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Effect of nitrogen and potassium on morpho-physiological characteristics of fine grain aromatic rice

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Abstract: A pot experiment was conducted at the pot yard of Bangladesh Institute of Nuclear Agriculture, Mymensingh during the period rom July to December 2009 to study the effect of nitrogen and potassium and their interaction on morpho-physiological characteristics of fine grain aromatic rice cv. RM 100-16. The two factor experiment comprised of four levels of nitrogen fertilizer *viz.*, 0, 25, 50 and 75 kg N ha^{-1}, and four levels of potassium application viz. 0, 15, 25 and 35 kg K ha^{-1}. The experiment was laid out in completely randomized design with four replications. Nitrogen was applied in the form of urea as per treatment. Potassium was applied in the form of muriate of potash. Results revealed that different levels of nitrogen and potassium application and their interaction had significant effect on morpho-physiological, biochemical; yield attributes and yields in fine grain aromatic rice. The results revealed that plant height, number of effective tillers $hill^{-1}$, total sugar content in leaves, number of grains $panicle^{-1}$ and 1000-grain weight increased with increasing nitrogen levels till 50 kg N ha^{-1} where as leaf area and straw weight $hill^{-1}$ chlorophyll, nitrate reductase activity and amino acid content in leaves increased till 75 kg N ha^{-1}. The highest grain yield was recorded in 50 kg N ha^{-1} (25.82 g ha^{-1}) due to production of highest number of effective tillers $hill^{-1}$ (19.2) and filled grains $panicle^{-1}$ (170.6). However, the highest harvest index was recorded in 25 kg N ha^{-1} (43.54%). For potassium effect, results revealed that plant height, number of effective tillers $hill^{-1}$, chlorophyll content and nitrate reductase activity in leaves, number of filled grains $panicle^{-1}$, 1000-grain weight and harvest index increased till 25 kg K ha^{-1} where as leaf area and straw weight $hill^{-1}$ total sugar and amino acid content in leaves increased till 35 kg K ha^{-1}. The highest grain yield was recorded in 25 kg K ha^{-1} (21.83 g $hill^{-1}$) due to production of highest number of effective tillers $hill^{-1}$ (14.6) and filled grains $panicle^{-1}$ (160.0). In contrast, control plant produced the lowest yield due to inferior growth, biochemical Parameters and yield attributes. For combined effect of nitrogen and potassium, results revealed that 50 kg N ha^{-1} with 25 kg K ha^{-1} produced the highest grain yield (27.02 g $hill^{-1}$) followed by $N_{50} \times K_{35}$ (26.00 g $hill^{-1}$).

Key words: Nitrogen, potassium, morpho-physiological characteristics, fine grain, aromatic rice.

Introduction

In Bangladesh, agriculture is dominated by intensive rice cultivation. Rice contributes to about 91.2% of the total intake of the people in Bangladesh. Rice is grown in about 72.5% of the arable land, which produces 2.62 million metric tones of rice but the average rice production is only 2.87 t ha^{-1} (BBS, 2009). Further, the productivity of aromatic fine rice is even lower than HYV coarse varieties (BBS, 2009). Aromatic rice varieties have occupied about 12.5% of the total aman rice cultivation (BBS, 2009). Among the fertilizer elements, nitrogen plays a key role in rice production and it is required in larger amount compared to other fertilizers. It affects the vegetative growth, development and yield. The important role of nitrogenous fertilizer in increasing rice yield has been widely recognized (BRRI, 1990). Rice yield may be increased by 70 to 80 per cent by proper utilization of nitrogen fertilizer (Patil and Mishra, 1994). The efficient fertilizer management can increase crop yield and reduce production cost. Excess amount of nitrogen fertilizer results in lodging of plant, prolonging growing period, delaying maturity and reducing yield (Uddin, 2003). Nonjudicious application of nitrogen fertilizer not only increases production cost but also reduces the quality of the product. So, it is necessary to find out the suitable rate of nitrogen fertilizer for efficient management and better yield of fine grain rice. Potassium is one of the primary as well as the third so called major nutrient element for plant growth and development. Many workers have reported a significant response of rice to potassium fertilizer (Singh and Patiram, 1987; Pal, 2005; Gupta, 2007; Moro *et al.*, 2008). Application of potassium at an optimum Level promoted photosynthetically activity which enhance grain yield (Rao *et al.*,1990).For fine grain rice ,the information isl limited on the effect of potassium fertilizer application on growth and yield. It is, therefore, necessary to do extensive research on fine grain rice. Keeping the above view in mind, the experiment was aimed to assess optimum level of nitrogen and potassium for maximizing the grain yield and quality of fine grain rice; and to find out suitable combination of nitrogen and potassium levels for maximizing grain yield of promising fine grain rice cv. RM 100-16.

