Bangladesh J. Bot. **54**(4): 987-993, 2025 (December) DOI: https://doi.org/10.3329/bjb.v54i4.86573

IMPACT OF EXOGENOUS PLANT GROWTH REGULATORS AND CUTTING MANAGEMENT ON THE RATOONING PERFORMANCE OF INBRED AND HYBRID RICE

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Keywords: Ratooning, Rice, Inbred, Hybrid, PGRs

Abstract

A field experiment was conducted to compare the performance of inbred and hybrid rice ratooning influenced by cutting height and exogenous application of plant growth regulators (PGRs). Two rice cultivars *viz.* BRRI dhan28 (inbred) and BRRI hybrid dhan5 (hybrid); three stubble cutting heights *viz*. 5, 15 and 20 cm from ground; and four PGR treatments *viz.* control (spraying water), spraying 100 ppm auxin, 100 ppm gibberellin and 100 ppm gibberellin + 100 ppm auxin were set in a factorial design with three replications. Results revealed that ratooning with hybrid rice recorded higher yield (92.68%) and yield attributes (14.70% effective tiller, 18% total tiller, 15.29% panicle length, 26.01% filled grain and 16.82% 1000-grain weight) compared to inbred rice. Stubble cutting height of 15 cm along with application of 100 ppm gibberellin + 100 ppm auxin resulted in highest yield and yield attributes. Therefore, the study concluded that hybrid rice was capable to produce higher ratoon yield than inbred rice maintaining 15 cm stubble cutting height along with PGRs application.

Introduction

Rice is the staple food for more than 3 billion people including Bangladesh and it has been estimated that global rice production needs to increase by 120 million tons by 2050 to meet the increasing demand. The population projection of Bangladesh is estimated to increase from 169 million to 230-250 million by 2050 (UNFPA 2022). To ensure food security, Bangladesh needs approximately 20% more rice production by 2050 to serve the increasing demand. The development of ratoon cropping allows increasing rice production as additional rice yield can be achieved with minimal agricultural inputs. Ratoon rice is the production of a second rice crop from the stubble left behind after the main crop has been harvested. The ratoon crop develops through the regeneration of rice tillers from the nodal buds of the stubble. Compared with traditional double cropping rice systems, ratoon rice systems have the advantages of saving labour, time, seed, and inputs supplies, as well as increasing cropping intensity and economic benefits.

Satisfactory yield of ratoon rice depends on various factors including varietal selection, stubble cutting height and cultivation management. Varietal selection is crucial as the growth, tillering ability and yield between inbred and hybrid rice cultivars are variable (Yuan *et al.* 2017). Generally hybrid rice possesses approximately 20% higher yield potential than inbred rice. However, the mechanisms behind the higher regeneration rate in hybrid rice cultivars compared to inbred rice remain poorly understood. The ratoon tiller regeneration and growth depend on the number of buds which remain on the stubbles. The tillers regenerated from higher nodes form more quickly, tend to grow faster and mature earlier. The tiller number of the ratoon crop increases with increasing the stubble cutting height. Therefore, optimum stubble cutting height is

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critical for higher production of ratoon rice. The yield of ratoon rice is generally lower compared to the main crop. However, improved cultivation and management techniques, such as application of plant growth regulators (PGRs), can enhance ratoon crop yields. Auxin and gibberellin (GA) are widely used to stimulate plant growth globally. Therefore, the present study was aimed to investigate the performance of inbred and hybrid rice cultivars influenced by stubble cutting management and the application of PGRs.

Materials and Methods

The experiment was conducted at the Agronomy farm, Sher-e-Bangla Agricultural University (SAU) in 2023. Treatments consisted of two rice cultivars *viz.* one inbred (BRRI dhan28) and one hybrid rice (BRRI hybrid dhan5); three stubble cutting height *viz.* C0 = 5 cm, C1 = 15 cm and C2 = 20 cm from the ground; and four treatments of PGRs *viz.* G0 = control (spraying water), G1 = spraying 100 ppm auxin, G2 = 100 ppm gibberellin and G3 = 100 ppm gibberellin + 100 ppm auxin. The experiment was conducted with factorial RCBD design with three replications. Standard cultivation practices, including fertilizer applications and pest management, were followed accordingly for both the main and ratoon crops.

