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Effect of plant growth regulators and boron levels on growth and yield of Rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted during *kharif* season (2021) at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.). The soil of experimental plot was sandy loam in texture, nearly natural in soil reaction (pH 7.1), low in organic carbon (0.28%), available N (225 kg/ha), available P (19.50 kg/ha) and available K (213.7 kg/ha). The Treatments are 1.GA_3 25 ppm + B_1 1 kg/ha, 2.GA_3 25 ppm + B_2 2 kg/ha, 3.GA_3 25 ppm + B_3 3 kg/ha, 4.IAA 50 ppm + B_1 1 kg/ha, 5.IAA 50 ppm + B_2 2 kg/ha, 6.IAA 50 ppm + B_3 3 kg/ha, 7.NAA 75 ppm + B_1 1 kg/ha, 8.NAA 75 ppm + B_2 2 kg/ha, 9.NAA 75 ppm + B_3 3 kg/ha. The experiment was laid out in Randomized Block Design with 9 treatments and replicated thrice. The results reported that the application of GA_3 25 ppm + B_3 3 kg/ha recorded maximum plant height (70.10 cm), Number of tillers/plant (15.07), plant dry weight (23.60 g/plant), number of panicle per meter (692.00), panicle length (32.60 cm), number of panicle per hill (10.10), test weight (29.3 g), number of grains per panicle (158.10), Seed yield (3.60 t/ha), stover yield (4.10 t/ha). Maximum Gross returns (89143.30 INR/ha), Net returns (54928.33INR/ha) and B:C ratio (1.60) was recorded maximum in the treatment with the application GA_3 25 ppm + B_3 3 kg/ha.

Keywords: Plant growth regulators, boron, growth, yield, *Kharif*, Gibberellic acid, NAA, IAA

Introduction
Rice (*Oryza sativa* L.) is the staple food for nearly half of the world's population. However, more than 90 per cent of rice is consumed in Asia, where it is the staple food for a majority of the population, including 560 million hungry people in the region (Mohanty, 2013) [5], Globally, India stands first in rice are and second production after China. It is also a staple food for more than 65% of the Indian population, accounts for more than 42% of food production. Rice is a tropical plant, flourishes comfortably in hot and humid climate. It is fundamentally a *Kharif* crop in India, demands temperature of around 25 °C and above. Rice plant requires varying temperatures at different growth stages. Optimum temperatures for germination (20-25 °C), seedling emergence and establishment (25-30 °C), tillering (25-31 °C), anthesis (30-33 °C) and ripening (20-25 °C).

Plant growth regulators are known as to be change the growth and development pattern of growth in plants Physiological and biochemical process and thereby increase in the yield of the crop. The localized application of some plant growth regulators is reported to have profound effects on assimilate partitioning, enhancing the crop productivity. Plant growth regulators are effective on several crop plants to balance the source sink relationship and thereby increasing them, they are used as an aid to enhance yield in many crops. Indole Acetic acid (IAA), Gibberellic acid (GA^3) and (NAA) can manipulate a variety of growth and development phenomena in various crops. IAA has been found to increase the plant height, number of leaves per plant with consequent enhancement in seed yield Application of growth regulators significantly increased the total dry matter accumulation irrespective of varieties due to increase in cell division and other physiological activities, due to increase in leaf area more photosynthates are produced and total dry matter of plant was increased.

Boron (B) is an essential micronutrient and is known to promote flowering, pollen germination and grain filling. Boron deficiency mainly occurs in high rainfall areas of course textured sandy soils, acid soils and calcareous soils. Boron plays important role in sugar translocation, root growth and pollination, RNA metabolism, IAA metabolism, phenol metabolism, membranes metabolism, cell wall structure, cell wall synthesis, sugar translocation, cell division, enzymatic reactions, indirectly involved in activation of dehydrogenase enzyme and plant growth regulation.

Materials and Methods

The experiment was carried out during kharif season of 2021 at the CRF (Crop Research Farm) SHIATS, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The crop Research Farm is situated at 25.75^0 N latitude, 87.19^0 E longitude and at an altitude of 98m above mean sea level. Prayagraj has a subtropical and semi-arid climatic condition, with both extremes of temperature, *i.e*. winter and summer. The soil of experimental site was sandy loam in texture available Nitrogen 278.93 Kg/ha, Phosphorus 10.8 Kg/ha, Potassium 206.4 Kg/ha and Soil pH 6.9. The experiment was laid out in Randomized Block Design (RBD) with three replications and nine treatments: T_1- GA_3 25 ppm + B_1 1 kg/ha, T_2- GA_3 25 ppm + B_2 2 kg/ha, T_3- GA_3 25 ppm + B_3 3 kg/ha, T_4- IAA 50 ppm + B_1 1 kg/ha, T_5- IAA 50 ppm + B_2 2 kg/ha, T_6- IAA 50 ppm + B_3 3 kg/ha, T_7- NAA 75 ppm + B_1 1 kg/ha, T_8- NAA 75 ppm + B_2 2 kg/ha, T_9- NAA 75 ppm + B_3 3 kg/ha. The recommended dose fertilizer for the crop is 120:60:60 kg/ha. Rice variety pusa basmati-1 was used with spacing of 20cm × 10cm in net plot area of 3m × 3m. A well-drained fertile land with good irrigation facility was selected for growing nursery. After making proper bunds the plot was flooded then manually puddled and leveled and sown next day sufficient moisture was maintained in the nursery throughout the period and it took around 21 days to ready for transplanting. One quadrate was harvested in every plot for the determination of results and data was subjected to statistical analysis separately by using analysis of variance technique. The difference among treatments means was compared by using least significant difference test at 5% probability levels.

