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Integrated nutrient management on growth and yield performance of dry direct seeded boro rice

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ABSTRACT

Integrated use of organic and inorganic fertilizers is the most important component of the agricultural production system to sustain crop productivity and soil health. The aim of this research was to examine the effect of integrated nutrient management on growth and yield performance of rice cv. BRRI dhan58 under dry direct seeded system. An experiment was conducted in the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh- 2202, Bangladesh during February to July 2018. There were nine treatment combinations of inorganic and organic fertilizers viz. i. No fertilizer (T_1); ii. Fertilizers except N (FEN) + 150 kg N ha^{-1} (T_2); iii. FEN + Trico-compost (TC) @ 5 t ha^{-1} (T_3); iv. FEN + TC + 120 kg N ha^{-1} (T_4); v. FEN + TC + 150 kg N ha^{-1} (T_5); vi. FEN + TC + 180 kg N ha^{-1} (T_6);vii. FEN + Cowdung (CD) @ 5 t ha^{-1}+ 120 kg N ha^{-1} (T_7); viii. FEN + CD + 150 kg N ha^{-1} (T_8); and ix. FEN + CD + 180 kg N ha^{-1} (T_9) in this experiment. The experiment was randomized complete block design (RCBD) with three replications. The result showed that all the crop characters except number of non-effective tiller hill^{-1}, sterile spikelet panicle^{-1} and harvest index (%) were significantly affected by combination of inorganic and organic fertilizers. The combined application of inorganic and organic fertilizers improved the yield and related attributes of rice under dry direct seeded system. The results of the present study concludes that inorganic fertilizers i.e. N: P: K: S: Zn @ 150:20: 65: 18: 1.3 ha^{-1}along with cowdung (CD) or trico-compost (TC) @ 5 t ha^{-1} could be applied for obtaining maximum yield of boro rice under dry direct seeded system in Old Brahmaputra Floodplain Agroecological zone.

Key words: inorganic fertilizer, organic fertilizer, cowdung, trico-compost, grain yield

INTRODUCTION

Rice contributes 95% of food production in Bangladesh. About 74.85% of cropped area of Bangladesh is used for rice production, with annual production of 38.608 million metric tons from 11.804 million hectares of land where *Boro* rice covers 4.873 million hectares (41.28% of total rice area) of land with production of 20.885 million metric tons (AIS, 2022). The conventional methods of rice production that Bangladeshi farmers use require large amounts of energy, water and labour, which are becoming increasingly scarce and expensive. However, to get optimum yield conservation agricultural methods are introduced to all over the world. Direct seeding of rice refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery. Dry seeding has been the principal method of rice establishment mostly used for local varieties under rain fed/low input production environment since the 1950s in developing countries (Kaur and Singh, 2017) but dry direct seeding is a recently developed alternative rice production technology targeted to produce high yielding rice varieties under high input environment to obtain maximum yield with less water in a sustainable way (Rahman, 2019).

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Proper and balanced fertilizer is a must for expected production of crops. Application of imbalanced and/or excessive nutrients led to declining nutrient-use efficiency making fertilizer consumption uneconomical and producing adverse effects on atmosphere (Good and Beatty, 2011) and groundwater quality causing health hazards and climate change. Experiment with urea N in combination with poultry manure and cowdung in transplanted rice found that application of manures and different doses of urea N fertilizer significantly increased the yield components and grain and straw yields (Deena *et al.,* 2022). Effective nutrient management has played a major role in accomplishing the enormous increase in *boro* rice production. The overall strategy for increasing crop yields and sustaining them at a high level must include an integrated approach to the management of soil nutrients, along with other complementary measures. Integrated nutrient management (INM) is one of the most important components of the agricultural production system to sustain higher crop yields vis-à-vis maintain soil health. The interactive advantages of combining organic and inorganic sources of nutrients in integrated nutrient management have shown additive effect in comparison to the use of each component separately (Chakrobortty *et al*., 2021). The results emanating from long-term fertilizer experiments have clearly indicated that imbalance use of chemical fertilizers affected soil health, causing substantial decrease in soil organic carbon (Pahalvi *et al*., 2021; Wan *et al*., 2021). The sole application of either manure or chemical fertilizers cannot sustain soil fertility and crop yield on a long-term (BARC, 2018). As a general rule, the use of organic fertilizers especially in composted form produces positive effects on soil health and fertility and consequently increases crop yield on a long-term basis (Mehdizadeh *et al*., 2013).