The auxin and gibberellin used in this study was commercially available as ß-indolylacetic acid (IAA) and gibberellic acid (GA), respectively and were applied after 2 days of harvesting of the main crops. The main crop was harvested manually, and the remaining stubble height was maintained according to the treatments. The main rice yield and ratoon yield were measured using 2 m^2 sample areas of each plot. Five hills from each plot of main and ratoon crop were randomly selected and properly tagged before harvesting for recording the yield components *viz.* effective tiller, panicle length, filled grain, unfilled grain and 1000-grain weight. Biological yield was measured by adding grain and straw yield. Harvest index was calculated as the ration of grain yield to total biological yield.

All data were analyzed by using SPSS 20.0 for windows (SPSS Inc.). The significant differences among the treatment means were compared by Least Significant Difference (LSD) at 1% levels of probability. Different lower case letters in the Figs represent significant differences.

Results and Discussion

Yield contributing traits and yield of inbred and hybrid rice were significantly differed as first crop. Hybrid rice variety harvested as first crop recorded 27.47, 8.21, 14.52, 0.87, 12.82, 15.31, 10.46, 4.93, and 5.61% higher effective tillers, total tillers, panicle length, filled grains, 1000-grain weight, grain yield, straw yield, biological yield and harvest index, respectively compared to inbred rice variety (Figs 1 and 2). Generally, yield and yield contributing characteristics of rice are governed by the genetic make-up. It was reported that hybrid rice varieties possessed approximately 20-30% higher yield potential than inbred varieties (Yuan *et al.* 2017).

Similarly, hybrid rice variety harvested as ratoon crop had 14.70, 18.00, 15.29, 26.01 and 16.82% higher effective tillers, total tillers, panicle length, filled grains and 1000-grain weight, respectively than inbred rice (Fig. 1). Ratoon hybrid variety reported significantly higher grain yield, straw yield, biological yield and harvest index (92.68, 12.84, 15.95 and 66.13%, respectively) compared to inbred rice (Fig. 2). This is consistent with previous studies; those reported higher regeneration capacity and higher ratoon yield of hybrid rice than inbred rice (Dong *et al.* 2017, Saito *et al.* 2024). One possible explanation could be due to higher biomass production, leaf area index, tillering capacity of hybrid varieties that contributed to the higher grain, straw and biological yield over inbreed rice varieties. Additionally, higher regeneration capacity of hybrid rice varieties also contributed to the increased ratoon yield (Chen *et al.* 2018).

Results showed that ratoon produced the highest effective tillers, total tillers, panicle length, filled grains, unfilled grains and 1000-grain weight of rice at 15 cm stubble cutting height followed by 20 cm and 5 cm stubble cutting height recorded the lowest (Figs 3 and 4). Similarly, ratoon from 15 cm stubble cutting height recorded the highest grain yield, straw yield, biological yield and harvest index compared to 5 cm and 20 cm stubble cutting height. Banoc *et al*. (2022) also reported similar findings, showing that 15 cm was the optimum stubble cutting height for rice ratooning to achieve the highest ratoon yield. Maintaining high stubble cutting height produced higher grain yield in the ratoon crop due to an increased number of effective tillers, panicle length and filled grains (Nakano *et al.* 2023). The increased yield attributes and yield at higher stubble cutting height might be due to contribution of ample leaf area index and nonstructural carbohydrates present in the stubbles than those grown at lower cutting height. Lower cutting height reduced the grain yield because of higher missing hills and delayed maturity, whereas increasing the cutting height (15-30 cm) accelerated maturity and improved biological and grains yield and harvest index (Fallah *et al*. 2022).

