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Effect of split application of nitrogen fertilizer on morpho-physiological parameters of rice genotypes

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Abstract

An experiment was carried out to assess the effect of four nitrogen levels viz. T_1 (full doze of urea i.e. 215 kg urea ha^{-1} at 15 DAT), T_2 (full doze of urea at two equal splits, ½ at 15 DAT + ½ at 30 DAT), T_3 (full doze of urea at two equal splits, ½ at 15 DAT + ½ at 55 DAT) and T_4 (full doze of urea at three equal splits, $^1/_3$ at 15 DAT + $^1/_3$ at 30 DAT + $^1/_3$ at 55 DAT) on morpho-physiological attributes of Boro rice genotypes viz. V_1 (BINAdhan 5), V_2 (Tainan 3) and V_3 (BINAdhan 6). Plant height, number of tillers $hill^{-1}$, number of leaves $hill^{-1}$, leaf area $hill^{-1}$ (cm^2), DM (dry matter) of root, stem and leaves $hill^{-1}$, TDM (total dry matter) $hill^{-1}$ and chlorophyll content in leaves (at 74 DAT), were increased with the split application of N. Among the treatments, T_4 showed the best performance and grain yield (45.25 g $hill^{-1}$) compared to control (30.61 g $hill^{-1}$). Among the genotypes, BINAdhan 5 and BINAdhan 6 showed similar performance in respect of most of the parameters but BINA dhan 6 produced the highest grain yield (40.26 g $hill^{-1}$) compared to BINA dhan 5 (35.54 g $hill^{-1}$) and Tainan 3 (33.90 g $hill^{-1}$). Full dose of urea (215 kg urea ha^{-1}) applied at three equal split at 15, 30 and 55 DAT was found to be the most beneficial one for the all the rice genotypes. Leaf chlorophyll content had a strong contribution to grain yield of rice.

Keywords: Rice; Nitrogen; Split application; Tillers; Physiology; Chlorophyll, Yield

Introduction

Rice (*Oryza sativa* L.) is the world's single most important food crop, being the primary food source for more than one third of the world's population, and grown in 11% of the world's cultivated area (Khush, 1993). In Bangladesh majority of food grains come from rice. About 80% of cropped area of this country is used for rice production, with annual production of 43729000 metric tons (IRRI, 2006) in total acreage of 1, 10, 59.000 ha. The average yield of rice in Bangladesh is 3.90 t ha^{-1} (BRRI, 2007). This yield of rice is much lower than world average. It is mainly due to lack potential varieties and management practices. Improved varieties and judicious application of fertilizer are two of the most effective means for maximizing yield of rice. The fact is that rice plants require more nutrients to produce more yields. Nitrogen is a mojor essential plant nutrient and a key input for increasing crop yield. Yield increase (70-80%) of field rice could be obtained by the application of nitrogen fertilizer (IFC, 1982). Optimum dose of nitrogen fertilization plays a vital role in growth and development of rice plant. Its growth is seriously hampered when lower dose of nitrogen is applied which drastically reduces yield. Nitrogen has a positive influence on the production of effective tillers per plant, yield and yield attributes (Jashim et al., 1984; BRRI, 1990). Excessive nitrogen fertilization encourages excessive vegetative growth which makes the plant susceptible to insects, pests and diseases which ultimately reduces yield. So, it is essential to find out the optimum rate of nitrogen application for efficient utilization of this element by the plants for better yield.

By applying proper dose we can save money and can also keep our environment sound. Because the heavy use of fertilizer affects the soil and also the environment through the residual effect of fertilizer. Selection of the most appropriate level of nitrogen fertilization is a major concern of economic viability of crop production and the impact of agriculture. Therefore, the present study was undertaken to find out proper split application of N fertilizer for optimum growth and yield components of Boro (winter) rice genotypes (BINAdhan 5, Tainan 3 and BINAdhan 6).

Materials and methods

The experiment was conducted at Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh, during Boro season (November to April). Geographically, the experimental area is located at 24^{o} 75′ N and 90^{o} 50′ E longitude at the elevation of above 18 m the sea level. The soil of the experimental pot was silty-loam having noncalcarious properties. The soil was more little neutral (pH 6.8) in nature.

