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DRY MATTER PARTITIONING, YIELD AND GRAIN PROTEIN CONTENT OF FINE AROMATIC *BORO* RICE (cv. BRRI dhan50) IN RESPONSE TO NITROGEN AND POTASSIUM FERTILIZATION

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Keywords: Dry matter partitioning, Growth stage, Yield, Grain protein content, Nitrogen level, Potassium level, Aromatic rice

Abstract

An experiment was conducted to study dry matter partitioning, yield and grain protein content of fine aromatic *Boro* rice (cv. BRRI dhan50) in response to nitrogen and potassium fertilization. The experiment consisted of four levels of nitrogen *viz.*, 0, 50, 100 and 150 kg/ha and four levels of potassium *viz.*, 0, 30, 60 and 90 kg/ha. The results revealed that at growth stage, the highest total dry matter partitioning and accumulation were obtained from 150 kg N/ha along with 90 kg K/ha at physiological maturity stage. At harvest, the highest number of tillers/hill (8.58), number of grains/panicle (113.9), grain yield (5.15 t/ha) and grain protein content (8.30%) were obtained from 100 kg N/ha along with 90 kg K/ha. Total dry matter partitioning and accumulation were greatly influenced by the application of 150 kg N/ha along with 90 kg K/ha. Application of 100 kg N/ha along with 90 kg K/ha interaction appeared as the promising practice in fine aromatic rice (cv. BRRI dhan50) cultivation in terms of yield and grain protein content.

Introduction

Rice (*Oryza sativa* L.) crop is interwoven in the cultural, social and economic livelihood of millions of people in Bangladesh and it plays the key role for food and nutritional security of the country. The people in Bangladesh depend on rice as staple food which has tremendous influence on agrarian economy of Bangladesh. About 74.85% of cultivation area of Bangladesh is used for rice production, with annual production of 33.80 million ton from 11.00 million ha of land (BBS 2017). *Boro* rice covers 4.48 million ha (41.94% of total rice area) of land with production of 18.01 million ton (BBS 2017). Aromatic rice contributes a small but special group of rice which covers 2% of the national rice acreage of Bangladesh and 12.5% of the total transplant Aman rice cultivation (Roy *et al.* 2018). Most of the aromatic rice varieties in Bangladesh are traditional photoperiod sensitive type and grown during *Aman* season (Kabir *et al.* 2004). Bangladesh Rice Research Institute (BRRI) developed BRRI dhan50 (Banglamati) recommended for only *Boro* season has gained much popularity among farmers for its fragrance and relatively high productivity (Paul *et al.* 2020).

Fertilizer is one of the most important factors in rice production. It increases the yield but this yield increase depends on a function of some parameters such as fertilizer application, application rate, climatic and ecological condition. However, fertilizer influences yield increase, over recommended application and also cultivating varieties that do not respond positively to fertilizer introduction resulting in yield reduction. Nitrogen is the major essential plant nutrient and key input, which can augment production of rice to a great extent. Since nitrogen is a principle

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and constituent element of protein and plant needs a great amount of it, one of the resources for this chemical fertilizers is urea (Jalali-Moridani and Amiri 2014). Potassium has an outstanding role in the physiology of rice yield increase. For instance, it causes rise in size, kernel weight, stress tolerance including orifice opening and closing, resistance to unfavorable weather conditions, improvement of tillering, stems strengthening, and reduction of lodging, higher resistance to diseases such as blast, leaf taint and stem putrefaction (De Datta and Mikelson 1985). The combined effect of nitrogen and potassium fertilizer provided the better growth performance and higher grain yield of rice (Yadanar *et al.* 2018). The proposed study was conducted to assess the interaction effect of nitrogen and potassium on dry matter partitioning, yield and grain protein content of fine aromatic *Boro* rice (cv. BRRI dhan50).

Materials and Methods

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during December, 2017 to May, 2018. The experiment consisted of four levels of nitrogen *viz.,* 0, 50, 100 and 150 kg/ha and four levels of potassium *viz.,* 0, 30, 60 and 90 kg/ha. The 35 days old healthy seedlings were transplanted in the well puddled experimental plots (4.0 m × 2.5 m) on 6 January, 2017 following RCBD with three replications. The space between two replications was 1.0 m and plot to plot was 0.75 m. Phosphorus, sulphur and zinc were applied in each plot as a common dose @ 25, 18 and 3.5 kg/ha, respectively. The amount of nitrogen, phosphorus, potassium, sulphur and zinc required for each unit plot was applied in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively. Intercultural operations were done for ensuring and maintaining normal growth of the crop when necessary.