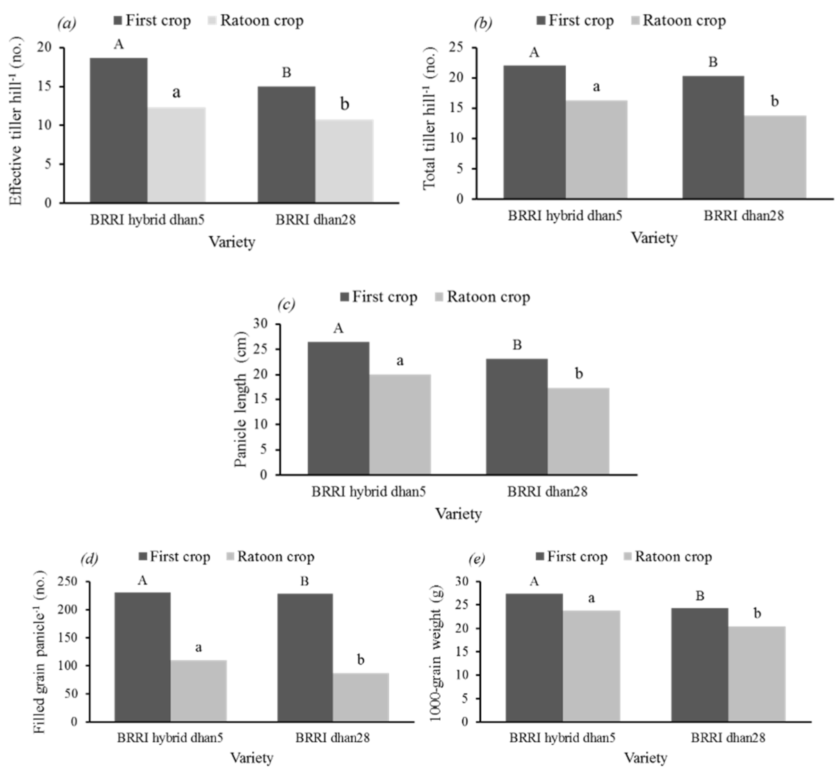

Fig. 1. Effects of rice varietal differences on yield contributing traits: (a) effective tiller hill^{-1}, (b) total tiller hill^{-1}, (c) panicle length, (d) filled grains panicle^{-1}, and (e) 1000-grain weight in both first and ratoon crops. Mean was calculated from three replicates for each treatment. Values in a column with different letters are significantly different at $p < 0.01$ applying LSD test.

Application of plant growth regulators (PGRs) had significant effect on effective tillers, total tillers, panicle length, filled grains, unfilled grains, 1000-grain weight, grain yield, straw yield, biological yield and harvest index of rice (Figs 5 and 6). The number of effective tillers ranged from 11 to 16.15 by the application of PGRs (100 ppm auxin + 100 ppm GA) (Fig. 5a).

Application of 100 ppm auxin + 100 ppm GA reported 46.81% increase in effective tillers. Application of 100 ppm auxin, 100 ppm GA, and 100 ppm auxin + 100 ppm GA reportedly increased total number of tillers by 5.55, 9.28, 11.94%, respectively than the control (Fig. 5b). Panicle length was ranged from 16.33 to 20.5 cm with the application of PGRs (100 ppm auxin + 100 ppm GA) which is 25.53% higher than the control treatment (Fig. 5c). The number of filled grains was ranged from 76 to 121.5 with the application of PGRs (100 ppm auxin + 100 ppm GA) marking 59.86% increase over control treatment (Fig. 5d). Application of PGRs reportedly decreased the number of unfilled grains with 23.52% less was recorded with 100 ppm auxin + 100 ppm GA compared to the control treatment. Maximum 1000-grain weight was recorded with the application of 100 ppm GA which was statistically similar with the application of 100 ppm auxin and 100 ppm auxin + 100 ppm GA.