Earthen pots were used in this experiment. The size of the pot was 30×20 cm. The soil was collected from 0-15 cm depth. The collected soil was well pulverized and dried in the sun and decomposed cowdung was mixed with the soil. A basal dose of triple super phosphate (TSP), muriate of potash (MP) and gypsum were used as the source of phosphorus, potassium and gypsum applied at the rate of 180 kg ha^{-1}, 100 kg ha^{-1} and 20 kg ha^{-1}, respectively (1 ha = 3 x 10^6 kg fresh soil) at the time of final pot preparation.

There was 3 different rice varieties used in the experiments viz. BINAdhan5 (V_1), Tainan 3 (V_2) and BINAdhan6 (V_3). Different Nitrogen application treatments were T_1 (Full dose of urea at 15 DAT (Days after transplanting), T_2 (Full dose of urea at two equal splits, ½ at 15 DAT + ½ at 30 DAT), T_3 (Full dose of urea at two equal splits, ½ at 15 DAT + ½ at 55 DAT and T_4 (Full dose of urea at three equal splits, $^1/_3$ at 15 DAT + $^1/_3$ at 30 DAT + $^1/_3$ at 55 DAT). The recommended dose (Full dose) was 215 kg urea ha^{-1} (1 ha = 3 x 10^6 kg fresh soil). The experiment was carried out in a Randomized Complete Block Design (RCBD) with 3 replications as factorial arrangement.

Pregerminated seeds were sown in wet nursery bed and proper care was taken to raise the seedlings in seedbed. Forty five (45) day old 3 seedlings were transplanted in each pot.

Seedling in some hills died off, and these were replaced by gap filling after one week of transplanting with the seedling from the same source. Intercultural operations were done properly. About 5-6 cm water layer was maintained in the pot until the crop attained maturity.

Data were collected at 65 and 90 DAT. Chlorophyll content was measured at post flowering stage following the procedure of Arnon (1949). Leaf samples were collected at post flowering stage and was weighed separately. In a digital scale 0.05 g of fresh leaves was measured separately. Samples were maturated in 80% acetone. These were then centrifuged for 10 minutes and finally made a volume of 5 ml with acetone (80%). The optical density was measured at 645 and 663 with a spectrophotometer. Chlorophyll content (expressed as mg/gfw of a sample) was estimated as follows:

$$\text{Total chlorophyll} = (20.2 \times D_{645} + 8.02 \times D_{663}) \times \frac{5}{1000 \times 0.05} \text{ mg/gfw}$$

$$\text{Chlorophyll a} = (12.7 \times D_{663} - 2.69 \times D_{645}) \times \frac{5}{1000 \times 0.05} \text{ mg/gfw}$$

$$\text{Chlorophyll b} = (22.9 \times D_{645} - 4.68 \times D_{663}) \times \frac{5}{1000 \times 0.05} \text{ mg/gfw}$$

The data were analysed following Analysis of Variance (ANOVA) technique and mean differences were adjusted by the multiple comparison test (Gomez and Gomez, 1984) using the statistical computer based programme MSTAT-C v.2.1. (Russel, 1994). Means were compared by using DMRT test.

Results and discussion

Plant height

The effect of split application of N fertilizer on plant height appeared to be considerable at 65 and 90 DAT, while it was statistically negligible at maturity (Table 1). The tallest plant height (103.79 cm) was produced in T_4, where full doze of urea was applied at three equal splits, $^1/_3$ at 15 DAT + $^1/_3$ at 30 DAT + $^1/_3$ at 55 DAT (T_4). At 65 DAT, the shortest plant (62.08 cm) was obtained from T_1, which is followed by T_2. The result indicated that three split application of nitrogen fertilizer was found more effective in increasing plant height of Boro rice genotypes than that of 2 splits or single application. This result was supported by Reddy et al. (1987) and Akanda et al. (1986). Availability of nitrogen throughout the growth stages might be responsible for the better performance. Among the genotypes, V_3 produced the tallest plants followed by V_1. But V_2 showed the lowest plant height (Table 2). This variation in plant height might be due to varietal characteristics. For treatment combinations, the plant height was the same at maturity, while it differed at 65 and 90 DAT (Table 3). At 65 DAT the tallest plant (72.46 cm) was found in V_3T_4 which was statistically similar to V_3T_3 (70.73 cm) and V_1T_4 (70.76 cm) combination while the shortest (59.96 cm) in V_2T_1 which was similar to V_1T_1, V_1T_2 and V_1T_3. These results were supported by Reddy et al. (1987) and Akanda et al. (1986).

