SAARC J. Agric., 23(2): 1-8 (2025) DOI: https://doi.org/10.3329/sja.v23i2.78031

SAARC Journal of Agriculture
Journal Homage: https://www.banglajol.info/index.php/SJA

Yield Performance of Boro Rice Due to Application of Stalwart Nano Product and Carbendazim

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Abstract

Rice is cultivated worldwide, and using nanoproducts opens a new era in the agricultural system. To evaluate the yield and yield parameters of Boro rice, an experiment was conducted at the Sher-e-Bangla Agricultural University, Dhaka from December 2019 to May 2020 to study the effect of Stalwart Nano Product (SNP2) and Carbendazim on the yield of Boro rice. The experiment considered two rice varieties (BRRI dhan28 and BRRI dhan63) and SNP2 with or without Carbendazim as treatment factors. The study was conducted to minimize the yield gap with the treatment used. Effective tiller number hill^{-1}, filled grain panicle^{-1}, 1000-seed weight (g), grain yield (t ha^{-1}), and straw yield (t ha^{-1}) were selected as parameters. Results revealed that BRRI dhan63 showed better performance than BRRI dhan28 regarding grain yield (6.11 t ha^{-1}) and straw yield. At the individual effect of the application of chemical spray (SNP2 and carbendazim combination), the highest number of effective tiller hill^{-1}, number of filled grain panicle^{-1} and grain yield (5.74 t ha^{-1}) was recorded from T_5 (Carbendazim @ 2g L^{-1} + SNP2 @ 1.0 ml L^{-1}) treatment. However, in the case of the combined effect, the higher grain yield (6.35 t ha^{-1}) was recorded in BRRI dhan63 treated with T_5 treatment. The result revealed that using the nanoproduct and Carbendazim boosted yield compared to the control treatment (T_0) in both studied varieties.

Keywords: Carbendazim, Grain yield, Nanoproduct, Rice

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Received: 28.11.2024 Accepted: 31.12.2025

Introduction

"Rice security" is synonymous with food security. Proper rice cultivation and management are essential for maintaining food security. Among three rice growing seasons in Bangladesh, Boro rice alone captured 53.12% of total production (BBS, 2024). Thus, Boro rice fulfills the maximum demand for rice grain. For this reason, Boro rice was selected for the experiment as a test crop.

European Commission states that the particle size of nanoparticles is in the range of 100 nm or below. The yield of crops can be increased in conventional agriculture by using chemical pesticides, fertilizers, and other industrial items. Compared to traditional agricultural methods, nanotechnology has grown in acceptability and effectiveness in the agricultural sector in recent years (Singh et al., 2021). The significant decrease in active ingredients entering the agricultural system is one of the many benefits of employing nanotechnology. The compact size of nanoparticles, long shelf life, and high efficiency make it the preferred choice of farmers over conventional techniques (Singh et al., 2021). Nanotechnology in agriculture and its techniques enhance crop yields (Worrall *et al*., 2018). The extensive applications of nanoparticles in the agricultural sectors cover nano biosensors, plant growth regulators, nano fertilizers and pesticides, nutrient management, and protection against phytopathogens (Chandra et al., 2020). Bala et al. (2019) evaluated the efficacy of ZnO-NPs as a Remedial Zinc (Zn) nano fertilizer of rice; the study confirmed the potential foliar application of Zn micronutrient as nano fertilizer could be the best remedy for Zn deficiency symptoms of rice.

Stalwart Nano Product 2 (SNP2) is one kind of formulation that is composed of copper (Cu), Zinc (Zn), and Magnesium (Mg). For the growth and development of plants, the three components are essential to plant micronutrients. Cu is an essential plant micronutrient that can be incorporated into different enzymes and plays a significant role in the plant body; biologically produced Cu nanoparticles exhibit excellent antibacterial and antifungal properties (Kasana et al., 2016). Poornima and Koti (2019) found that the effects of ZnO-NPs on Sorghum grain yield were 9.5% higher in 500 ppm of foliar spray as compared with 1000 ppm of bulk foliar spray. Yadav et al. (2013) found that Carbendazim as the maximum reduction of spot blotch incidence, and severity and gave the highest yield compared with micronutrients and only water of Wheat. Thus, Carbendazim, a phytohormone in addition to a fungicide, has a favorable impact on increasing production.