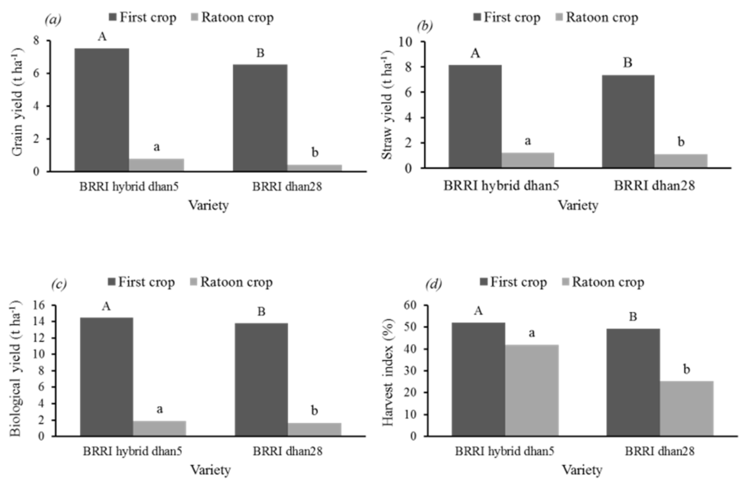

Fig. 2. Effects of rice varietal differences on yield: (a) grain yield, (b) straw yield, (c) biological yield, and (d) harvest index in both first and ratoon crops. Mean was calculated from three replicates for each treatment. Values in a column with different letters are significantly different at p <0.01 applying LSD test.

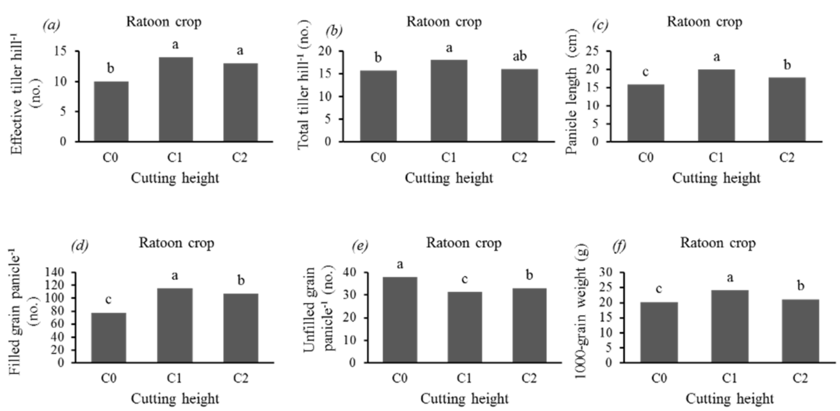

Fig. 3. Effects of stubble cutting height on yield contributing components of ratoon rice: (a) effective tillers hill^{-1}, (b) total tillers hill^{-1}, (c) panicle length, (d) filled grains panicle^{-1}, (e) unfilled grains panicle^{-1}, and (f) 1000-grain weight. Stubble cutting height: C0 = 5 cm, C1 = 15 cm and C2 = 20 cm from the ground. Mean was calculated from three replicates for each treatment. Values in a column with different letters are significantly different at p <0.01 applying LSD test.