Number of tillers hill^{-1}

Significant difference in tiller production hill^{-1} was observed due to split application of N fertilizer (Table 1). Both at 65 DAT and 90 DAT, the highest number of tillers hill^{-1} (25.11 and 20.66) were produced when urea was applied in three equal splits (T_4). At 65 DAT, T_3 also produced the similar result as T_4. At 90 DAT, the lowest number of tillers hill^{-1} (15.88) was produced when urea was applied as full dose without split. This is in agreement with the findings of Jayakumar et al. (2004) and Palchamy et al. (1989).However, result as reported by Akanda et al. (1986) did not corroborate with the present investigation. Lack of nitrogen through tillering period might be the causes of lowest number of tiller hill^{-1} at T_1. Shoo et al. (1989) observed that nitrogen at transplanting or in two equal splits dressing at transplanting and tillering increased the total number of tillers hill^{-1}. The number of tillers hill^{-1} differed significantly across the genotypes (Table 2). V_3 produced the highest number of tillers hill^{-1} (26.41 at 65 DAT) followed by V_1. The lowest number of tillers hill^{-1} produced by V_2. This result is probably due to difference of varietal performance. The split application of urea and genotype interactively affected the number of tillers hill^{-1} at 60 and 90 DAT. (Table 3). At 65 DAT, the highest number of tillers hill^{-1} (28.00) was found in V_3T_4 and V_3T_3 (27.66) combination while the lowest number of tillers hill^{-1} was found in V_2T_1 and V_2T_2.

Number of leaves hill^{-1}

Split application of urea significantly influenced on the number of leaves hill^{-1} (Table 1). The highest number of leaves hill^{-1} was produced when urea was applied at three equal splits (T_4) and the lowest number of leaves hill^{-1} was produced in T_1. Number of leaves hill^{-1} among the genotypes varied significantly both at 65 DAT and 90 DAT (Table 2). In both of the cases, the highest number of leaves hill^{-1} obtained from V_3 which was statistically similar with V_1 while the lowest number of leaves hill^{-1} was obtained from V_2. The interaction between split application of N fertilizer and genotypes on the number of leaves hill^{-1} was significant at 90 DAT and 65 DAT (Table 3). At 90 DAT, the highest number of leaves hill^{-1} (104.33) was found in V_1T_4, while the lowest number of leaves hill^{-1} was in V_1T_1 and V_3T_1. Sadeque *et al.* (1990) reported that the nitrogen application in three splits, gave the highest number of tillers hill^{-1}.

Leaf area hill^{-1}

Split application of urea fertilizer significantly influenced the leaf area hill^{-1} at 65 DAT and 90 DAT (Table 1). The highest leaf area hill^{-1} (1873 cm^2) at 65 DAT and (2239 cm^2) 90 DAT was produced when urea was applied in three equal splits (T_4). The lowest leaf area hill^{-1} (1096 cm^2 at 65 DAT and 1478 cm^2 90 at DAT) was found in T_1. The above result indicated that three equal splits were highly effective for increased leaf area hill^{-1}. The probable cause of the above result might be availability of urea fertilizer during growing period of rice plant. Hussain et al. (1989) and Palanimurugesan (1997) observed similar result. Leaf area hill^{-1} differed significantly among the genotypes (Table 2). The highest leaf area hill^{-1} (1682 cm^2 at 65 DAT and 2354 cm^2 90 at DAT) was found in V_3 and the lowest (1396 cm^2) at 65 DAT and (1353 cm^2) at 90 DAT was found in V_2. Leaf area $hill^{-1}$ significantly varied at 90 DAT and 65 DAT due to the interactive effect of split application of urea and genotypes (Table 3). The highest leaf area $hill^{-1}$ at 65 DAT (2209 cm^2) was found in combination V_3T_4 but the lowest (1106 cm^2) was in V_3T_1.