At each growth stage, five hills (plants) within each treatment were uprooted. Leaves, culms and panicles were separated, dried in paper bags by oven and weighed by an electronic balance and then average data (g/hill) on dry weights of leaf, culm and panicle were calculated. Total dry matter (TDM) was calculated as sum of the dry weights of the plant components. Percent of dry matter partitioning was calculated at maximum tillering, heading and physiological maturity stages by the following formula:

$$\text{Dry matter partitioning (\%)} = \frac{\text{Individual dry matter}}{\text{Total dry matter}} \times 100$$

Prior to harvest five hills (excluding border hills) were selected randomly from each unit plot and uprooted to record data on crop characters and yield components. After sampling, the whole plot was harvested on 2 May, 2018 at maturity. The harvested crops of each plot were separately bundled, properly tagged and then brought to threshing floor. The grains were cleaned, and sun dried to 14% moisture content. Straws were also dried properly. Finally grain and straw yields/plot were recorded and converted to t/ha. Harvest index (%) was calculated with the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Protein content (%) was estimated by Micro-Kjeldahl method (AOAC, 1984) at Professor Muhammad Hossain Central Laboratory, Bangladesh Agricultural University, Mymensingh.

Data were analyzed statistically using ANOVA and differences among treatment means were adjudged by DMRT (Gomez and Gomez 1984).

Results and Discussion

The interaction effect of nitrogen and potassium fertilization on leaf dry matter was significant (Fig. 1). Leaf dry matter/hill increased progressively with the advancement of time due to nitrogen and potassium fertilization from tillering to physiological maturity stage. Similar trend of leaf dry matter/hill was reported by Amanullah and Inamullah (2016) who reported that combined application of Zn × P × genotypes of rice increased leaf dry matter from heading to physiological maturity stage. At tillering stage, the interaction of 150 kg N/ha × 90 kg K/ha performed the best in terms of leaf dry matter/hill (1.16 g) followed by 150 kg N/ha × 60 kg K/ha and 100 kg N/ha × 60 kg K/ha and the interaction of 0 kg N/ha × 0 kg K/ha produced the lowest one (0.68 g) at tillering stage. At heading stage, the interaction of 150 kg N/ha × 90 kg K/ha performed the best in terms of leaf dry matter/hill (3.70 g) followed by 150 kg N/ha × 60 kg K/ha and the interaction of 0 kg N/ha × 0 kg K/ha produced the lowest one (1.45 g) at heading stage. At physiological maturity stage, the interaction of 150 kg N/ha × 90 kg K/ha performed the best in terms of leaf dry matter/hill (5.50 g) followed by 150 kg N/ha × 60 kg K/ha, while the interaction of 0 kg N/ha × 0 kg K/ha produced the lowest one (2.47 g) at physiological maturity stage (Fig. 1).

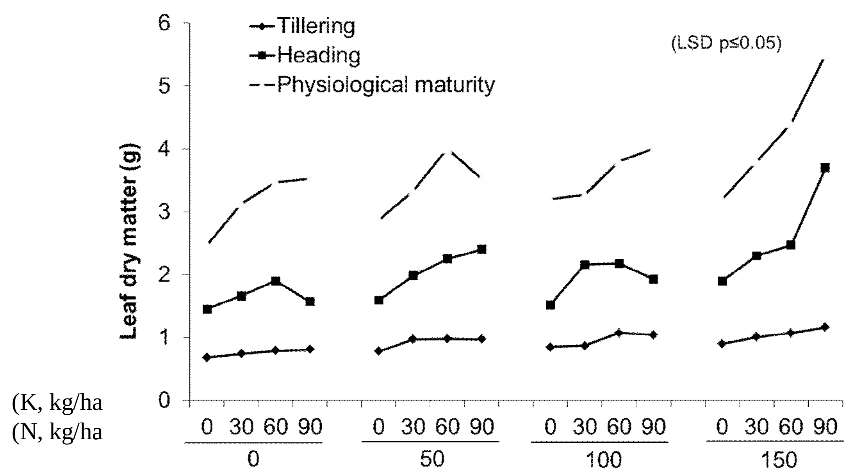

Fig. 1. Interaction effects of level of N and K on leaf dry matter at different growth stages of fine aromatic *Boro* rice (cv. BRRI dhan50).