Materials and Methods

A pot experiment was carried out at the pot yard of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during the period from July to December 2009 to study the effect of nitrogen and potassium and their interaction on morpho-physiological characteristics of fine grain aromatic rice. The advanced fine grain aromatic rice mutant, RM 100-16 was used as planting material. The mutant was developed by applied mutagenic agent, EMS to the local improved variety, Ukanimadhu. The mutant RM 100-16 shorter, matured seven days earlier with 10% higher yield than the mother, Ukanimadhu.The experiment comprised of two factors: Factor A: Four levels of nitrogen viz., 0 (conlrol), 25, 50 and 75 kg N ha^{-1} and Factor B: Four levels of potassium viz., 0 (control), 15, 25 and 35 kg K ha^{-1}. Nitrogen was applied in the form of urea and potassium was applied in the form of muriate of potash. The muriate of potash was applied at basal dose and urea was applied at three splits: one third of urea was top dressed at 10 DAT and the rest of the urea was top dressed in two equal splits at 35 and 55 DAT. The experiment was laid out in a Completely Randomized Design (CRD) with four replications. Two seedlings were sown in each pot on 08 August 2009. For raising rice seedlings, the soil was well prepared through

mixing fertilizers and cowdung. The seeds of each genotype were sown in the seed bed on 08 July 2009. Before sowing in seed bed, the grains were water soaked for 24 hours and then these were kept in gunny bag in dark condition. The seed beds were prepared in iron sheet (50 cm × 60 cm). The triple superphosphate, gypsum and zinc sulphate were used at the rate of 3.70, 0.80 and 0.50 g pot^{-1} corresponding to 50, 40, and 5 kg ha^{-1}, respectively. Earthen pots of 30 cm diameter and 35 cm height were used for the experiment. The pots of the experiment were filled with 12 kg of soils. Thirty days old seedlings were uprooted carefully from the seedbed for transplanting. To maintain required plant pot^{-1}, gap filling was done within a week of transplanting. Maturity of the crop was determined when about 90% grains became golden yellow. Before harvest, plant height, number of effective and non-effective tillers $hill^{-1}$ was recorded. After necessary data recorded, the hill of each pot was harvested at maturity on 08 December 2009. Data on the following parameters were recorded on plant height (cm), Number of effective tillers, number of non-effective tillers, leaf area, straw yield, leaf chlorophyll, nitrate reeducates, total sugar, amino acid, number of grains panicle, weight of 1000 grains, grain yield and harvest index. The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjudged by uncial's Multiple Range Test (DMRT) using the statistical computer package pogrom, MSTAT-C (Russell, 1986).

Results and Discussion

The results of the study regarding the effect of nitrogen and potassium rate on morphological, biochemical and yield attributes characters of fine grain rice have been presented and possible interpretations have been made.

