc	29.20a-d	2.66e	3.90cd	6.56def	40.46
N_9	85.33abc	10.02bc	9.14c	97.89abc	6.01bc	29.70a-d	2.80d	4.02c	6.82cd	41.19
N_{10}	86.10ab	9.58cd	8.40d	94.23cd	6.41ab	28.60cde	2.51g	3.60f	6.11gh	41.24
N_{11}	83.77abc	9.56cd	8.33d	91.65d	6.47ab	28.50de	2.47g	3.37g	5.85hi	42.44
Standard error	1.38	0.18	0.10	1.24	0.34	0.38	0.02	0.06	0.11	0.55
Level of significance	*	**	**	**	*	**	**	**	**	NS
CV (%)	3.97	4.54	2.84	3.15	13.33	3.17	1.83	3.70	4.01	3.27

**Significant at probability level (*p*) 0.01, *=Significant at probability level (*p*) 0.05, NS = Not significant, CV = coefficient of variation, N_1 = control; N_2= 100% recommended dose (RD) of N from urea; N_3 =75% N of RD from urea + 25% N of RD from poultry manure (PM); N_4 =50% N of RD from urea + 50% N of RD from PM; N_5 = 25% N of RD from urea + 75% N of RD from PM; N_6 =75% N of RD from urea + 25% N of RD from vermicompost (VC); N_7 = 50% N of RD from urea + 50% N of RD from VC; N_8 = 25% N of RD from urea + 75% N of RD from VC; N_9 = 75% N of RD from urea + 25% N of RD from cowdung (CD); N_{10} = 50% N of RD from urea + 50% N of RD from CD; N_{11}= 25% N of RD from urea + 75% N of RD from CD.

Interaction effect of nitrogen management approaches on yield and yield contributing characters

Interaction effect of variety and N management approaches was significant on the yields of *Boro* rice but was non-significant on yield contributing characters except no. of effective tillers hill^{-1} (Table 3). However, numerically the highest no. of tillers hill^{-1} (11.13) was observed in BRRI dhan74 with the combination of 100% N of RD from urea (N_2) and the lowest (9.07) was observed in BRRI dhan29 with control (N_1) treatment (Table 3). The highest no. of effective tillers hill^{-1}(10.6) was observed in BRRI dhan74 with the combination 75% N of RD from urea + 25% N of RD from PM (N_3) and lowest (7.47) was found in BRRI dhan29 in control treatment. The result was in agreement with the findings of Lawal and Lawal (2002). The N_3 management approach combined with BRRI dhan74 produced the highest (3.30 t ha^{-1}) grain yield and straw yield (6.15 t ha^{-1}) the lowest (2.36 t ha^{-1} and 2.99 t ha^{-1} of grain and straw yields, respectively) one was observed in combination of BRRI dhan29 with control (Table 3). Even for BRRI dhan29, the highest yields (3.08 and 3.89 t ha^{-1} of grain and straw, respectively) was produced from the same N management approaches, *i.e.*, 75% N of RD from urea + 25% N of RD from PM. Harvest index was highest (44.88%) in BRRI dhan29 with the combination of 25% N of RD from urea + 75% N of RD from CD (N_{11}) and the lowest (34.91%) one was in BRRI dhan74 with the combined application of 75% N of RD from urea + 25% N of RD from PM (N_3). Rahman *et. al.* (2009) and Yeasmin *et al.* (2009) also reported higher grain yield from the combined use of urea N and manure (PM and CD) than only urea-N application. Similar results were also obtained by Sarkar *et al.* (2007), Islam *et al.* (2007) and Sarkar *et al.* (2016). From the above results it is perceived that the integrated application of 75% N of RD from urea + 25% N of RD from PM (N_3) for both varieties, BRRI dhan29 and BRRI dhan74 was the best combination to obtain highest grain yield in *Boro* season. Poultry manure as an organic source of N combined with urea performed better than all other organic sources (VC and CD) possibly because of the higher N (+ other nutrient) content of PM than VC and CD which might cause increased N and other nutrient availability in soil and uptake of nutrients by rice plants. The PM along with urea fertilizer helped to increase the uptake of the major nutrients which promoted satisfactory growth of plant (Mohamoud *et al.*, 2002). Ranjitha *et al.* (2013) claimed maximum NPK uptake by rice from the integrated application of organic + inorganic N fertilizers. This adequate nutrient supply might be attributed to the greater partitioning of dry matter into economic part (Vajanthaa *et al.*, 2012). Apart from economic return, combined use of organic and inorganic fertilizers is very helpful for maintaining a long-term soil fertility and crop productivity (Eghball *et al.*, 2005).