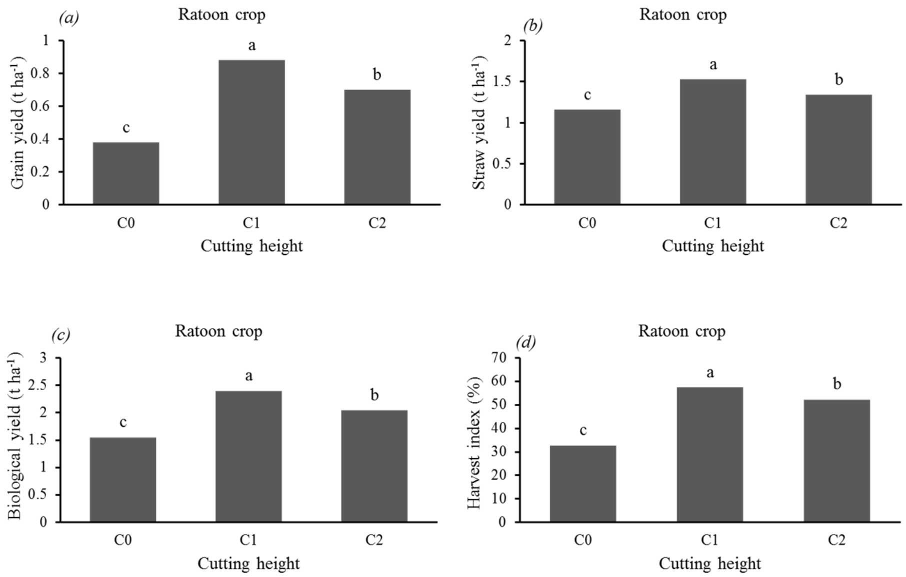

Fig. 4. Effects of stubble cutting height on yield of ratoon rice: (a) grain yield, (b) straw yield, (c) biological yield, and (d) harvest index. Stubble cutting height: C0 = 5 cm, C1 = 15 cm and C2 = 20 cm from the ground. Mean was calculated from three replicates for each treatment. Values in a column with different letters are significantly different at $p < 0.01$ applying LSD test.

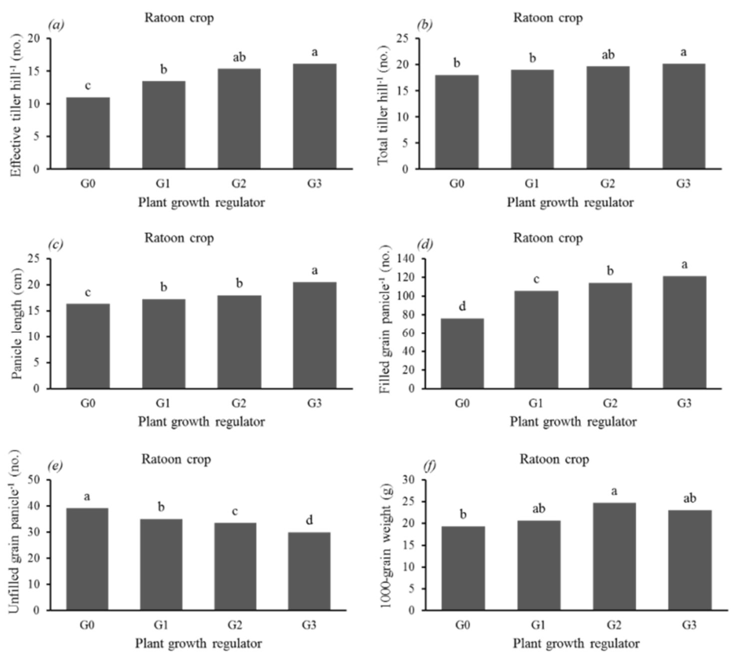

Fig. 5. Effects of plant growth regulators (PGRs) application on yield contributing components of ratoon rice: (a) effective tillers hill^{-1}, (b) total tillers hill^{-1}, (c) panicle length, (d) filled grains panicle^{-1}, (e) unfilled grains panicle^{-1}, and (f) 1000-grain weight. PGRs: G0 = control (spraying water), G1 = spraying 100 ppm auxin, G2 = 100 ppm gibberellin, and G3 = 100 ppm gibberellin + 100 ppm auxin. Mean was calculated from three replicates for each treatment. Values in a column with different letters are significantly different at $p < 0.01$ applying LSD test.