Main effect of nitrogen rate on morphological characters: The effect of nitrogen levels on Morphological characters such as plant height, number of effective and non-effective tillers $hill^{-1}$, leaf area and straw yield $hill^{-1}$ were significant. Results revealed that morphological characters were greater in nitrogen applied plant than control plants. Results further revealed that plant height and number of effective tillers $hill^{-1}$ increased with increasing nitrogen levels up to 50 kg N ha^{-1} where as number of non-effective tillers $hill^{-1}$, leaf area $hill^{-1}$ and straw weight $hill^{-1}$, increased with increasing nitrogen levels till 75 kg N ha^{-1}. The highest plant height (159.8 cm) and number of effective tillers (19.2) $hill^{-1}$ were observed in 50 kg N ha^{-1} followed by 75 kg N ha^{-1} (158.4 cm and 18.1, respectively). However, the number of non-effective tillers (6.13), leaf area (816.9 cm^2) and straw weight (68.91 g) $hill^{-1}$ were the highest in 75 kg N ha^{-1}. In contrast, the shortest plant (112.4 cm), the lowest number of effective tillers (5.38), leaf area (346.3 cm^2) and straw weight (28.11 g) $hill^{-1}$ were recorded in control plant where no nitrogen was applied (Table 1).These results are agreement with that of Rashid (2008) who reported that morpho-physiological characters increased with increased nitrogen rate of rice. Similar results were also reported by BINA (2008) in rice that morphological characters increased with increasing nitrogen level. Again, the lowest number of non-effective tillers (4.51) $hill^{-1}$ with highest number of effective tillers (19.2) $hill^{-1}$ was recorded in 50 kg N ha^{-1}. This result is disagrees with that of Hossain (2007) who reported that number of non-effective tillers $hill^{-1}$ decreased with increasing N levels.

Table 1. Effect of nitrogen and potassium on morphological characters in fine grain rice, RM 100-16

Treatment	Plant height (cm)	Effective tillers $hill^{-1}$	Non-effective tillers $hill^{-1}$	Leaf area $hill^{-1}$(cm^2)	Straw weight $hill^{-1}$ (g)
N levels					
0	112.4c	5.38d	6.19 a	346.3 d	28.11 c
25	147.7b	13.0c	4.56b	564.5 c	54.92 b
50	159.8a	19.2a	4.51b	792.5b	67.81a
75	158.4a	18.1b	6.13a	816.8a	68.91a
Level of sig.	**	**	**	**	**
LSD (0.01)	5.01	0.71	0.21	20.10	1.69
K levels					
0	139.8b	12.5b	5.88b	573.3c	50.19b
25	147.5a	14.6a	4.75c	622.5b	55.82a
50	147.3a	14.2a	4.0ad	656.8a	56.27a
75	145.8a	14.3a	6.75a	767.5a	57.48a
Level of sig.	**	**	**	**	**
LSD (0.01)	5.15	0.73	0.29	28.37	1.73
CV (%)	4.88	7.22	5.40	4.48	4.32

Main effect of potassium rate on morphological characters: For potassium levels, the highest plant height (147.3 cm) and number of effective tillers (14.6) $hill^{-1}$ were recorded in 25 kg K ha^{-1} where as the highest number of non-effective tillers (6.75), leaf area (667.5 cm^2) and straw yield (57.48 g) $hill^{-1}$ were observed in 35 kg K ha^{-1}. In contrast, the shortest plant (138.9 cm), lowest number of effective tillers (12.5), leaf area (573.3 cm^2) and straw yield (50.19 g) $hill^{-1}$ were recorded in control plant (Table 1). Slaton *et al.* (2001) reported that application of potassium increased morphological parameters than control plant which supported the present experimental result. Variations in LA due to different levels of potassium application on rice were also observed by Vijayalakshmi and Nathan (2004). BINA (2008) observed that increasing levels of N also increased the dry ratter yield significantly up to 60 kg N ha^{-1} that also supported the present investigation. This result is partially disagrees with Islam (2002) who reported that straw yield increased with increasing potassium levels.

Interaction effect of nitrogen and potassium rate on morphological characters: Interaction effect of nitrogen and potassium, results revealed that plant height (162.8 cm) was higher in 50 kg N ha^{-1} with 25 kg K ha $^{-1)}$, effective tiller (20.7) was higher in 75 kg N ha $^{-1}$ with 75 kg K ha^{-1} but leaf area (860 cm^2) and straw weight (70.67 g) $hill^{-1}$ were higher in 75 kg N ha^{-1} with 35 kg K ha^{-1} (Table 2).