Table 1. Effect of split application of N-fertilizer on plant height, tiller and leaf area of rice at different stages.

Treatment	Plant height (cm)			No. of tillers $hill^{-1}$		No. of leaves $hill^{-1}$		Leaf area $hill^{-1}$ (cm^2)	
	65 DAT	90 DAT	At maturity	65 DAT	90 DAT	65 DAT	90 DAT	65 DAT	90 DAT
T_1	62.08c	93.11b	100.64	22.55c	15.88d	73.44d	67.77d	1096d	1478d
T_2	63.36c	94.36b	101.00	23.55b	17.78c	76.44c	74.88c	1413c	1695c
T_3	65.80b	98.97a	102.95	24.66a	19.44b	80.88b	81.00b	1627b	1956b
T_4	70.08a	101.1a	103.79	25.11a	20.66a	84.44a	92.22a	1873a	2239a
$LSD_{0.05}$	1.55	4.12	NS	0.77	0.74	2.82	3.73	150.9	147.4
CV (%)	3.43	4.36	4.86	3.33	4.14	3.66	4.84	10.27	8.19

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

T_1 = Full dose of urea at 15 DAT (Days after transplanting)
T_2 = Full dose of urea at two equal splits, ½ at 15 DAT + ½ at 30 DAT)
T_3 = Full dose of urea at two equal splits, ½ at 15 DAT + ½ at 55 DAT
T_4 = Full dose of urea at three equal splits, $^1/_3$ at 15 DAT + $^1/_3$ at 30 DAT + $^1/_3$ at 55 DAT)

Table 2. Response of rice genotypes on plant height, tiller and leaf area under split application of nitrogen at different stages.

Treatment	Plant height (cm)			No. of tillers $hill^{-1}$		No. of leaves $hill^{-1}$		Leaf area $hill^{-1}$ (cm^2)	
	65 DAT	90 DAT	At maturity	65 DAT	90 DAT	65 DAT	90 DAT	65 DAT	90 DAT
V_1	63.65 b	97.15ab	103.08	23.74 b	18.74 a	78.16ab	79.50ab	1427 b	1820 b
V_2	62.96 b	94.53 b	99.78	21.74 c	17.58 b	77.75 b	76.50 b	1396 b	1353 c
V_3	69.39 a	98.97 a	103.42	26.41 a	19.00 a	80.50 a	80.91 a	1682 a	2354 a
$LSD_{0.05}$	1.34	3.57	NS	0.67	0.64	2.44	3.23	130.7	127.7
CV (%)	3.43	4.36	4.86	3.33	4.14	3.66	4.84	10.27	8.19

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$,
V_1 = BINAdhan 5, V_2 = Tainan 3, V_3 = BINAdhan 6

Dry matter accumulation

The effect of split application of nitrogen fertilizer was statistically significant on the dry matter (DM) of roots, stem, and leaves as well as total dry matter at the three growth stages (Table 4). The highest DM of roots $hill^{-1}$, stem $hill^{-1}$ and leaves $hill^{-1}$ was found where three equal split application of nitrogen was done (T_4). The highest total dry matter $hill^{-1}$ with T_4 was 111.24 g which was 46.44% higher than T_1 (single application). These findings are in agreement with Rambabu, et al. (1983), Rao, et al. (1986) and Ingram et al. (1991).

Table 3. Interaction effect of genotypes and split application of N-fertilizer on plant height, tiller and leaf area of rice at different stages.

