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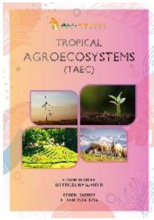

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RESEARCH ARTICLE

COMBINED EFFECT OF COWDUNG AND NPKS ON THE GROWTH, YIELD AND YIELD CONTRIBUTING TRAITS OF *BORO* RICE UNDER COASTAL ZONE OF BANGLADESH

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ABSTRACT

Rice is the major cereal crop of Bangladesh, but its production remains insufficient to fulfill the demand of the population. Prolonged applications of imbalanced and chemical fertilizer degrade soil fertility particularly in coastal areas which results in low yields. Therefore, the present experiment was carried out at the field of Agriculture Department, Noakhali Science and Technology University (NSTU), Noakhali-3814, from December 2022 to May 2023 to investigate the effects of organic and inorganic fertilizers on the growth, yield and yield contributing traits of *Boro* rice. The experiment comprised three treatments viz., T_0 = Control, T_1 = 50% NPKS + 50% cowdung (3 t ha^{-1}), T_2 = 75% NPKS + 25% cowdung (1.5 t ha^{-1}), T_3 = 100% NPKS. The experimental design employed a Randomized Complete Block Design (RCBD) with three replications. The highest plant height (117.4 cm), number of tillers per hill (15.83), panicle length (24.16 cm), number of grains per panicle (111.57), straw yield (7.6 t ha^{-1}), 1000 grains weight (25.27g), grain yield (7.5 t ha^{-1}), and harvest index (49.24%) was obtained from T_2 which comprised of 75% NPKS + 25% cowdung (1.5 t ha^{-1}) whereas the lowest value was obtained from control. Thus, this particular dose may be ideal for *Boro* rice production, enhancing growth, yield, and yield-contributing characteristics in coastal zones of Bangladesh.

KEYWORDS

Boro rice, Cowdung, NPKS, Growth, Yield

1. INTRODUCTION

Bangladesh is primarily an agricultural country, benefited from fertile soil and suitable weather, which promote the abundant growth of diverse crops. Agriculture sector contributed 11.38% to the GDP of Bangladesh while engaging approximately 45.33% of the total labor force (BBS, 2023). Rice (*Oryza sativa*), belonging to the family Gramineae, is the major staple food of Bangladesh, covering up about 76 percent of the net cropped area of Bangladesh (BBS, 2023). In Bangladesh rice is significantly grown on almost 80% of the arable land (Alam et al., 2021).The total area and production of rice are about 10.5 million hectares and 39.1 million metric tons, respectively (BBS, 2023). Among the three types of rice grown in the country, *Boro* accounts for about 53% of total rice production, with 20.7 million metric tons, followed by Aman (15.4 million metric tons) and Aus (2.9 million metric tons) (BBS, 2023). Despite Bangladesh having a favorable sub-tropical climate for *Boro* rice cultivation, its productivity is comparatively low compared to other Asian countries such as Indonesia and Malaysia. The low productivity of *Boro* rice in Bangladesh is mostly due to the continual production of rice with imbalanced and inorganic fertilizers, which have decreased soil fertility. Furthermore, Bangladesh comprises of about 31% (46,271 km^2) of coastal areas with approximately 40 million people where rice production is a challenge due to continuous salt accumulation particularly in dry season. Salinity threatens the crop production by affecting water uptake, ion toxicity, retarded growth and yield reduction (Gaydon et al., 2021; Mainuddin et al., 2020). Due mostly to the salinity of the soil and water, between 30 and 50 percent of Bangladesh's net cultivated area remains fallow throughout the Rabi and Kharif-1 seasons (Hossen et al., 2020). As *Boro* rice is a dry season crop, it is mostly subjected to capillary rise and salt accumulation. However, coastal agricultural systems are made worse by a lack of freshwater and the flooding of agricultural fields with salty seawater (Dasgupta et al., 2018). Therefore, addressing soil with appropriate soil fertility management approaches may contribute to the enhance productivity of the soil and crops.