The interaction effect of nitrogen and potassium fertilization on culm dry matter was significant (Fig. 2). Culm dry matter/hill increased progressively with the advancement of time due to nitrogen along with potassium fertilization from tillering to physiological maturity stage. Similar pattern of culm dry matter was reported by Amanullah and Inamullah (2016). At tillering stage, the interaction of 150 kg N/ha × 90 kg K/ha performed the best in terms of culm dry matter/hill (2.01 g) followed by 150 kg N/ha × 60 kg K/ha and the interaction of 0 kg N/ha × 0 kg K/ha produced the lowest one (0.98 g) at tillering stage. At heading stage, the interaction of 150 kg N/ha × 90 kg K/ha performed the best in terms of culm dry matter/hill (15.70 g), which was at par with 150 kg N/ha × 60 kg K/ha and the interaction of 0 kg N/ha × 0 kg K/ha produced the lowest one (9.88 g) at heading stage. At physiological maturity stage, the interaction of 150 kg N/ha × 90 kg K/ha performed the best in terms of culm dry matter/hill (16.33 g) followed by 150 kg N/ha × 60 kg K/ha, while the interaction of 0 kg N/ha × 0 kg K/ha produced the lowest one (9.93 g) at physiological maturity stage (Fig. 2).

The interaction effect of nitrogen and potassium fertilization on panicle dry matter was significant (Fig. 3). Panicle dry matter/hill increased progressively with the advancement of time due to nitrogen and potassium fertilization from heading to physiological maturity stage. At heading stage, the interaction of 150 kg N/ha × 90 kg K/ha performed the best in terms of panicle dry matter/hill (5.52 g), which was at par with 150 kg N/ha × 60 kg K/ha, while the interaction of 0 kg N/ha × 0 kg K/ha produced the lowest one (2.66 g) at heading stage. At physiological maturity stage, the interaction of 150 kg N/ha × 90 kg K/ha performed the best in terms of panicle

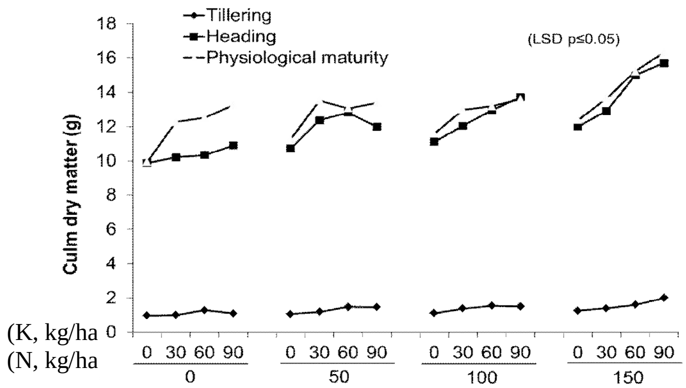

Fig. 2. Interaction effects of level of N and K on culm dry matter at different growth stages of fine aromatic *Boro* rice (cv. BRRI dhan50).

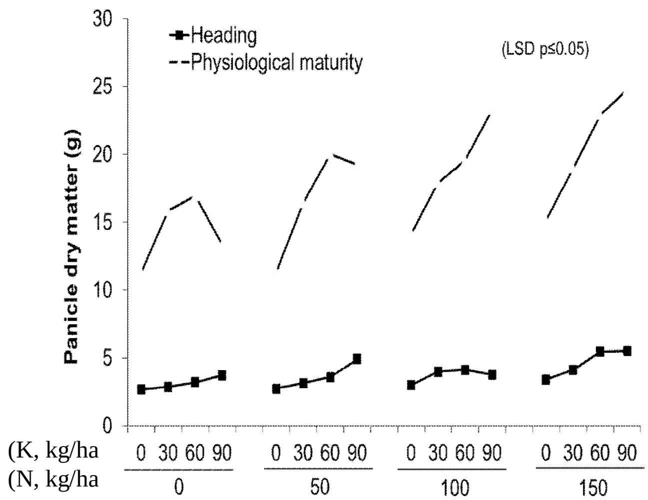

Fig. 3. Interaction effects of level of N and K on panicle dry matter at different growth stages of fine aromatic *Boro* rice (cv. BRRI dhan50).

dry matter/hill (24.78 g) followed by 150 kg N/ha × 60 kg K/ha and 100 kg N/ha × 90 kg K/ha while the interaction of 0 kg N/ha × 0 kg K/ha produced the lowest one (11.28 g) at physiological maturity stage (Fig. 3). Similar trend of panicle dry matter was reported by Amanullah and Inamullah (2016) who reported that combined application of zinc and phosphorus increased panicle dry matter from heading to physiological maturity stage irrespective of rice genotype.