Research reports regarding the effect of integrated nutrient management on growth and yield of transplanted rice is enormous but that for dry direct seeded rice is highly scarce. Therefore, the study in relation to integrated nutrient management in dry direct seeded rice is warranted for harnessing maximum yield of rice. Keeping this in view, the present study was undertaken to examine the effect of integrated nutrient management on growth and yield performance of dry direct seeded *boro* rice cv. BRRI dhan58.

MATERIALS AND METHODS

This experiment was conducted in the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh- 2202, Bangladesh. It is located at 24°75′ N latitude and 90°50′ E longitude having an altitude of 18 m. The experimental site belongs to the Sonatala series of Old Brahmaputra Floodplain Agro Ecological Zone (AEZ9) having non-calcareous dark grey floodplain soils. The region occupies the large area of Brahmaputra sediments, which were laid down before the river shifted into its present Jamuna channel about 200 years ago.

The experimental land was medium high with moderate drainage facilities and the soil was silt loam. The pH value was 6.40. Soil contained 2.27% organic matter, 1.31% organic carbon, 0.13% total N, 1.98 μ g^{-1} available P, 0.22 meq $100g^{-1}$ exchangeable K and 4.56 μg g^{-1} available S. The experimental area is under the sub-tropical climate which is characterized by its heavy rainfall during *Kharif* season (April to September) and scanty rainfall occurred during Rabi season (October to March). The monthly average maximum, minimum and average temperature, rainfall and relative humidity during the cropping period has been shown in Table 1.

Experimental treatments and design

Nine treatment combinations comprised of inorganic and organic fertilizers viz. i. No fertilizer (T_1); ii. Fertilizers except N (FEN) + 150 kg N ha^{-1} (T_2); iii. FEN + Trico-compost (TC) @ 5 t ha^{-1} (T_3); iv. FEN + TC + 120 kg N ha^{-1} (T_4); v. FEN + TC + 150 kg N ha^{-1} (T_5); vi. FEN + TC + 180 kg N ha^{-1} (T_6); vii. FEN + Cowdung (CD) @ 5 t ha^{-1}+ 120 kg N ha^{-1} (T_7); viii. FEN + CD + 150 kg N ha^{-1} (T_8); and ix. FEN + CD + 180 kg N ha^{-1} (T_9) were included in the experiment using a randomized complete block design (RCBD) with three replications. The size of each unit plot was 10 m^2 (4.0 m x 2.5 m). The spaces between blocks and plots were 1.0 m and 0.5 m respectively.

Crop Husbandry

Seeds of BRRI dhan58 were primed by soaking in water for 24 hours followed by incubating for 30 hours at ambient room temperature. Then the seed was sown at 15 cm distance in 25 cm apart

rows with 4 seeds hill^{-1} on 19 February 2018 under dry direct seeded system. The experimental plots were fertilized with P, K, S and Zn @ 20, 65, 18, and 1.3 ha^{-1}, respectively in the form of triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate (monohydrate) as per treatment specifications. Fertilizer N was applied in the form of urea at the rates specified in the treatment. At the time of final land preparation, respective unit plots were applied with different levels of cowdung and Trico-compost according to treatment definition and the manures were thoroughly mixed with the soil. All the fertilizers except urea were applied at the time of final land preparation while urea was applied in three equal splits at 15, 30 and 45 days after sowing (DAS). As a protocol for weed control, a pre-emergence herbicide Panida 33EC, 33% EC formulation of Pendimethalin ($C_{13}H_{19}N_3O_4$; 3, 4-Dimethyl-2, 6-dinitro-N-(pentan-3-yl)-aniline) was applied at the rate of 2.5L ha^{-1} on 20 February 2018. In addition, two hand weeding were done at 20 and 35 DAS, respectively. Irrigation was given at 36 DAS and no further irrigation was required during the whole crop period due to sufficient rainfall during the later stage of the crop.