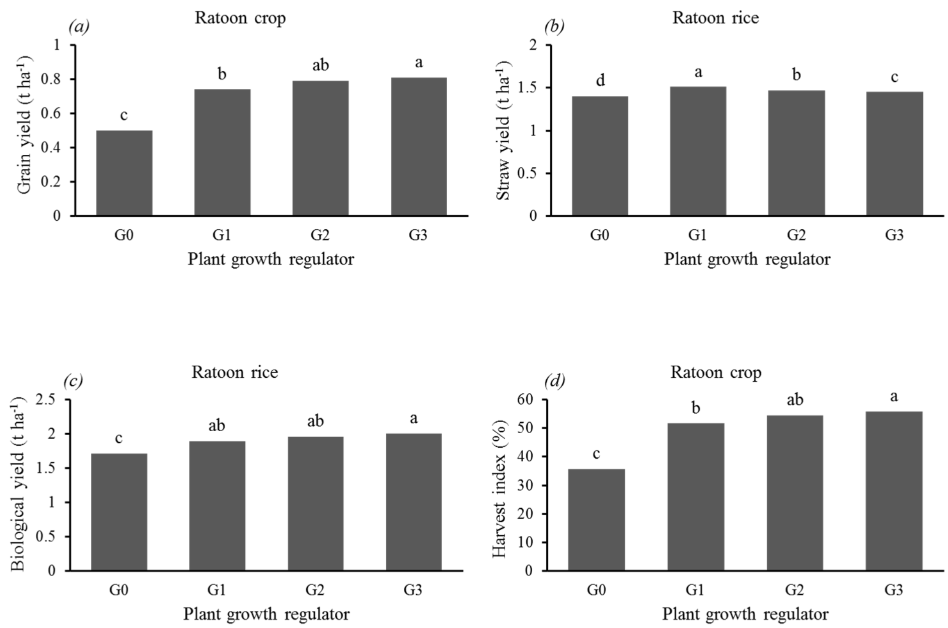

Fig. 6. Effects of plant growth regulators (PGRs) application on yield of ratoon rice: (a) grain yield, (b) straw yield, (c) biological yield, and (d) harvest index. PGRs: G0 = control (spraying water), G1 = spraying 100 ppm auxin, G2 = 100 ppm gibberellin, and G3 = 100 ppm gibberellin + 100 ppm auxin. Mean was calculated from three replicates for each treatment. Values in a column with different letters are significantly different at $p < 0.01$ applying LSD test.

Grain yield, straw yield, biological yield and harvest index increased with the application of PGRs (Fig. 6). Grain yield was reportedly increased by 48, 58, 62% at 100 ppm auxin, 100 ppm GA, and 100 ppm auxin + 100 ppm GA, respectively over the control treatment (Fig. 6a). The highest biological yield was observed with the application of 100 ppm auxin + 100 ppm GA which was statistically similar with the application of 100 ppm GA, and 100 ppm auxin (Fig. 6c). Biological yield was increased by 10.52, 14.62, 17.54% at 100 ppm auxin, and 100 ppm GA, 100 ppm auxin + 100 ppm GA, respectively compared to control treatment. Harvest index was ranged from 35.7 to 55.85% with the application of 100 ppm auxin + 100 ppm GA (Fig. 6d).

This study revealed that application of PGRs, specifically auxin and gibberellin, enhanced yield-contributing traits, leading to increased grain and straw yield. Fitri *et al.* (2019) reported that exogenous gibberellin application significantly improved ratoon rice growth and yield by elevating endogenous gibberellin levels, enhancing cell number and size, thereby improving vegetative growth, including plant height, tiller formation, and panicle length. Auxin and gibberellin exhibited diverse physiological effects depending on plant type and species. Liu (2011) highlighted that gibberellin significantly influenced vegetative growth, which extended into the generative phase, enhanced photosynthetic capacity and resulted in higher grain and straw yields.

The study concluded that hybrid rice cultivars outperformed inbred cultivars in both yield and yield attributes under ratoon cropping. A stubble cutting height of 15 cm was recommended for maximizing grain and straw yield in ratoon rice. Additionally, the application of PGRs, particularly auxin and gibberellin significantly improved the yield and yield attributes of ratoon rice.

Acknowledgement

The authors acknowledge Sher-e-Bangla Agricultural University Research System (SAURES) for providing financial support for the study during 2022-2023.

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(Manuscript received on 30 November, 2024; revised on 20 November, 2025)