The interaction effect of nitrogen and potassium fertilization on total dry matter was significant (Fig. 4). Total dry matter/hill increased progressively with the advancement of time due to nitrogen and potassium fertilization from tillering to physiological maturity stage. Amanullah and Inamullah (2016) reported similar result in total dry matter due to combined application of Zn × P × genotypes of rice. At tillering stage, the interaction of 150 kg N/ha × 90 kg K/ha performed the best in terms of total dry matter/hill (3.17 g) followed by 150 kg N/ha × 60 kg K/ha, while the interaction of 0 kg N/ha × 0 kg K/ha produced the lowest one (1.66 g) at tillering stage. At heading stage, the interaction of 150 kg N/ha × 90 kg K/ha performed the best in terms of total dry matter/hill (24.92 g) followed by 150 kg N/ha × 60 kg K/ha, while the interaction of 0 kg N/ha × 0 kg K/ha produced the lowest one (13.99 g) at heading stage. At physiological maturity stage, the interaction of 150 kg N/ha × 90 kg K/ha performed the best in terms of total dry matter/hill (46.61 g) followed by 150 kg N/ha × 60 kg K/ha and 100 kg N/ha × 90 kg K/ha while the interaction of 0 kg N/ha × 0 kg K/ha produced the lowest one (23.68 g) at physiological maturity stage (Fig. 4).

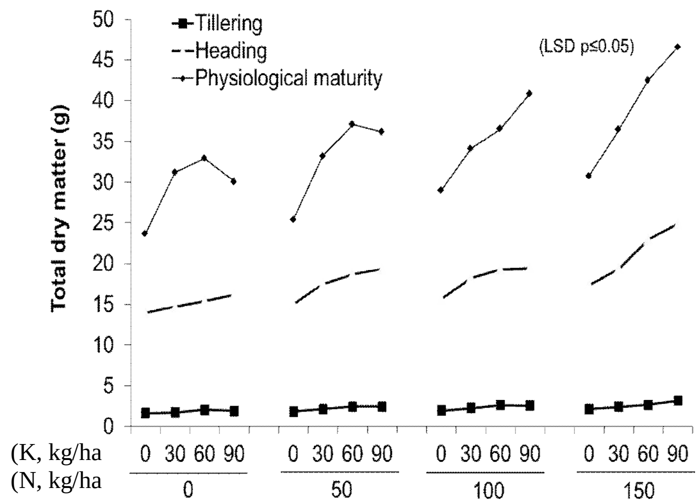

Fig. 4. Interaction effects of level of N and K on total dry matter accumulation at different growth stages of fine aromatic *Boro* rice (cv. BRRI dhan50).

At the early growth stage of rice (tillering), the dry matter partitioning into culm was higher than leaves at the tillering stage. At later growth stages (heading and physiological maturity), the increase in N × K level up to the highest level accumulated more total dry matter and increased dry matter partitioning into culms than leaves and panicles at heading stage and increased dry matter partitioning into panicles than leaves and culms at physiological maturity stages (Table 1).

Crop characters, yield components and yield of BRRI dhan50 were significantly influenced by the interactions of nitrogen and potassium fertilization except plant height, total tillers/hill, panicle length, number of sterile spikelets/panicle and 1000-grain weight. The highest number of effective tillers/hill was found (7.42) from the interaction of 100 kg N/ha × 90 kg K/ha followed by 100 kg N/ha × 60 kg K/ha, while the lowest number of effective tillers was found (5.58) in the interaction of 0 kg N/ha × 0 kg K/ha (Table 2). The lowest number of non-effective tillers/hill (0.91) was obtained from the treatment combination of 50 kg N/ha × 0 kg K/ha and the highest number of non-effective tillers/hill (1.42) was found in the interactions of 50 kg N/ha × 30 kg K/ha, 50 kg N/ha × 60 kg K/ha and 100 kg N/ha × 30 kg K/ha, while they were statistically identical to 150 kg N/ha × 90 kg K/ha, 150 kg N/ha × 30 kg K/ha and 100 kg N/ha × 60 kg K/ha

(Tab1e 2). The highest total spikelets/panicle (125.80) was found in the interaction of 100 kg N/ha × 90 kg K/ha, which was statistically identical to 100 kg N/ha × 60 kg kg/ha and the lowest number of total spikelets/ panicle (107.5) was in the interaction of 0 kg N/ha × 30 kg K/ha (Table 2). The highest number of grains/panicle (113.9) was found in the interaction of 100 kg N/ha × 90 kg K/ha, which was statistically identical to 100 kg N/ha × 60 kg K/ha and the lowest number of grains/panicle (93.50) was in the interaction of 0 kg N/ha × 0 kg K/ha (Table 2). Similar result was

Table 1. Interaction effects of level of N and K on per cent of dry matter content at different growth stages of fine aromatic Boro rice (cv. BRRI dhan50).