Table 1. Monthly average temperature, relative humidity and rainfall of the experimental site during the period from January to June 2018

Month	Air temperature (^{0}C)			Rainfall (mm)	Relative humidity (%)
	Maximum	Minimum	Average		
January	22.6	10.8	16.7	0.0	83.5
February	26.4	16.0	21.2	0.0	76.8
March	31.1	20.0	25.6	33.0	76.1
April	30.4	21.4	25.9	915.2	79.1
May	30.2	23.5	26.8	488.5	83.2
June	32.3	26.0	29.2	301.9	84.9

Sampling, harvesting and processing

The crop was harvested on 20 June 2018 at full maturity, when about 80% of the grains became golden yellow in color. Five hills (excluding border hills) were randomly selected for each plot and uprooted before harvesting for recording the necessary data on various plant characters. Crop was harvested from central 1.5 m × 3.0 m area of each plot to record the yields of grain, and straw. Five hills were randomly selected for measuring plant height and tiller production and also to record the data on yield contributing characters. The harvested crop of each plot was separately bundled, properly tagged and then brought to the threshing floor. The crop was threshed by pedal thresher. Grains were sun dried and cleaned. Straw was also sun dried properly. Finally, grain yield was adjusted to 14% moisture and converted to ton per hectare. Grain yield and straw yield were altogether regarded as biological yield. Then harvest index was calculated as the ratio of grain yield to biological yield expressed as percentage.

Statistical analysis

The collected data were compiled and tabulated in proper form and were subjected to statistical analysis. Data were analyzed using the analysis of variance (ANOVA) technique with the help of a computer package programme STATISTIX10. Mean differences were adjudged by Least Significance Difference (LSD) Test.

RESULTS AND DISCUSSION

Integrated nutrient management had significant effect on plant height, number of total tiller hill^{-1}, number of effective tiller hill^{-1}, panicle length, number of grain panicle^{-1}, and 1000-grain weight but not on number of non-effective tiller and number of sterile spikelet panicle^{-1}. The tallest plant (105.79 cm) was observed in T_6 (FEN+TC+180 kg N ha^{-1}), which was statistically identical to the treatment T_5 and T_9 (Table 2). The highest number of total tiller hill^{-1} (12.23) was found withT_8 (FEN +CD+150 kg N ha^{-1}). Maximum number of effective tiller hill^{-1} (10.67) was obtained with the

treatment T_5 (FEN+TC+150 kg N ha^{-1}) and T_8 (FEN+CD+150 kg N ha^{-1}). The longest panicle (22.74 cm) was found from the treatment T_7 (FEN+CD @ 5 t ha^{-1}+120 kg N ha^{-1}). The highest number of grains (126.00) was obtained from T_8 (FEN+CD+150 kg N ha^{-1}), which was statistically identical to T_7. The highest 1000-grain weight (24.60 g) was obtained from T_8 (FEN+CD+150 kg N ha^{-1}), which was statistically identical to T_2.T_4, T_5, T_6, T_7 and T_9. The result revealed that the lowest plant height (83.58 cm), number of total tillers (6.75) and effective tillers $hill^{-1}$ (5.17), shortest panicle (21.00 cm), number of grains $panicle^{-1}$ (120.33) and 1000-grain weight (23.17 g) were obtained with T_1 (No fertilizer). The present study revealed that the plots receiving T_5 (FEN + TC + 150 kg N ha^{-1}) and T_8 (FEN + CD + 150 kg N ha^{-1}) produced the similar highest values for all the crop characteristics and yield attributes. Thus application of 150 kg N ha^{-1} along with TC or CD @ 5 t ha^{-1} plus other fertilizers at recommended rates (P:K:S:Zn @ 20:65:18:1.3 kg ha^{-1}) favours development of different growth and yield chaacters. Islam ***et al***. (2016) reported that the application of chemical fertilizer and organic matter increased the tillers of rice plant, panicle length, number of grains $panicle^{-1}$ and 1000-grain weight. Moreover, Kader ***et al.*** (2022) found maximum number of tiller $hill^{-1}$ in the treatment with 75% NPKS + 5 t ha^{-1} of poultry manure.