Table 2. Interaction effect of N and K levels on morphological characters in fine grain aromatic rice, RM 100-16

Treatment		Plant height (cm)	Effective tillers ha^{-1}	Non-effective tillers $hill^{-1}$	Leaf area ha^{-1} (cm^2)	Straw weight $hill^{-1}$ (g)
N_0	K_0	110.7 d	4.50 e	7.00 b	310j	23.84 h
	K_{15}	112.0 d	5.25 e	5.00 de	330 ij	28.42 g
	K_{25}	115.5 d	5.75 e	5.75 c	370 hi	29.36 g
	K_{35}	111.2 d	6.00 e	7.00 b	375 h	30.83 g
N_{25}	K_0	140.5 c	11.0 d	4.25 gh	523 g	48.13 f
	K_{15}	150.5 be	13.0 c	3.75 ij	565 f	54.90 e
	K_{25}	149.8 be	14.0 c	2.75 k	580 f	58.46 d
	K_{35}	150.0 be	14.0 c	7.50 a	590 f	58.20 de
N_{50}	K_0	155.0 ab	17.5 b	5.25 d	710 e	63.28 c
	K_{15}	160.5 ab	19.5 a	4.50 fag	785 cd	70.24 a
	K_{25}	162.8 a	19.8 a	3.55 j	830 ab	67.51 ab
	K_{35}	161.0 ab	20.0 a	4.75 Fe	845 ab	70.20 a
N_{75}	K_0	152.8 ab	17.0 b	7.00 b	750 de	65.51 be
	K_{15}	158.8 ab	20.7 a	5.75 c	810 be	69.72 a
	K_{25}	161.0 ab	17.2 b	4.00 hi	847 ab	69.74 a
	K_{35}	161.0 ab	17.3 b	7.75 a	860 a	70.67 a
Level of sig.		*	**	**	*	*
LSD (0.01)		10.03	1.43	0-41	40.12	3.37
CV (%)		4.88	7.22	5.40	4.48	4.32

Table 3. Effect of nitrogen and potassium on biochemical parameters in fine grain aromatic rice, RM 100-16

Treatment	Chlorophyll (mg g^{-1}fw)	Nitrate reeducates (µmol NO^{2-} g^{-1}fw)	Total sugar (mg g^{-1}fw)	Amino acid (mg g^{-1}fw)
N-levels				
0	1.75 d	6.83 d	50.50 c	13.10 c
25	1.91 c	8.23 c	71.23 b	18.97 b
50	2.15 b	9.65 b	74.73 a	21.58[a]
75	2.38 a	9.98 a	74.46 a	21.88 a
Level of sig.	**	**	**	**
LSD (0.05)	0.05	0.27	2.12	1.01
K-levels				
0	1.98 c	8.35 b	56.55 c	13.70 c
15	2.03 b	8.74 a	66.65 b	19.18 6
25	2.09 a	8.83 a	73.02 a	21.05 a
35	2.09 a	8.76 a	74.68 a	21.60 a
Level of sig.	**	**	**	**
LSD (0.05)	0.05	0.34	2.99	1.42
CV (%)	3.22	3.70	4.39	7.51

Main effect of nitrogen rate on biochemical parameters: The effect of nitrogen levels on biochemical parameters such as chlorophyll, nitrate reductases, total sugar and amino acid content in leaves were significant. Results revealed that biochemical parameters increased with increasing nitrogen levels till 75 kg N ha $^{-1}$ except total sugar. The total sugar increased with increasing nitrogen levels till 50 kg N ha^{-1}. The highest chlorophyll (2.38 mg g^{-1} fw), nitrate reductases activity (9.98 µ mol NO_2 g^{-1} fw) and amino acid (21.88 mg g^{-1} fw) content in leaves were recorded in 75 kg N ha^{-1}. The highest total sugar (74.73 mg g^{-1} fw) was observed in 50 kg N ha^{-1} that was statistically similar to 75 kg N ha^{-1}. In contrast, the lowest chlorophyll (1.75 mg g^{-1} fw) , nitrate reductases (6.83 µ mol NO_2 g^{-1} fw), total sugar (5.50 mg g^{-1} fw) and amino acid (13.10 mg g^{-1} fw) content in leaves were observed in control plant where no nitrogen was applied (Table 3) . This result is in full agreement with that of Rashid (2008) who stated that the total sugar, nitrate reductases activity and amino acid in leaves increased with increasing nitrogen levels from 20 to 80 kg ha^{-1} in rice.