Neglecting judicious applications of nutrients in the soil not only degrade soil fertility but also make the soil unproductive, especially in coastal areas. It is true that relying just on chemical fertilizers is unlikely to promote sustainable agricultural production, and focusing solely on organic manure fails to produce better crop yields (Bair, 1990). The key proven beneficial strategy is the use of organic resources, which includes organic manure combining with inorganic fertilizers (Arif et al., 2014). The combined application of chemical fertilizers and organic manure offers considerable promise for improving soil fertility and improving crop stability. There are three main sources of resupplying plant nutrients in agricultural soils: inorganic fertilizers, organic fertilizers, and bio-fertilizers (Havlin and Heiniger, 2020). However, organic manure is a major environmentally friendly element which reserves nutrients, particularly N, P, and S and micronutrients. In Bangladesh, the majority of cultivated soils have less than the recommended 2% organic matter, often falling below 1.5 %. This deficiency is exacerbated by intensive cropping and the excessive use of chemical fertilizers without sufficient organic manure. According to the study, in order to improve the chemical,

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biological, and physical characteristics of land that has been affected by salt stress, the use of organic amendments should be given priority (Naveed et al., 2021). Integrating inorganic fertilizers with organic resources resulted in the highest grain and straw yields (Arif et al., 2014). Cow dung along with nitrogen fertilizer significantly increased plant height and dry matter weight in NERICA rice (Bhadra et al., 2019). Cow dung adds organic matter to the soil, thus improves water infiltration, cation exchange capacity, microbial populations, nutrient cycling and overall soil health (Raj et al., 2014). According to long-term research of BRRI, applying cow dung at a rate of 5 t ha^{-1} $year^{-1}$ increased rice productivity and halted the deterioration of soil resources (Bhuiyan, 1994). Although there has been several researches done addressing the issue of fertilizer management in case of *Boro* rice, very few studies have focused on the proper combined fertilization approach for coastal areas of Bangladesh.

Application of both chemical and organic fertilizers need to be applied for the improvement of physical properties of salt-induced soil and supply of essential plant nutrients for higher yield. Therefore, the present investigation was undertaken to develop a suitable integrated dose of inorganic fertilizers and organic manures for *Boro* rice and to observe the effects of different levels of inorganic fertilizers and organic manures on the yield as well as yield components of *Boro* rice in coastal regions of Bangladesh.

2. Materials and Methods

2.1 Experimental site and soil

The experiment was conducted at the research field of the Noakhali Science and Technology University, Noakhali, Bangladesh during the period from December 2022 to May 2023 in agro-ecological region of the Young Meghna Estuarine Floodplain (AEZ-18). The experiment site was almost level land having sandy loam soil, moderately alkaline with pH value 7.5 (Rahaman et al., 2023).

2.2 Experimental treatment and design

Single factor experiment was designed using Randomized Complete Block Design (RCBD) with three treatments and three replications. The Treatments were; T_0 = Control, T_1 = 50% NPKS + 50% cow dung (3 t ha^{-1}), T_2 = 75% NPKS + 25% cow dung (1.5 t ha^{-1}), T_3 = 100% NPKS. Each block was divided into 3 plots, there were 12 unit plots altogether in the experiment. Each plot was 1.5 m × 1.5 m in size. The distances between blocks and between plots were kept 1 m and 0.50 m respectively.

2.3 Experimental material

BRRI dhan 67 was employed as the experimental material which was collected from Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh. It is a high-yielding rice variety developed by the Bangladesh Rice Research Institute (BRRI).

2.4 Seed sprouting and raising of seedling

The collected seeds were soaked in the water for 24 hours and covered with wet gunny bags. The seeds were started sprouting after 48 hours and almost all seeds were sprouted after 72 hours. A designated plot of land underwent thorough preparation, including puddling through repeated ploughing and laddering. The seedbed received a nutrient boost with the application of well-decomposed cow dung. On 11 January 2023, pre-germinated seeds of the BRRI dhan 67 variety were uniformly broadcasted in a well-prepared nursery bed.

2.5 Main land preparation for transplanting

The experimental land was prepared with the use of a tractor which loosened the experimental land. The land underwent ploughing, followed by cross ploughing and laddering. This step aimed to break down larger soil clods into smaller pieces, promoting a finer tilth, which is essential for better yield. All weeds and stubbles were removed from the experimental field. After all the preparatory steps, the land was uniformly leveled.

2.6 Manure and fertilizers application

Recommendation dose of chemical fertilizers for Boro rice cultivation show in Table 1. The entire amounts of triple super phosphate (TSP), potassium, gypsum, were applied during final land preparation. Urea was applied as top dressing in three equal splits at 15, 30 and 45 days after transplanting (DAT). The entire amount of well-rotten cowdung was applied 10 days before of final land preparation.

Table 1: Recommendation dose of chemical fertilizers

Fertilizer	Quantity (kg/ha^{-1})
Urea	262.5 kg ha^{-1}
TSP	97.5 kg ha^{-1}
MP	120 kg ha^{-1}
Gypsum	97.5 kg ha^{-1}

2.7 Uprooting and transplanting of seedlings

Seedlings were meticulously uprooted from the nursery bed, and prior to uprooting, a slight irrigation was applied to ease the process. The transplanting of uprooted seedlings took place in unit plots on 22 February, 2023, maintaining a spacing of 25 cm × 15 cm (row to row and plant to plant). The transplantation rate was set at 1-2 seedlings per hill.