Grain and straw yield

Integrated use of inorganic and organic fertilizers had significant effect on grain yield and straw yield of BRRI dhan58 (Table 3). The highest grain yield (5.23 t ha^{-1}) was observed in T_5 (FEN+TC+ 150 kg N ha^{-1}) and T_8 (FEN+CD+150 kg Nha^{-1}) treatments, which was statistically identical to T_2, T_4, T_7, and T_9. The lowest grain yield (2.27 t ha^{-1}) was observed in control treatment (T_1) which was statistically similar to T_3 (FEN + Trico-compost (TC) @ 5 t ha^{-1}). The percent of yield increasing over control was the highest (130.39%) for T_5 and T_8 (Table 2). In case of straw yield, the highest straw yield (7.56 t ha^{-1}) was observed in T_9 (FEN+CD+180 kg N ha^{-1}) and that was statistically identical to T_2, T_4, T_5, T_6, T_7, and T_8. The lowest straw yield was observed in T_1 (4.80 t ha^{-1}).

The highest grain yield was found in T_5 and T_8, the amount of inorganic nitrogen was same in the both treatments, which suggests that grain yield was greatly influenced by amount of nitrogen rather than cowdung or trico-compost. Grain yield increased by 130.39% in T_5 and T_8 and the yield increase was the lowest (22.46%) in T_2 [(FEN) + Trico-compost (TC) @ 5 t ha^{-1}]. The result suggests that inorganic nitrogen is very important source for yield improvement.

Table 2. Effect of integrated nutrient management on crop characteristics and yield components of BRRI dhan58 under dry direct seeded system

Treatment combinations	Plant height (cm)	Total tiller $hill^{-1}$ (no.)	Effective tiller $hill^{-1}$ (no.)	Non effective tiller $hill^{-1}$ (no.)	Panicle length (cm)
T_1	83.58c	6.75g	5.17e	1.58	21.00d
T_2	98.83ab	10.25de	9.17bc	1.08	22.12b
T_3	90.33bc	7.77f	5.73e	2.03	21.56c
T_4	98.33ab	9.58e	8.25d	1.33	22.30ab
T_5	103.58a	12.00ab	10.67a	1.33	22.40ab
T_6	105.79a	9.57e	8.32cd	1.25	22.50ab
T_7	99.50ab	11.18bc	10.00ab	1.18	22.70a
T_8	97.53ab	12.23a	10.67a	1.45	22.50ab
T_9	103.75a	10.83cd	9.20b	1.63	22.10b
CV (%)	5.86	5.30	5.82	29.42	1.07
Level of significance	**	***	***	NS	***
SE (±)	4.69	0.43	0.40	0.34	0.19

* In a column, figures with same letter(s) or without letter do not differ significantly, whereas figures with dissimilar letter(s) differ significantly; **= Significant at 1% level of probability; ***= Significant at 0.01% level of probability; NS= Non significant;[T_1 =No fertilizer, T_2 = Fertilizers except N (FEN)

+ 150 kg N ha^{-1};T_3 = FEN + Trico-compost (TC) @ 5 t ha^{-1}; T_4 = FEN + TC + 120 kg N ha^{-1}; T_5 = FEN + TC + 150 kg N ha^{-1}; T_6 = FEN + TC + 180 kg N ha^{-1};T_7 = FEN + Cowdung (CD) @ 5 t ha^{-1}+ 120 kg N ha^{-1}; T_8 = FEN + CD + 150 kg N ha^{-1}; and T_9 = FEN + CD + 180 kg N ha^{-1}]