Nitrogen × potassium (kg/ha)	Per cent of dry matter partitioning								
	Growth stage								
	Tillering			Heading			Physiological maturity		
	Leaf	Culm	Panicle	Leaf	Culm	Panicle	Leaf	Culm	Panicle
0 × 0	41	59		10	71	19	10	42	48
0 × 30	43	57		11	69	19	10	39	51
0 × 60	38	62		12	67	21	11	38	51
0 × 90	43	57		10	67	23	12	44	44
50 × 0	42	58		11	71	18	11	44	44
50 × 30	45	55		11	71	18	10	41	49
50 × 60	40	60		12	69	19	11	35	54
50 × 90	40	60		12	62	25	10	37	53
100 × 0	43	57		10	71	19	11	40	49
100 × 30	39	61		12	66	22	10	38	52
100 × 60	41	59		11	67	21	10	36	54
100 × 90	41	59		10	71	19	10	33	57
150 × 0	42	58		11	69	20	10	40	49
150 × 30	42	58		12	67	21	10	37	52
150 × 60	40	60		11	65	24	10	36	54
150 × 90	37	63		15	63	22	12	35	53

reported by Esfahani *et al.* (2005) who stated that the number of spikelets/panicle increased with the application of nitrogen and potassium. The highest grain yield (5.15 t/ha) was achieved from the interaction of 100 kg N/ha × 90 kg K/ha followed by 150 kg N/ha × 90 kg K/ha and the lowest one (1.47) was in the interaction of 0 kg N/ha × 0 kg K/ha (Table 2). It was found that all of the higher grain yields were obtained with nitrogen and potassium balanced fertilization treatments. Brar and Imas (2014) pointed out that when nitrogen and potassium are applied together, the increase in grain yield is greater than the increase in yield when they are applied individually. Similar result was reported by Uddin *et al.* (2013) and Farrokh *et al.* (2012) who reported that higher dose of nitrogen along with potassium increased rice grain yield in comparison with no application of both fertilizers. The highest straw yield (6.95 t/ha) was obtained from the treatment combination of 100 kg N/ha × 90 kg K/ha, which was statistically identical to 150 kg N/ha × 90 kg K/ha and 100 kg N/ha × 60 kg K/ha and the lowest straw yield (3.25 t/ha) was obtained from 0 kg

Table 2. Interaction effects of level of nitrogen and potassium on crop characters, yield components and yield of fine aromatic Boro rice (cv. BRRI dhan50).