For maintaining food security for the next generation, SNP2 or Carbendazim or their combination are applied to Boro rice combined with other agronomic practices; we can achieve our goal economically. The main problem of rice production is the potential yield cannot be achieved through the maximum use of all agronomic practices in practical field rice cultivation. There are some differences in potential yield and farm yield; through using nanoproduct or Carbendazim or their blended solutions, growth and yield can be increased and the difference between potential yield and farm yield can be reduced from the further practices. However, plant responses to the combined effects of SNP2 and Carbendazim remain insufficiently understood, particularly in cereals such as rice. Based on the above issues, the present study was conducted to study the effect of SNP2 and Carbendazim on the growth and yield of Boro rice.

Materials and Methods

Research Location

The research was conducted at Agronomy field and laboratory at Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka from December 2019 to May 2020. The experimental site is located at 23^0 77′ N latitude and 90^0 35′ E longitudes at an altitude of 8.6m above mean sea level under the Agro-ecological zone of Madhupur tract (AEZ No. 28).

Experimental Design

The experiment consisted of two factors consisting of factor A: variety (2) *viz*. (i) BRRI dhan28 (V_1) & BRRI dhan63 (V_2) and factor B: application of chemical spray (SNP2 and Carbendazim combination) (7): Control (T_0); Carbendazim @ 2g L^{-1} (T_1); SNP2 @ 1.0 ml L^{-1} (T_2); SNP2 @ 2.0 ml L^{-1} (T_3); SNP2 @ 3.0 ml L^{-1} (T_4); Carbendazim @ 2g L^{-1} + SNP2 @ 1.0 ml L^{-1} (T_5) & Carbendazim @ 2g L^{-1}+ SNP2 @ 2.0 ml L^{-1} (T_6). The experiment was conducted in a Randomized Complete Block Design (RCBD) with three replications. The total plot number was 42 (2×7×3). Individual plot size was $4m^2$ (4m×1m). The chemical spray was applied 5 times at 15 days intervals (e. g. 19 February, 05 March, 20 March, 4 April, and 20 April respectively). The drain size between 2 replications was 1m and the gap between 2 plots was 0.5m. The field layout was prepared on 22 January 2020 for transplanting the seedlings. It is noted that Carbendazim is a fungicide against bacterial leaf blight and blast disease in rice. The SNP2 is an eco-friendly formulation that is made up off Cu, Mg, and Zn. Several combinations with SNP2 were used as treatments.

Description of the test crop

BRRI dhan28: It is a mega-variety of Boro rice. It is medium in size and slender in shape, white in color, life cycle is 140 days. Yield is 5.5-6.0-ton ha^{-1} (Bangladesh Rice Knowledge Bank, BRRI). In our experiment, we considered this variety as V_1.

BRRI dhan63: It is transplanted Boro rice and a high-yielding variety (HYV) too. Its yield is 6.5-7.0-ton ha^{-1}, life cycle is 148-150 days. The rice looks like “Basmoti” rice in Pakistan. No shattering is occurred (Bangladesh Rice Knowledge Bank, BRRI). In our experiment, we considered it as V_2.

Raising of seedlings and crop management

Seeds of the rice varieties were collected from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur. The required seeds were soaked in water for 24 hours and after soaking these were kept tightly in jute stack air for 4 days. When about 90% of the seeds were sprouted, it was sown uniformly in a well-prepared wet nursery bed on 14 December 2019. The layout was done before 3 days of transplanting and fertilizers (Urea 225 kg ha^{-1}, TSP 50 kg ha^{-1}, MoP 100kg ha^{-1}, Gypsum 75 kg ha^{-1} and $ZnSO_4$ 5 kg ha^{-1} for the variety BRRI dhan28 and Urea 225 kg ha^{-1}, TSP 75 kg ha^{-1}, MoP 100kg ha^{-1}, Gypsum 100 kg ha^{-1} and $ZnSO_4$ 10 kg ha^{-1} for the variety BRRI dhan63) were applied as basal dose before 1 day of transplanting. All the required amounts of fertilizers were applied as basal doses. Urea was top dressed in each plot by 3 equal splits at 15, 30, and 45 DAT (days after transplanting). Transplanting was done on 25 January 2020 when the seedlings were 42 days old. The spacing was 20 cm ×15 cm and planted 3 seedlings $hill^{-1}$. Gap filling was done 4 times, 28 January, 3 February, 9 February, and 11 February respectively. Weeding was done 6 times; 11 February, 17 February, 24 February, 26 February, 02 March, and 08 March respectively. Alternate wetting and drying (AWD) irrigation method was followed and excess water was removed from the field when it was necessary. When 85% to 90% of the grains became golden yellow, the crop was harvested. After harvesting 5 random plants were selected for recording data on yield components and $1m^2$ land from each plot for measuring grain and straw yield.