Treatment	Plant height (cm)			No. of tillers hill^{-1}		No. of leaves hill^{-1}		Leaf area hill^{-1} (cm^2)	
	65 DAT	90 DAT	At maturity	65 DAT	90 DAT	65 DAT	90 DAT	65 DAT	90 DAT
V_1T_1	60.23 f	95.25 abc	102.43	22.66 def	16.66 e	71.66 f	65.66 f	1106 ef	1543 f
V_1T_2	61.36 f	96.36 a	102.73	23.00 de	18.00 d	73.66 ef	71.66 ef	1257 de	1555 f
V_1T_3	62.26 ef	96.53 a	103.13	24.66 c	19.66 bc	79.66 bcd	76.33 de	1659 bc	1937 de
V_1T_4	70.76 ab	100.46 a	104.03	24.66 c	20.66 b	87.66 a	104.33 a	1689 b	2246 bc
V_2T_1	59.96 f	88.30 c	97.03	21.33 f	15.66 f	75.00 def	71.00 ef	1202 def	1042 g
V_2T_2	60.43 f	89.06 bc	97.36	21.33 f	16.00 ef	76.33 cde	72.00 ef	1264 de	1338 f
V_2T_3	64.43 de	99.83 a	102.10	21.66 ef	19.33 c	79.33 bcd	79.00 cd	1399 cd	1483 f
V_2T_4	67.03 cd	100.96 a	102.63	22.66 de	19.33 c	80.33 bc	84.00 bc	1720 b	1547 f
V_3T_1	66.06 cd	95.76 ab	102.46	23.66 cd	15.33 f	73.66 ef	66.66 f	980.6 f	1850 e
V_3T_2	68.30 bc	97.66 a	102.90	26.33 b	19.33 c	79.33 bcd	81.00 cd	1718 b	2192 cd
V_3T_3	70.73 ab	100.56 a	103.63	27.66 ab	19.33 c	83.66 ab	87.66 b	1823 b	2449 b
V_3T_4	72.46 a	101.90 a	104.70	28.00 a	22.00 a	85.33 a	88.33 b	2209 a	2923 a
$LSD_{0.05}$	2.68	7.14	NS	1.35	1.29	4.88	6.46	261.3	255.3
CV (%)	3.43	4.36	4.86	3.33	4.14	3.66	4.84	10.27	8.19

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$.

Dry matter accumulation in different parts of rice plants was also significantly influenced by genotypes. Among the rice genotypes, BINAdhan 6 (V_3) performed the best regarding dry matter accumulation in root. At 65 and 90 DAT maximum stem dry matter was produced by V_3 alone while at maturity it is statistically same with V_1. At 65 DAT maximum leaf dry matter was produced by V3 while at 90 DAT it was similar with V1. Regarding leaf dry matter, V_1 and V_2 produced statistically similar results at both of the stage. At every stage, BINAdhan 6 (V_3) produced significantly highest dry matter (Table 5) However, BINAdhan 5 (V_1) produced the lowest dry matter.

Significant difference in TDM production was observed due to interactive effect of split application of urea fertilizer and genotypes (Table 6). The highest TDM hill^{-1} (38.00 g at 65 DAT, 104.26 g at 90 DAT and 119.90 g at maturity) was found in V_3T_4 combination. It was mainly due to the accumulation of more dry matter in root, stem and leaves with these combination of nitrogen split application and genotypes. At every stage, the lowest TDM hill^{-1} (16.23 g at 65 DAT, 43.80 g at 90 DAT and 68.06 g at maturity) was found in V_2T_1 combination.

Chlorophyll content

Interaction between split application of nitrogen fertilizer and genotypes on chlorophyll content in leaves was significant (Figure 1). The highest chlorophyll content in leaves (1.56 mg/gfw) was found in V_3T_4 combination and the lowest (0.914 mg/gfw) in V_2T_1. The split application in different stages facilitated to accumulate more chlorophyll in rice plant which resulted more chlorophyll. Poshtmasari *et al.* (2007) showed the similar results. From the regression study a strong contribution (R^2=0.72) of leaf chlorophyll to grain yield was found from the study (Figure 2). It reveals that an increase of chlorophyll content can increase grain yield of rice genotypes. An increase of 1 mg chlorophyll/fresh weight can contribute to increase 24.76 g of grain per hill.