Main effect of potassium rate on biochemical parameters: For potassium levels, results showed that chlorophyll, nitrate reeducates, total sugar and amino acid content in leaves increased with increasing potassium levels till 25 kg N ha ^{1}. The highest chlorophyll (2.19 mg g^{-1} fw), nitrate reductases (8.84 µ mol NO_2 g^{-1} fw), total sugar (74.68 mg g^{-1} fw) and amino acid (21.60 mg g^{-1} fw) were recorded in 35 kg K ha^{-1}. In contrast, the lowest chlorophyll (1.98 mg g^{-1} fw), nitrate reeducates (8.35 µ mol NO_2 g^{-1} fw), total sugar (56.55 mg g^{-1} fw) and amino acid (13.70 mg g^{-1} fw) content in leaves were observed in control plant where no potassium was applied (Table 3). The chlorophyll was higher in potassium applied plot than

control in rice as reported by Islam (2002) who supported the present experimental result. This result is in full agreement with that of BINA (2008) who stated that RNA increased with increasing nitrogen levels from 20 to 80 kg ha $^{-1}$ in rice.

Table 4. Interaction effect of N and K levels on biochemical parameters in fine grain aromatic rice, RM 100-16

Treatment		Chlorophyll (mg g^{-1}fw)	Nitrate reeducates (µmol NO^{2-} g^{-1}fw)	Total sugar (mg g^{-1}fw)	Amino acid (mg g^{-1}fw)
N_0	K_0	1.75 gh	6.64 e	38.80 h	10.90 f
	K_{15}	1.73 h	6.80 e	46.20 g	13.20 e
	K_{25}	1.77 gh	7.00 e	58.20 f	13.80 e
	K_{35}	1.75 gh	6.88 e	58.80 Fe	14.50 e
N_{25}	K_0	1.83 fag	8.06 d	60.00 deb	13.80 e
	K_{15}	1.90 Fe	8.26 d	71.00 c	18.60 d
	K_{25}	1.97 e	8.31 d	75.30 bc	21.10 c
	K_{35}	1.95 e	8.28 d	78.60 ab	22.40 bc
N_{50}	K_0	2.09 d	9.04 c	63.20 de	15.20 e
	K_{15}	2.16 cd	9.89 ab	74.40 be	22.00 c
	K_{25}	2.16 cd	9.90 ab	80.10 a	24.30 ab
	K_{35}	2.17 cd	9.75 ab	81.20 a	24.80 a
N_{75}	K_0	2.23 c	9.65 b	64.20 d	14.90 e
	K_{15}	2.34 b	10.0 a	75.00 bc	22.90 be
	K_{25}	2.47 a	10.1 a	78.50 ab	25.00 a
	K_{35}	2.48 a	10.1 a	80.12 a	24.70 a
Level of sig.		*	*	*	**
LSD (0.05)		0.054	0.43	4.23	2.02
CV (%)		3.22	3.70	4.39	7.51

Table 5. Effects of nitrogen and potassium on yield attribute and yield in fine grain aromatic rice, RM 100-16

Treatment	Grains panicle^{-1}	1000-grain weight (g)	Grain yield hill^{-1} (g)	Harvest index (%)
N-levels				
0	113.8d	10.65c	10.84 d	38.52b
25	158.4 b	11.07 b	23.89 6	43.54 a
50	170.6 a	11.41 a	25.82 a	38.11 b
75	138.3 c	11.23 a	20.64 c	29.93 c
Level of sig.	**	**	**	**
LSD (0.05)	8.38	0.24	0.92	1.57
K-levels				
0	116.9 c	10.92 b	18.42 c	37.51 ab
15	149.9 b	11.03 ab	20.13 b	36.65 b
25	160.0 a	11.23 a	21.81 a	38.90 a
35	154.3 ab	11.18 a	20.83 6	37.04 b
Level of sig.	**	*	**	*
LSD (0.05)	8.60	0.30	0.95	1.61
CV (%)	8.11	2.78	6.40	5.88