Data collection and analysis method

The following data were collected from the experiment

Effective tiller $hill^{-1}$: Effective tiller means that the tiller has ability to produce panicles. Therefore, it is also called the number of panicle $hill^{-1}$. The number of effective tillers $hill^{-1}$ was taken from 5 selected hills.

Number of filled grains $panicle^{-1}$: From randomly selected 5 hills, the number of filled grains was counted. For each panicle of each hill was counted separately and averaged.

1000-seed weight: One thousand cleaned dried filled seeds were randomly collected from the seed stock obtained from 5 hills of each plot and dried in an oven at 14% moisture content and weight by electric balance.

Grain and straw yield: Grain and straw yield were collected from $1m^2$ taken separately from each plot and dried in the oven at 80±5 ^{0}C until a constant weight was obtained.

Statistical analysis of data:

The collected data was statistically analyzed through the assistance of the computer program Statistix 10, analysis of variance was carried out using the "Balanced ANOVA Table" following RCBD (factorial analysis). At a 5% level of significance, Least Significant Difference (LSD) was used to determine the mean separation among the treatments.

Results and Discussion

Effect of varieties

The result presents in Figure 1 shown that significant effect of variety on 1000 seeds weight, grain yield, and stover yield. Variety did not play any significant effect on effective tiller number hill^{-1} and number of filled grain panicle^{-1}. The highest 1000-seed weight (23.03 g) was found from BRRI dhan28 and the lowest (22.04 g) was found from BRRI dhan63. However, the maximum grain yield (6.11 t ha^{-1}) and straw yield (5.71 t ha^{-1}) were recorded from BRRI dhan63 whereas BRRI dhan28 produces the lowest grain yield (4.95 t ha^{-1}) and straw yield (4.67 t ha^{-1}). The results were consistent with Hossain et al. (2022) and found that BRRI dhan63 produced a higher grain yield than BRRI dhan28.

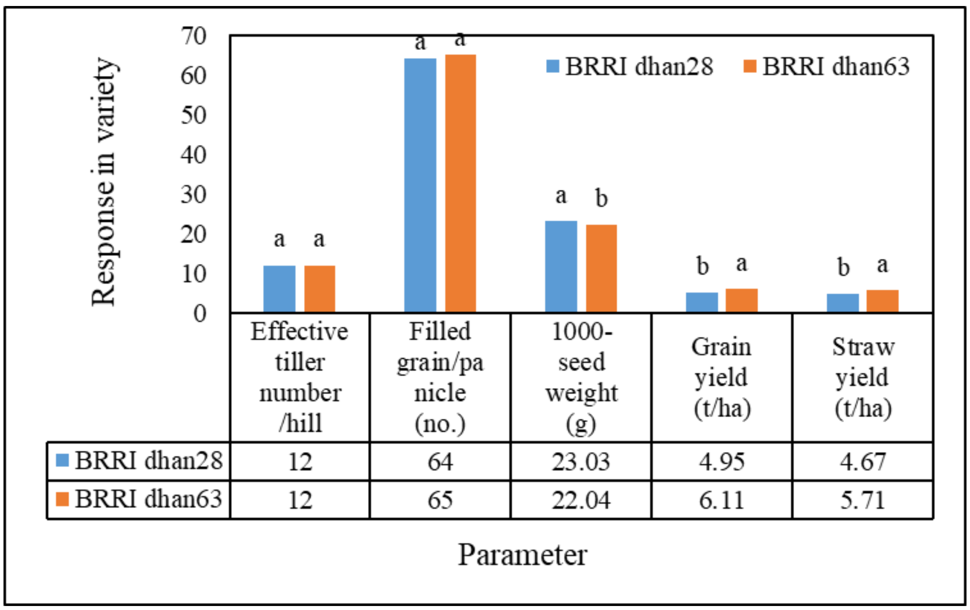

Fig. 1. Varietal effect of Boro rice on effective tiller number hill^{-1}, filled grain panicle^{-1}, 1000- seed weight (g), grain yield, and straw yield. For effective tiller hill^{-1}, (LSD $_{(5\%)}$ = 4.25, CV (%) = 8.30%); filled grains panicle^{-1}, (LSD $_{(5\%)}$ = 1.59, CV (%) = 3.89 %); 1000- seed weight (g), (LSD $_{(5\%)}$ = 0.06, CV (%) = 0.47%); grain yield (t ha^{-1}), (LSD $_{(5\%)}$ = 0.02, CV (%) = 0.66%); straw yield (t ha^{-1}), (LSD $_{(5\%)}$ = 0.15, CV (%) = 4.68%).