2.8 Intercultural operation

Seedlings that died off in certain hills were promptly replaced through gap filling. Individual plot bunds were repaired as needed to prevent the movement of water between plots. This timely repair ensured proper water management and prevented potential damage to the crop caused by unwanted water flow. Throughout the entire growth period, two hand weeding sessions were conducted at 20 and 35 days after transplanting (DAT). After two weeks post-transplanting, specific weeds such as durba, shama, chesra, maluncha, and mutha were identified in each plot and promptly uprooted through hand pulling to prevent competition with the main crop. During the entire cultivation period, rainfall was insufficient, necessitating artificial irrigation (8-10 times). Fungicide and pesticide were applied three times to control diseases and insects.

2.9 Harvesting, threshing, cleaning and processing

The crop reached full maturity before harvesting, with different varieties maturing on varying dates. Harvesting was determined when 90 % of the grains exhibited a golden yellow color. After harvesting, the crop from each unit area was bundled, tagged, and taken to the threshing floor. Pedal threshers were employed for threshing, followed by sun-drying the grains to achieve a moisture level of 14 %. Straws were also sun-dried properly. Finally, straw and grain yield per plot were recorded and converted to ton per hectare.

2.10 Data collection

Before harvesting, ten hills were randomly chosen and marked with bamboo sticks in each plot, excluding border rows. Plant height (cm), Number of tillers per hill, Panicle length (cm), Number of grains per panicle, 1000 grains weight (g), Grain yield (t ha^{-1}), Straw yield (t ha^{-1}), Harvest index (%).

2.11 Statistical analysis

Data recorded for growth, yield and yield contributing characters were compiled and tabulated in proper form for statistical analyses. ANOVA, Least Significant Difference (LSD) was carried out by using "Minitab 17 statistical software". The significance of difference between the pairs of treatments was evaluated at 5 % and 1% level of probability.

3. Results and Discussion

3.1 Plant height (cm)

The combined application of cowdung and NPKS treatments significantly influences plant height (Figure 1). Within the different doses of fertilizers, T_2 showed the highest plant height (117.44 cm), followed by T_3 (113.52 cm), while the lowest plant height was observed in T_0 (105.91 cm).The highest plant height obtained from T_2 is about 11% more than the lowest plant height found in T_0. Our research is in line with the studies of researchers who also found satisfactory plant height from combine action of organic and inorganic fertilizer than using solely chemical fertilizers

(Mangalassery et al., 2019; Babar et al., 2011; Singh et al., 2018). They observed that optimum dose of organic manure contributed to the effective plant height (Asha et al., 2025).

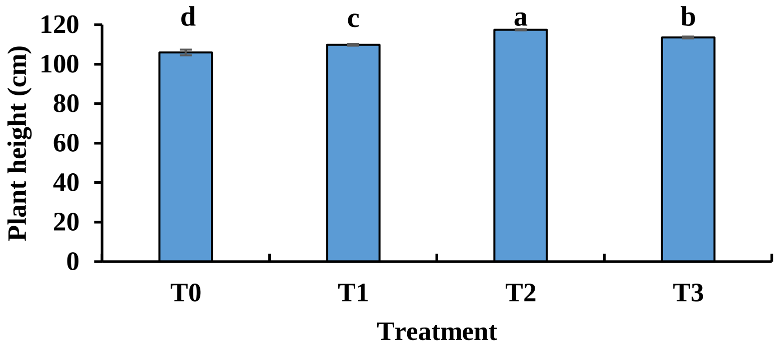

Figure 1: Effect of organic and inorganic fertilizer on plant height of rice.T_0 = Control, T_1 = 50% NPKS + 50% cowdung (3 t ha^{-1}), T_2 = 75% NPKS + 25% cowdung (1.5 t ha^{-1}), T_3 = 100% NPKS

3.2 Number of tillers per hill

The overall number of tillers per hill count was significantly affected by the combined application of cowdung and NPKS treatments (Figure 2). Among the various fertilizer doses, T_2 (15.8) exhibited the highest number of tillers per hill, followed by T_3 (13.5), while T_0 (8.16) showed the lowest count. T_3 showed approximately 65% increase than the control. They similarly observed the positive effect of organic manure and inorganic fertilizer on the tiller production of rice (Maiti et al., 2006; Singh, 2018; Nayak et al., 2007; Alvi et al., 2020). According to the study, a considerable rise in the number of tillers per square meter may be related to increased nitrogen availability, which is necessary for cell division (Sing, 2018). Plants receive a more comprehensive diet from organic sources, particularly micronutrients, which increase the number of tillers on plants (Yadav et al., 2016).