Table 4. Effect of split application of N-fertilizer on dry matter accumulation in rice at different stages.

Treatment	Dry matter of root $hill^{-1}$ (g)			Dry matter of stem $hill^{-1}$ (g)			Dry matter of leaves $hill^{-1}$ (g)		Total dry matter $hill^{-1}$ (g)		
	65 DAT	90 DAT	At maturity	65 DAT	90 DAT	At maturity	65 DAT	90 DAT	65 DAT	90 DAT	At maturity
T_1	8.89 d	12.80 c	10.09 d	7.08 d	31.77 d	21.03 d	3.60 d	7.57 d	19.56 d	58.88 d	75.96 d
T_2	12.76 c	16.79 b	12.74 c	9.07 c	36.44 c	33.51 c	4.67 c	8.72c	26.52c	70.04 c	81.93 c
T_3	15.25 b	17.70 b	14.37 b	10.02 b	43.31 b	38.51 b	5.37 b	10.05 b	31.26 b	80.41 b	96.91 b
T_4	17.34 a	19.57 a	17.95 a	11.00 a	47.91 a	42.63 a	6.18 a	11.42 a	34.53 a	90.38 a	111.24a
$LSD_{0.05}$	0.97	1.01	0.97	0.69	2.24	1.26	0.39	0.63	2.24	1.69	3.95
CV (%)	7.37	6.23	7.25	7.63	5.75	4.55	8.06	6.88	8.19	3.31	4.42

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$
T_1 = Full dose of urea at 15 DAT (Days after transplanting
T_2 = Full dose of urea at two equal splits, ½ at 15 DAT + ½ at 30 DAT)
T_3 = Full dose of urea at two equal splits, ½ at 15 DAT + ½ at 55 DAT
T_4 = Full dose of urea at three equal splits, $^1/_3$ at 15 DAT + $^1/_3$ at 30 DAT + $^1/_3$ at 55 DAT)

Table 5. Response of rice genotypes on dry matter accumulation under split application of nitrogen at different stages.

Treatment	Dry matter of root $hill^{-1}$ (g)			Dry matter of stem $hill^{-1}$ (g)			Dry matter of leaves $hill^{-1}$ (g)		Total dry matter $hill^{-1}$ (g)		
	65 DAT	90 DAT	At maturity	65 DAT	90 DAT	At maturity	65 DAT	90 DAT	65 DAT	90 DAT	At maturity
V_1	13.18 b	16.99 b	14.56 b	9.05 b	42.48 b	37.35 a	4.73 b	9.83 ab	26.58 b	78.22 b	93.65 b
V_2	12.72 b	13.6 c	11.35 c	8.80 b	31.09 c	33.77 b	4.49 b	8.40 b	26.00 b	60.54 c	82.34 c
V_3	14.80 a	19.51 a	15.46 a	10.05 a	46.01 a	38.13 a	5.66 a	10.09 a	31.32 a	86.02 a	98.54 a
$LSD_{0.05}$	0.84	0.88	0.84	0.60	1.94	1.09	0.33	0.55	1.94	1.46	3.42
CV (%)	7.37	6.23	7.25	7.63	5.75	4.55	8.06	6.88	8.19	3.31	4.42

V_1 = BINAdhan 5, V_2 = Tainan 3, V_3 = BINAdhan 6

Grain yield

The effect of split application of N fertilizer on grain yield $hill^{-1}$ was statistically significant (Table 7). The highest grain yield $hill^{-1}$ (45.25g) was produced when N was applied in 3 equal splits, $^1/_3$ at 15 DAT + $^1/_3$ at 30 DAT + $^1/_3$ at 55 DAT (T_4). Similar result was reported by BRRI (1978). The lowest grain yield $hill^{-1}$ (30.61g) was produced when full doze of N was applied as basal (T_1) which was statistically similar to T_2. Similar result was also reported by Bhuyian *et al.* (1990). Grain yield $hill^{-1}$ also differed significantly among the genotypes (Table 7). The highest grain yield (40.26 g $hill^{-1}$) was produced in V_3 and the lowest (33.90g $hill^{-1}$) in V_2 which was statistically similar to V_1.