Effect of Nanoproducts and Carbendazim

The result represented in Figure 2 shows the significant effect of nano product and Carbendazim on effective tiller hill^{-1}, number of filled grain panicle^{-1}, grain yield, and straw yield. No significant difference was observed in case of 1000-seed weight. The maximum number of effective tiller hill^{-1}(15), number of filled grain panicle^{-1} (70)

and grain yield (5.74 t ha^{-1}) was recorded from T_5 (Carbendazim @ 2g L^{-1} + SNP2 @ 1.0 ml L^{-1}) treatment. The lowest number of effective tiller hill^{-1} (11) was observed from T_6 (Carbendazim @ 2g L^{-1} + SNP2 @ 2.0 ml L^{-1}) treatment. The lowest number of filled grain panicle^{-1} (60) was counted from T_0 (control) treatment. The maximum grain yield (5.74 t ha^{-1}) was recorded for T_5 treatment and the minimum grain yield (5.15 t ha^{-1}) was recorded from the T_1 treatment. The highest straw yield (5.52 t ha^{-1}) was found in T_3 treatment and it is statistically similar to the T_5 treatment (5.45 t ha^{-1}). Zhang *et al*., (2021) observed that ZnO-NPs increased the grain yield of rice compared with the control linked to more panicle number (4.83–13.14), spikelet panicle^{-1} (4.81-10.69), 1000-seed weight (3.82-6.62) and filled grain rate (0.28%-2.36%). Yang *et al*. (2021) found that ZnO-NPs increased grain yield, NPK uptake, and grain Zn concentration.

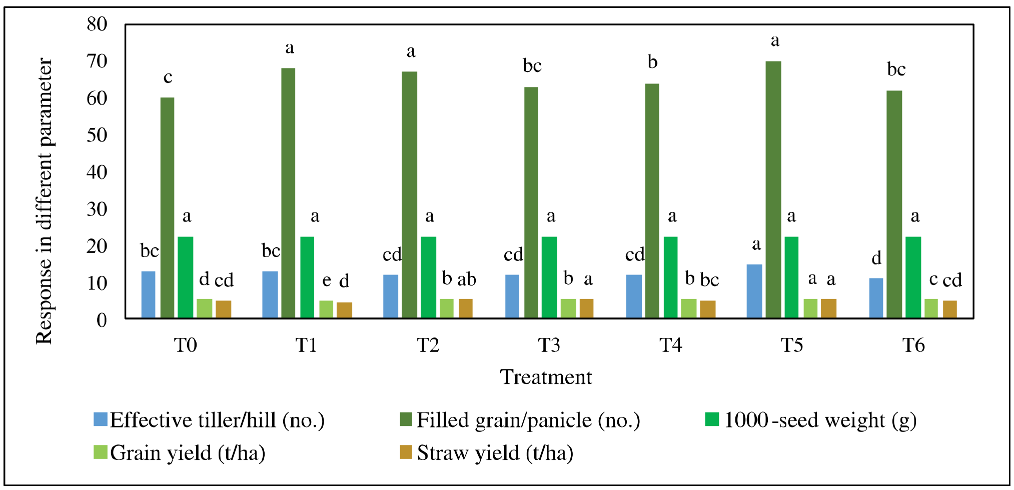

Fig. 2. Effect of nanoproduct and Carbendazim on effective tiller number hill-1, filled grain panicle-1, 1000-seed weight, grain yield and straw yield. T0 = Control, T1 = Carbendazim 2g L-1, T2 = 1.0 ml L-1 SNP2, T3 = 2.0 ml L-1 SNP2, T4 = 3.0 ml L-1 SNP2, T5 = Carbendazim, 2g L-1 + 1.0 ml L-1 SNP2, T6 = Carbendazim, 2g L-1 + 2.0 ml L-1 SNP2; For 150DAT (effective tiller hill-1), LSD (5%) = 7.96, CV (%) = 8.30%; For filled grains panicle-1, (LSD (5%) = 2.98, CV (%) = 3.89 %); 1000-seed weight (g), (LSD (5%) = 0.12, CV (%) = 0.47%); grain yield (t ha-1), (LSD (5%) = 0.04, CV (%) = 0.66%); straw yield (t ha-1), (LSD (5%) = 0.28, CV (%) = 4.68%)

The combined effect of treatments included parameters

The interaction effect of variety and chemical spray significantly affects all yield parameters and yield (Table 1). The maximum number of effective tiller hill^{-1} (15) was found from V_1T_5 and V_2T_5 treatment and the minimum number of effective tiller hill^{-1} (10) was observed from V_1T_6 treatment. The highest number of filled grain panicle^{-1} (70) was recorded from the V_2T_5 treatment followed by V_1T_5 (60) and the lowest number of filled grain panicle^{-1} (58) was recorded from the V_1T_0 treatment.