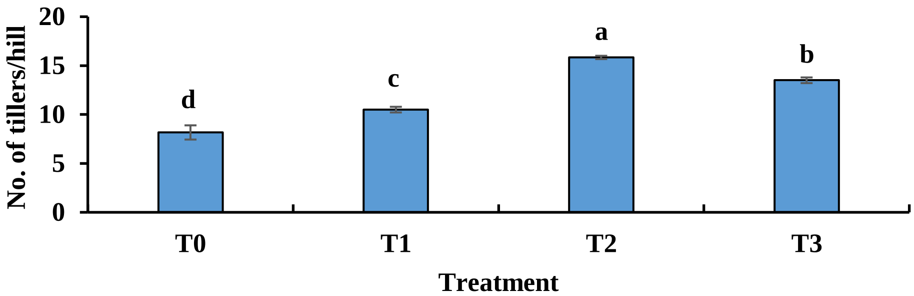

Figure 2: Effect of organic and inorganic fertilizer on number of tillers per hill of rice. T_0 = Control, T_1 = 50% NPKS + 50% cowdung (3 t ha^{-1}), T_2 = 75% NPKS + 25% cowdung (1.5 t ha^{-1}), T_3 = 100% NPKS

3.3 Panicle length (cm)

The integrated application of organic (cowdung) and inorganic (NPKS) treatments had substantial effect on panicle length (Figure 3). Among the all assigned treatments, T_2 illustrated the highest panicle length (24.16 cm), followed by T_3 (23.50 cm). However, the narrowest panicle length (18.06 cm) was observed in T_0. The difference between lowest panicle length and highest panicle length is almost 34%. In accordance with our research, found that combined action of inorganic and organic fertilizers enhance panicle length (Nasim et al., 2021); Galib et al., 2022; Moe et al., 2017).

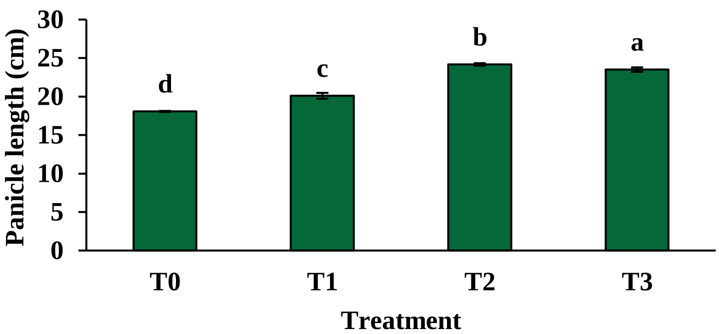

Figure 3: Effect of organic and inorganic fertilizer on panicle length of rice.T_0 = Control, T_1 = 50% NPKS + 50% cowdung (3 t ha^{-1}), T_2 = 75% NPKS + 25% cowdung (1.5 t ha^{-1}), T_3 = 100% NPKS

3.4 Number of grains per panicle

The combined application of cowdung and NPKS fertilizer treatments were significantly influenced on number of grains per panicle (Figure 4). T_2 showed the highest number of grains per panicle (111.57), while the lowest was observed in T_0 (83.83). Our findings align with the researches done by researchers who found that the quantity of grains per panicle was significantly increased by the use of chemical fertilizers and organic manures (Iqbal et al., 2020; Kakar et al., 2020; Alvi et al., 2020; Galib et al., 2022). Growth-regulating substances from the use of organic manures as fertilizers encouraged grain filling and improved the physical, chemical, and microbiological characteristics of the soil (Ma et al., 2021).

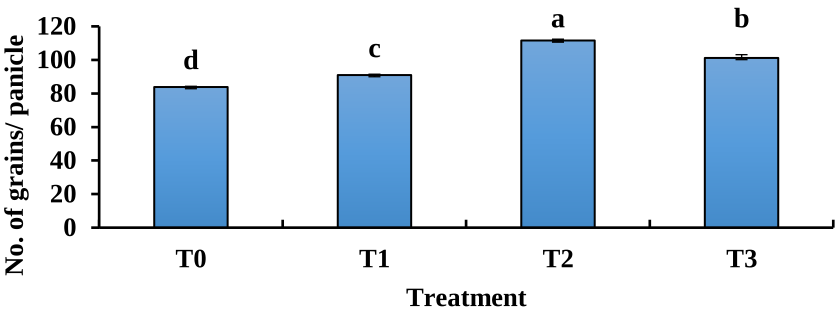

Figure 4: Effect of organic and inorganic fertilizer on number of grains per panicle rice.T_0 = Control, T_1 = 50% NPKS + 50% cowdung (3 t ha^{-1}), T_2 = 75% NPKS + 25% cowdung (1.5 t ha^{-1}), T_3 = 100% NPKS