Table 3. Interaction effects of variety and nitrogen (N) management approaches on yield and yield contributing characters of *Boro* rice.

Interaction (variety × N management approaches)	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	No. of grains Panicle^{-1}	No. of sterile spikelet panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1×N_1	84.90	9.07	7.47j	85.05	7.46	22.90	2.36m	2.99j	5.36l	44.07ab
V_1×N_2	91.60	9.93	9.13cd	98.27	5.92	24.70	2.80ef	3.77efg	6.56e-i	42.60a-d
V_1×N_3	91.50	10.80	10.00b	98.92	5.54	25.70	3.08b	3.89ef	6.97cde	44.31ab
V_1×N_4	84.60	9.60	8.47fgh	94.05	6.43	24.20	2.61ij	3.46hi	6.07ijk	43.16ab
V_1×N_5	89.90	9.33	8.20ghi	93.25	6.49	23.90	2.50kl	3.45hi	5.95jk	42.01b-f
V_1×N_6	90.60	10.07	9.27c	98.68	5.85	25.10	2.85de	3.87ef	6.72d-h	42.44a-e
V_1×N_7	88.30	9.80	8.80def	95.13	6.22	24.30	2.68ghi	3.71e-h	6.39g-j	41.97b-f
V_1×N_8	91.70	9.60	8.53e-h	94.58	6.28	24.30	2.63hij	3.58gh	6.21ijk	42.38a-e
V_1×N_9	89.50	9.87	9.00cde	95.86	6.18	24.60	2.73fg	3.74efg	6.47f-i	42.20b-e
V_1×N_{10}	89.40	9.33	8.20ghi	92.72	6.57	23.80	2.47kl	3.32i	5.79kl	42.64abc
V_1×N_{11}	87.10	9.33	8.13hi	91.14	6.61	23.60	2.45l	3.01j	5.47l	44.88a
V_2×N_1	77.70	9.27	7.90i	90.28	6.99	32.90	2.44l	3.65fgh	6.09ijk	40.04c-g
V_2×N_2	78.30	10.20	9.33c	100.36	5.85	34.80	2.91cd	4.35c	7.26bc	40.08c-g
V_2×N_3	80.60	11.13	10.60a	103.29	4.99	35.00	3.30a	6.15a	9.45a	34.91h
V_2×N_4	79.60	9.87	8.66d-g	96.90	6.12	33.90	2.61ij	4.17cd	6.78c-g	38.51g
V_2×N_5	79.90	9.85	8.66d-g	96.57	6.15	33.80	2.55jk	3.97de	6.52e-i	39.15g
V_2×N_6	81.60	11.07	10.50a	103.24	5.51	34.80	2.98c	4.62b	7.60b	39.22g
V_2×N_7	85.50	10.13	9.13cd	99.06	6.02	34.20	2.82e	4.25c	7.07cd	39.89efg
V_2×N_8	84.50	10.00	8.73def	97.58	6.02	34.10	2.70gh	4.22cd	6.91c-f	39.01g
V_2×N_9	81.10	10.17	9.27c	99.92	5.86	34.80	2.87de	4.30c	7.17bcd	40.02d-g
V_2×N_{10}	82.80	9.83	8.60e-h	95.74	6.25	33.40	2.55jk	3.88ef	6.43f-j	39.58fg
V_2×N_{11}	80.50	9.80	8.53e-h	92.16	6.34	33.40	2.50kl	3.74efg	6.24h-k	40.08d-g
Standard error	1.95	0.26	0.15	1.75	0.47	0.53	0.03	0.08	0.15	0.78
Level of significance	NS	NS	*	NS	NS	NS	*	**	**	**
CV (%)	3.97	4.54	2.84	3.15	13.33	3.17	1.83	3.70	4.01	3.27

Conclusion

This study concluded that BRRI dhan74 performed better than BRRI dhan29 in terms of yield. Integrated application of 75% N of RD from urea + 25% N of RD from PM was the best N management approach for *Boro* rice cv. BRRI dhan29 and BRRI dhan74 to obtain highest grain yield. However, this approach needs to be tested in different locations of Bangladesh before making final inference.

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