Table 6. Interaction effect of genotypes and split application of N-fertilizer on dry matter accumulation in rice at different stages.

Treatment	Dry matter of root hill^{-1} (g)			Dry matter of stem hill^{-1} (g)			Dry matter of leaves hill^{-1} (g)		Total dry matter hill^{-1} (g)		
	65 DAT	90 DAT	At maturity	65 DAT	90 DAT	At maturity	65 DAT	90 DAT	65 DAT	90 DAT	At maturity
V_1T_1	10.13 e	11.70 g	11.56 e	7.86 f	33.80 f	31.23gh	3.66 de	8.33 de	21.66g	61.50 h	79.13fg
V_1T_2	10.70 e	17.73de	13.70cd	8.93def	37.43de	34.03ef	4.16 cd	8.40 de	23.80fg	71.63 f	84.70ef
V_1T_3	14.13 d	18.63bcd	13.83 c	9.16cde	45.60 c	40.43b	5.50 b	10.46 b	27.26ef	83.13 d	92.73cd
V_1T_4	17.76 a	19.90bc	19.13 a	10.23bc	53.10 a	43.73 a	5.60 b	12.13 a	33.60bc	96.63 b	118.05a
V_2T_1	6.96 e	10.70 g	8.00 f	5.40 g	22.20 g	28.56 i	3.86 cde	6.46 f	16.23 h	43.80 i	68.06 h
V_2T_2	13.90 d	14.40 f	10.90 e	8.76def	32.20 f	30.80 h	4.06 cd	8.36 de	26.73ef	61.33 h	73.60gh
V_2T_3	14.20 cd	14.43 f	12.03de	10.36bc	34.53ef	37.26cd	4.50 c	9.20 cd	29.06de	66.76 g	91.96cd
V_2T_4	15.80 bc	15.10 f	14.46 c	10.66 b	35.43ef	38.46bc	5.53 b	9.60 bc	32.00 cd	70.26 f	95.76 c
V_3T_1	9.60 e	16.00ef	10.70 e	8.00 ef	39.33 d	33.30fg	3.30 e	7.93 e	20.80 g	71.33 f	80.70 f
V_3T_2	13.70 d	18.26cd	13.63cd	9.53bcd	39.70 d	35.70de	5.80 b	9.40bcd	29.03de	77.15 e	87.50de
V_3T_3	17.43ab	20.06 b	17.26 b	10.56 b	49.80 b	37.83cd	6.13 b	10.50 b	37.46ab	91.33c	106.05 b
V_3T_4	18.46 a	23.70 a	20.26 a	12.10 a	55.20 a	45.70 a	7.43 a	12.53 a	38.00 a	104.26a	119.90a
$LSD_{0.05}$	1.69	1.76	1.69	1.20	3.88	2.19	0.67	1.10	3.88	2.93	6.85
CV (%)	7.37	6.23	7.25	7.63	5.75	4.55	8.06	6.88	8.19	3.31	4.42

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$

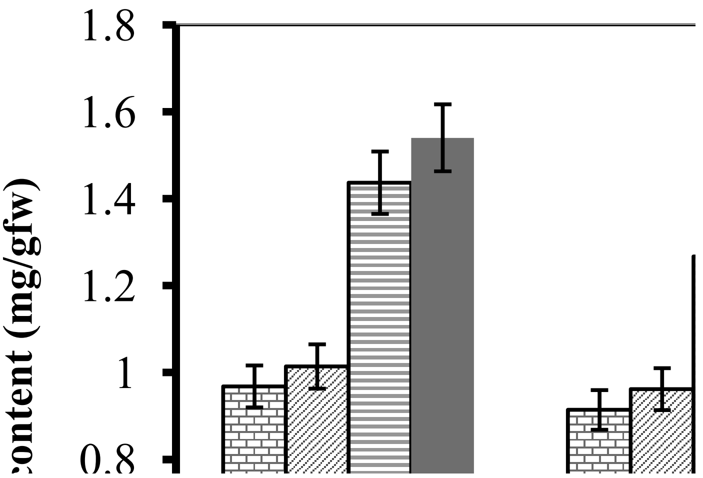

Figure 1. Effect of split application of nitrogen fertilizer on chlorophyll content in leaves in Boro rice genotypes at 74 DAT ($LSD_{0.05}$=0.0927).