3.5 1000 grains weight (g)

The 1000-grains weight remained affected by the mixed application of cowdung and NPKS fertilizer treatments, showing significant influence (Table 2). The 1000-grains weighted the maximum in T_2 (25.26 g), while T_0 (16.43 g) showed the lowest count. T_3 also weighed better which was 23.7 g. The maximum 1000 grain weight is 53% more in weight than the minimum 1000 grains weight. According to the study, 1000-grains weight increased when chemical fertilizer and organic manure were combined (Yang et al., 2004; Alvi et al., 2020; Galib et al., 2022). Compared to the control, it was found that each treatment considerably increased the yield of grain and straw.

3.6 Grain yield (t ha^{-1})

The grain yield was significantly influenced by the combined application of organic and inorganic fertilizer treatments (Table 2). The highest grain yield was found in T_2 (7.50 g) whereas the lowest grain yield (3.72 g) was produced by T_0. T_1 (4.83 g) showed 30% more grain yield than control, T_3 (5.6 g) showed 51% more grain yield than control. They claimed that the application of both organic and inorganic fertilizers increased the yields of straw and rice grain (Rahman et al., 2009; Alvi et al., 2020). It has been demonstrated that organic manure increases nutrient availability and photosynthetic activity (Khaitov et al., 2019).

3.7 Straw yield (t ha^{-1})

The combined application of cowdung and NPKS fertilizer treatments showed significant impact on straw yield (Table 2). The maximum straw yield (7.73 t ha^{-1}) was produced in T_2. On the other hand, the lowest straw yield (4.63 t ha^{-1}) was recorded in T_0. The straw yield increased almost 67% from T_0 which had no treatment to T_2 which had 75% of recommended dose of fertilizers + 25% cowdung. Combining inorganic fertilizers with organic manure increased plant vegetative growth and, consequently, the yield of rice straw (Islam et al., 2013). Present results align with those of (Moe et al., 2017; Alvi et al., 2020; Galib et al., 2022).

3.8 Harvest index (%)

The combined application of cowdung and NPKS fertilizer treatments had a significant influence on the harvest index (Table 2). However, within the different doses of fertilizers, T_2 showed the highest harvest index (49.24 %), while the lowest harvest index (44.5%) was observed in T_0. The difference between lowest harvest index and highest harvest index is almost 11 %. They similarly observed highest harvest index with the integrated approach of organic and inorganic fertilizer (Hossaen et al., 2011; Alvi et al., 2020).

Table 2: Effect of organic and inorganic fertilizer on yield and yield attributes of Boro rice

Treatment	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
T_0	16.43c	3.72d	4.63d	44.5b
T_1	19.23b	4.83c	5.52c	46.6ab
T_2	25.26a	7.50a	7.73a	49.24a
T_3	23.70a	5.60b	6.70b	45.52b
CV%	4.4	4.6	3.7	3.09
Level of significance	**	**	**	*

T_0 = Control, T_1 = 50% NPKS + 50% cowdung (3 t ha^{-1}), T_2 = 75% NPKS + 25% cowdung (1.5 t ha^{-1}), T_3 = 100% NPKS; CV = Co-efficient of variation; ** = Significant at 1% level of probability

4. Conclusion

It has been determined that the combined application of cowdung and NPKS fertilizer holds promise for sustainable crop production in coastal area of Bangladesh. Low yields in saline-prone areas can be amendment by balanced fertilizer application, and avoid long-term use of inorganic fertilizers which has reduced soil fertility. The study demonstrated the effect of combined action of organic and inorganic fertilizers, the use of chemical fertilizer alone, and the absence of fertilizer. The highest yield and yield contributing attributes were achieved through T_3 (75% NPKS + 25% cowdung (1.5 t ha^{-1}). Enhancing growth, yield-contributing traits, and overall yield of *Boro* rice is notably influenced by the application of this treatment. Compared to the traditional fertilization and non-judicious application of fertilizer, this particular package offers a promising mean for yield increase along with boosting soil fertility in saline-affected areas. Nevertheless, further research on *Boro* rice under the same treatment is imperative across various Agro-ecological Zones (AEZs) in Bangladesh.

Conflict of Interest

The authors declare no conflict of interest.

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