Nitrogen × potassium (kg/ha)	Plant height (cm)	No. of total tillers/ hill	No. of effective tillers/hill	No. of non-effective tillers/hill	Panicle length (cm)	No. of total spikelets/ panicle	No. of grains/ panicle	No. of sterile spikelets/ panicle	1000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Protein content (%)
0 × 0	75.42	6.58	5.58i	1.00de	21.01	107.80 c	93.50e	14.34	18.23	1.47h	3.25h	4.72h	31.23f	5.39d
0 × 30	76.75	7.00	5.92h	1.08cde	21.05	107.50 c	94.29de	13.19	18.37	1.88g	3.55gh	5.43g	34.63e	6.79c
0 × 60	78.83	7.17	5.92h	1.25abc	21.07	111.10bc	98.58b-e	12.54	18.67	2.16f	3.87g	6.03f	35.79de	7.49b
0 × 90	80.08	7.33	6.00gh	1.33ab	21.10	112.80bc	100.3bc	12.42	18.69	3.30e	4.50f	7.80e	42.33a	7.49b
50 × 0	76.33	6.83	5.92h	0.913e	21.14	109.40bc	95.39 cde	13.98	18.47	3.14e	4.69f	7.83e	40.09b	6.79c
50 × 30	79.33	7.67	6.25efg	1.42a	21.15	111.00bc	98.10b-e	12.90	18.85	3.36e	4.83f	8.19e	41.02ab	8.10a
50 × 60	81.00	7.75	6.33ef	1.42a	21.18	112.50bc	100.0bc	12.48	18.87	3.89d	5.31e	9.20d	42.31a	8.06a
50 × 90	80.83	7.92	6.75cd	1.17bcd	21.19	114.10b	101.7b	12.38	19.06	3.91d	6.51bc	10.43c	37.62cd	8.10a
100 × 0	80.45	7.92	6.83bc	1.08cde	21.30	111.40bc	98.11b-e	13.29	19.08	3.71d	5.56de	9.27d	40.02b	7.49b
100 × 30	82.25	8.25	6.83bc	1.42a	21.33	113.50b	100.9b	12.60	19.12	3.73d	5.77d	9.50d	39.26bc	8.13a
100 × 60	83.90	8.42	7.08b	1.33ab	21.34	121.50a	109.4a	12.16	19.20	4.41bc	6.62abc	11.03b	39.99b	8.19a
100 × 90	84.00	8.58	7.42a	1.16bcd	21.36	125.80a	113.9a	11.85	19.23	5.15a	6.95a	12.10a	42.56a	8.30a
150 × 0	77.67	7.17	6.13fgh	1.09cde	21.20	110.90bc	97.37b-e	13.57	18.52	3.32e	4.84f	8.16e	40.68ab	6.79c
150 × 30	81.00	7.83	6.50de	1.33ab	21.22	111.40bc	98.82bcd	12.63	19.05	3.71d	5.72de	9.43d	39.34bc	7.33b
150 × 60	82.83	7.92	6.92bc	1.00de	21.25	114.10b	101.7b	12.36	19.07	4.24c	6.21c	10.45c	40.57ab	7.49b
150 × 90	83.33	8.33	6.92bc	1.41a	21.26	114.10b	102.1b	11.99	19.18	4.60b	6.90ab	11.50b	40.01b	8.16a
$S\bar{x}$	1.45	0.10	0.09	0.05	0.353	1.62	1.57	0.35	0.146	0.073	0.135	0.166	0.668	0.145
Level of sig.	NS	NS	*	**	NS	*	*	NS	NS	**	**	*	**	**
CV (%)	3.16	2.24	2.38	7.90	2.89	2.48	2.72	4.74	1.34	3.57	4.41	3.27	2.96	3.37

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 1% level of probability,* = Significant at 5% level of probability, NS = Not significant.

N/ha × 0 kg K/ha (Table 2). Application of nitrogen with higher dose increased plant height and number of tillers in rice which subsequently increase straw yield. Straw yield increased due to application of higher dose of nitrogen was reported by Jisan *et al.* (2014) and Ray *et al*. (2015). The highest biological yield (12.10 t/ha) was obtained from the treatment combination of 100 kg N/ha × 90 kg K/ha followed by 150 kg N/ha × 90 kg K/ha and 100 kg N/ha × 60 kg K/ha and the lowest biological yield (4.72 t/ha) was obtained from 0 kg N/ha × 0 kg K/ha (Table 2). The highest harvest index (42.56%) was obtained from the treatment combination of 100 kg N/ha × 90 kg K/ha, which was statistically identical to 0 kg N/ha × 90 kg K/ha and 50 kg N/ha × 60 kg K/ha and the lowest harvest index (31.23%) was obtained from 0 kg N/ha × 0 kg K/ha (Table 2).

The effect of interaction of nitrogen and potassium fertilization on grain protein content was significant (Table 2). The interaction of 100 kg N/ha × 90 kg K/ha produced the highest grain protein content (8.30%), which was statistically identical to 150 kg N/ha × 90 kg K/ha, 100 kg N/ha × 60 kg K/ha and 100 kg N/ha × 30 kg K/ha, while the lowest grain protein content (5.39%) was observed in the interaction of 0 kg N/ha × 0 kg K/ha (Table 2). The grain protein content in rice was increased by the application of nitrogen was reported by Ray *et al.* (2015). That the application of K significantly increased grain protein content of wheat was reported by Alam *et al.* (2009).

Results of this study confirmed that 100 kg N/ha × 90 kg K/ha gave better performance in respect of growth, yield and grain protein content. Total dry matter partitioning and accumulation were sharply influenced by 150 kg N/ha × 90 kg K/ha interaction. It can be concluded that, total dry matter partitioning and accumulation were greatly influenced by 150 kg N/ha × 90 kg K/ha and 100 kg N/ha × 90 kg K/ha interaction appeared as the promising practice in fine aromatic *Boro* rice (cv. BRRI dhan50) cultivation in terms of yield and grain protein content.

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