The interaction effect of genotypes and split application of N fertilizer on grain yield was significant (Table 7). The highest grain yield (47.96 g hill^{-1}) was obtained from V_3T_4 which was statistically similar to V_1T_4 and V_3T_3. The lowest grain yield (28.96 g hill^{-1}) was obtained from V_2T_1 which was statistically similar to V_2T_2. Similar result was reported by Tantwi et al. (1991).

Table 7. Effect of genotypes, split application of N-fertilizer and their interaction the on grain yield of boro rice

Treatment	Grain yield hill^{-1} (g)
N Application	
T_1	30.61 c
T_2	31.56 c
T_3	38.83 b
T_4	45.25 a
$LSD_{0.05}$	2.27
Genotypes	
V_1	35.54 b
V_2	33.90 b
V_3	40.26 a
$LSD_{0.05}$	1.97
N application × Genotypes	
V_1T_1	30.26 e
V_1T_2	31.36 e
V_1T_3	32.76 de
V_1T_4	47.80 a
V_2T_1	28.96 e
V_2T_2	29.10 e
V_2T_3	37.53 bc
V_2T_4	40.00 b
V_3T_1	32.60 de
V_3T_2	34.30 cd
V_3T_3	46.20 a
V_3T_4	47.96 a
$LSD_{0.05}$	3.94
CV (%)	5.45

Means separation in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$.
T_1 = Full dose of urea at 15 DAT (Days after transplanting; T_2 = Full dose of urea at two equal splits, ½ at 15 DAT + ½ at 30 DAT); T_3 = Full dose of urea at two equal splits, ½ at 15 DAT + ½ at 55 DAT; T_4 = Full dose of urea at three equal splits, $^1/_3$ at 15 DAT + $^1/_3$ at 30 DAT + $^1/_3$ at 55 DAT)
V_1 = BINAdhan 5; V_2 = Tainan 3; V_3 = BINAdhan 6

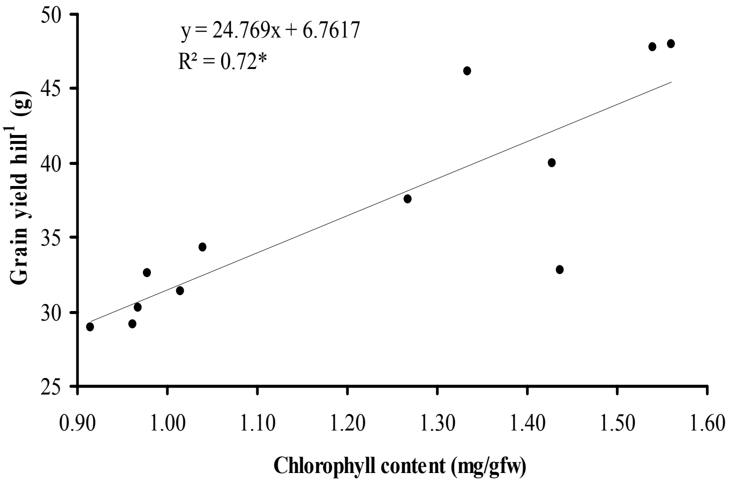

Figure 2. Relationship between leaf chlorophyll content and grain yield of rice as affected by split application of N and genotypes

Conclusion

From the results, it is hereby inferred that split application of nitrogen has a great influence on the morpho-physiological characteristics of rice where 3 equal split of full doses of N showed the best results. The result also varies from different variety where BINA dhan 6 showed the best results among three varieties. Among the split application of N, three equal split at 15, 30 and 55 DAT produced the highest grain yield (45.25 g hill^{-1}) which is 47.82% higher than control. BINAdhan 6 produced the highest grain yield (40.26 g hill^{-1}) which was 13.28% and 18.28% higher than BINAdhan 5 and Tainan 3.

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