Significantly the highest 1000-seeds (23.6 g) were found in V_1 (BRRI dhan28) compared to V_2 (BRRI dhan63) (22.02g) along with different chemical spraying. Significantly the highest grain yield (6.35 t ha^{-1}) was obtained from V_2T_5 treatment, followed by V_2T_4 (6.23 t ha^{-1}) and V_2T_3 (6.22 t ha^{-1}), whereas the lowest grain yield (4.43 t ha^{-1}) was obtained from V_1T_1 treatment. The maximum straw yield (6.04 t ha^{-1}) was recorded from V_2T_3 treatment which was statistically identical with V_2T_2 (5.73 t ha^{-1}), V_2T_4 (5.97 t ha^{-1}), V_2T_5 (5.92 t ha^{-1}) and V_2T_6 (5.81 t ha^{-1}). The lowest straw yield (4.29 t ha^{-1}) was obtained from V_1T_6 which was statistically similar to V_1T_1 (4.31 t ha^{-1}) and V_1T_4 (4.34 t ha^{-1}).

Table 1. Combined effect of nanoproduct and Carbendazim on effective tiller $hill^{-1}$, filled grains $panicle^{-1}$, 1000-seed weight (g), grain yield (t ha^{-1}) and straw yield (t ha^{-1}) of Boro rice

Treatment combinations	Effective tiller $hill^{-1}$ (no.)	Filled grains $panicle^{-1}$ (no.)	1000-seed weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
V_1T_0	13 bc	58 f	23.00 a	5.00 g	4.84 c
V_1T_1	14 ab	69 ab	23.03 a	4.43 h	4.31 d
V_1T_2	13 bc	69 ab	23.02 a	5.10 f	4.95 bc
V_1T_3	13 bc	63 cde	23.05 a	5.09 f	5.00 bc
V_1T_4	12 cd	62 def	23.03 a	4.96 g	4.34 d
V_1T_5	15 a	69 ab	23.06 a	5.14 f	4.99 bc
V_1T_6	10 e	60 ef	23.02 a	4.96 g	4.29 d
V_2T_0	14 ab	62 cdef	22.02 c	5.76 e	5.22 bc
V_2T_1	13 bc	66 abc	22.03 c	5.87 d	5.29 b
V_2T_2	11 de	65 bcd	22.03 c	6.22 b	5.73 a
V_2T_3	11 de	63 cde	22.05 c	6.23 b	6.04 a
V_2T_4	13 bc	65 bcd	22.05 c	6.28 b	5.97 a
V_2T_5	15 a	70 a	22.06 bc	6.35 a	5.92 a
V_2T_6	13 bc	63 cde	22.03 c	6.03 c	5.81 a
LSD $_{(5\%)}$	11.27	4.22	0.17	0.06	0.40
CV (%)	8.30%	3.89 %	0.47%	0.66%	4.68%

V_1 = BRRI dhan28; V_2 = BRRI dhan63; T_0 = Control, T_1 = Carbendazim 2g L^{-1}, T_2 = 1.0 ml L^{-1} SNP2, T_3 = 2.0 ml L^{-1} SNP2, T_4 = 3.0 ml L^{-1} SNP2, T_5 = Carbendazim, 2g L^{-1} + 1.0 ml L^{-1} SNP2, T_6 = Carbendazim, 2g L^{-1} + 2.0 ml L^{-1} SNP2

Conclusion

The present study concluded that yield and yield contributing characters of rice can be effectively manipulated by different variety and application of chemical spray (nanoproduct and Carbendazim). BRRI dhan28 produced bolder seed than BRRI dhan63. The maximum number of effective tiller hill^{-1} (15), highest number of filled grain panicle^{-1} (70) and the highest grain yield (6.35 t ha^{-1}) were obtained from BRRI dhan63 with applying Carbendazim @ 2g L^{-1} + SNP2 @ 1.0 ml L^{-1}.

Acknowledgement

National Science and Technology (NST), Ministry of Science and Technology, The People's Republic of Bangladesh's provided the fellowship for financial assistance to conduct the experiment.

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