Integrated use of inorganic and organic fertilizers gave higher yield of rice than sole inorganic fertilizers (Bilkis *et al.*, 2017). Anik *et al.* (2017) found that chemical fertilizer was more effective in increasing rice yields than cowdung alone. Use of Trichoderma compost technology is at initial level in our country. Trichoderma fungi decomposes organic materials in which they grow, colonize plantroot system and attack other fungi in the plant's root system and releases compounds that activate plant defense mechanism (Reino *et al*., 2008). The potential of organic amendments over chemical fertilizers in suppression of disease incidence has long been recognized (Bonanomi *et al*., 2007*).* Rahman *et al.* (2013) observed a 15-20% yield increase due to combined use of fertilizers with poultry manure or household compost over 100% sole fertilizer treatment. Poultry manure can supply organic C to soil in one way and some growth hormones and concentrates feed to poultry birds can influence the plant growth on the other way. This, sustainable production of crops cannot be achieved by using chemical fertilizers alone because of deterioration in soil physical and biological environments (Ma *et al*., 2023). Integrated use of both organic manure and chemical fertilizers appears as the best approach in providing greater stability in production and improving soil fertility status, as evidenced in the past (Arif *et al*., 2014).

Table 3. Effect of integrated nutrient management on yield and yield components of BRRI dhan58 under dry direct seeded system

Treatments	Grains $panicle^{-1}$ (no.)	Sterile spikelet $panicle^{-1}$ (no.)	1000-grain wt (g)	Grain yield (t ha^{-1})	Percent increase over control (%)	Straw yield (t ha^{-1})
T_1	120.33c	12.00	23.17b	2.27c	-	4.80b
T_2	124.67ab	10.67	24.17a	4.68a	106.17	6.88a
T_3	122.00bc	9.67	23.45b	2.78bc	22.46	5.08b
T_4	125.00ab	11.33	24.37a	5.03a	121.58	6.99a
T_5	125.00ab	9.67	24.53a	5.23a	130.39	7.08a
T_6	124.00ab	11.33	24.33a	4.32ab	90.30	7.50a
T_7	125.33a	11.00	24.27a	5.10a	124.66	7.05a
T_8	126.00a	9.33	24.60a	5.23a	130.39	7.13a
T_9	124.67ab	10.67	24.23a	4.45a	96.03	7.56a
CV (%)	1.55	11.61	1.20	20.95	-	12.86
Level of significance	*	NS	***	**	-	**
SE (±)	1.57	1.00	0.24	0.74	-	0.70

* In a column, figures with same letter(s) or without letter do not differ significantly, whereas figures with dissimilar letter(s) differ significantly; **= Significant at 1% level of probability; ***= Significant at 0.01% level of probability; NS= Non significant; [T_1 =No fertilizer, T_2 = Fertilizers except N (FEN) + 150 kg N ha^{-1}; T_3 = FEN + Trico-compost (TC) @ 5 t ha^{-1}; T_4 = FEN + TC + 120 kg N ha^{-1}; T_5 = FEN + TC + 150 kg N ha^{-1}; T_6 = FEN + TC + 180 kg N ha^{-1};T_7 = FEN + Cowdung (CD) @ 5 t ha^{-1} + 120 kg N ha^{-1}; T_8 = FEN + CD + 150 kg N ha^{-1}; and T_9 = FEN + CD + 180 kg N ha^{-1}]

CONCLUSION

The study revealed that the highest grain yield (5.23 t ha^{-1}) was obtained in T_5 (FEN + TC + 120 kg N ha^{-1}) andalso in T_8 (FEN+CD+150 kg N ha^{-1}) treatments. In these treatments, trico-compost or

cowdung were applied @ 5 t ha^{-1}along with recommended doses of fertilizers (N:P:K:S:Zn @150:20: 65:18:1.3 kg ha^{-1}). Based on the present study it may be concluded that maximum grain yield of *boro* rice cv. BRRI dhan58 under dry direct seeded system could be obtained by applying all chemical fertilizers at recommended doses(N:P:K:S:Zn @150:20: 65:18:1.3 kg ha^{-1}) along with cowdung or trico-compost@ 5 t ha^{-1}.

Conflict of interest: There is no conflict of interest.

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