Table 6. Interaction effect of nitrogen and potassium levels on yield attributes and aromatic rice, RM 100-16

Treatment		Grains panicle^{-1}	1000-grain weight (g)	Grain yield hill^{-1} (g.)	Harvest index (%)
N_0	K_0	71.32 e	10.45 d	9.16 i	38.42 be
	K_{15}	123.0 d	10.48 d	10.52 hi	37.00 c
	K_{25}	129.7 d	10.80 c	11.21 gh	38.18 be
	K_{35}	131.3 d	10.87 c	12.47 g	40.49 be
N_{25}	K_0	127.0 d	10.88 c	21.38 de	44.42 a
	K_{15}	168.5 ab	10.90 c	24.49 be	44.61 a
	K_{25}	171.0 ab	11.18 ab	25.97 ab	44.40 a
	K_{35}	167.0 ab	11.32 ab	23.70 c	40.72 b
N_{50}	K_0	140.2 cd	11.25 ab	24.35 be	38.48 be
	K_{15}	173.7 a	11.35 ab	25.92 ab	36.90 c
	K_{25}	185.6 a	11.55 a	27.02 a	40.00 be
	K_{35}	183.0 a	11.48 a	26.00 ab	37.04 c
N_{75}	K_0	129.0 d	11.08 be	18.80 f	28.70 e
	K_{15}	134.5 d	11.38 ab	19.60 Fe	28.11 e
	K_{25}	153.7 be	11.40 a	23.02 cd	33.01 d
	K_{35}	136.0 d	11.04 be	21.14 de	29.91 de
Level of sig.		**	*	*	*
LSD (0.05)		16.76	0.40	1.85	3.14
CV (%)		8.11	1.78	6.40	5.88

Interaction effect of nitrogen and potassium rate on biochemical parameters

For interaction effect of nitrogen and potassium, results revealed that all the above biochemical parameters were higher in 75 kg *N* ha^{-1} with 25-35 kg K ha^{-1}(Table 4)

Main effect of nitrogen rate on yield attributes: The effect of nitrogen on yield attributes such as number of grains $panicle^{-1}$, 1000-grain weight, harvest index and grain yield were significant. The highest grain yield (25.82 g) was recorded in 50 kg N ha^{-1} due to production of higher number of grains (170.6) $panicle^{-1}$ and increased 1000-grain (11.23 g) weight (Table 5). However, the highest (43.54 %) harvest index was observed in 25 kg N ha^{-1} indicating dry matter partitioning to economic was good at this N level. These results are in conformity with those of Murky *et al.* (1992) and Nazim *et al.* (1995) who reported that zero or lesser amount of N application had the lowest number of filled grains $panicle^{-1}$ compared to higher doses in rice.

Main effect of potassium rate on yield attributes: For potassium levels, results showed that the highest grain (21.81 g) yield was observed in 25 kg K ha $^{-1}$ due to production of increased number of filled grains panicle's and higher 1000-grain (11.23 g) weight (Table 5). In contrast, control plant produced the lowest yield (18.42 g) due to production of fewer effective tillers $hill^{-1}$ and grains $panicle^{-1}$. Variations in grains $panicle^{-1}$ due to different levels of potassium application was observed by Bushel (2001) in rice.

Interaction effect of nitrogen and potassium rate on yield attributes: For interaction effect of nitrogen and potassium, results revealed that 50 kg N ha $^{-1}$ with 25 kg K ha $^{-1}$ produced the highest grain yield (27.02 g $hill^{-1}$) followed by 50 kg N ha $^{-1}$ with 35 kg K ha $^{-1}$ (26.00 g $hill^{-1}$) and the lowest (9.16 g) was found in 0 kg N ha $^{-1}$ with 0 kg K ha $^{-1}$ (Table 6).

Based on the experimental results, it may be concluded that-Application of nitrogen and potassium had tremendous effect on growth, biochemical parameters and yield in fine grain aromatic rice; and Application of 50 kg N ha^{-1} with 25 kg K ha^{-1} appears to be the best combination for getting maximum yield in fine grain aromatic rice cv. RM 100-16.

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