Result and Discussion

Growth Parameters: Crop growth parameters in rice were measured in terms of plant height (cm), Number of tillers/hill, Plant dry weight (g/hill) are shown in table 1. At harvest, maximum plant height (70.10 cm) was recorded with application of GA_3 @ 25 ppm + B_3 @ 3 kg/ha which was significantly superior over all other treatments and statistically at par with treatment application of GA_3 @ 25 ppm + B_1 @ 1 kg/ha (69.00 cm) and GA_3 @ 25 ppm + B_2 @ 2 kg/ha (68.90 cm). Application of different doses of gibberellic acid leads to an increase of plant height as compared to control in both the seasons i.e. *Kharif* and rabi. The increase in plant height is due to plant hormones promoted vegetative growth by active cell division, cell enlargement and cell elongation and thus helped in improving growth characteristics and also facilitated reproductive growth. Narendra *et al.* (2018). At harvest observed that maximum number of tillers per plant was recorded with application of GA_3 @ 25 ppm + B_3 @ 3 kg/ha (15.07) which were significantly superior over all except with treatment of application of GA_3 @ 25 ppm + B_2 @ 2 kg/ha (14.53) which were statistically at par with treatment of application of GA_3 @ 25 ppm + B_3 @ 3 kg/ha. Gibberellic acid Increase the strength of physiological source by increasing chlorophyll and effective age of leaves. Gibberellic acid are extensively involved in all phase of plant growth and development. They promote leaf expansion, number of leaves per plant, flowering, and pollen, stem elongation, and seed development. Ghodrat *et al*. (2012). At harvest maximum plant dry weight (23.60 g) recorded with treatment of application of GA_3 @ 25 ppm + B_3 @ 3 kg/ha which was significantly superior over all other treatments except with treatment of application of GA_3 @ 25 ppm + B_2 @ 2 kg/ha (22.90) which were statistically at par with treatment of application of GA_3 @ 25 ppm + B_3 @3 kg/ha.

Table 1: Effect of plant growth regulators and boron level on growth attributes of rice.

Treatments	Plant height(cm)	No. of. tillers/hill	Plant dry weight (g/hill)
GA_3 25 ppm + B_1 1 kg/ha	69.00	14.13	22.50
GA_3 25 ppm + B_2 2 kg/ha	68.90	14.53	22.90
GA_3 25 ppm + B_3 3 kg/ha	70.10	15.07	23.60
IAA 50 ppm + B_1 1 kg/ha	55.40	12.87	20.80
IAA 50 ppm + B_2 2 kg/ha	60.20	13.27	21.40
IAA 50 ppm + B_3 3 kg/ha	57.60	13.60	21.60
NAA 75 ppm + B_1 1 kg/ha	56.40	12.93	21.00
NAA 75 ppm + B_2 2 kg/ha	56.00	13.47	21.70
NAA 75 ppm + B_3 3 kg/ha	56.80	13.80	22.10
F- test	S	S	S
S.Em (±)	1.67	0.20	0.28
CD (5%)	5.00	0.61	0.84

Yield parameters

The observation regarding yield attributes *viz.*, Number of Panicle/m^2, Panicle length (cm), Number of grains per panicle, Number of panicle per hill and Test weight (g) are shown in table 2. Significantly highest no. of panicle/m^2 was observed with treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha (692.00) and the treatment with application of GA_3 @ 25 ppm + B_2 @ 2 kg/ha (642.00) was statistically at par with the treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha. Significantly highest panicle length was recorded with treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha (32.60 cm) and the treatment with application of GA_3 @ 25 ppm + B_2 @ 2 kg/ha (31.90) was statistically at par with the treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha. Larger panicle is associated with higher number of grains per panicle resulting into higher productivity (Tiwari *et al.* 2011). Significantly highest number of grains per panicle was observed with treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha (158.10) and the treatment with GA_3 @ 25 ppm + B_2 @ 2 kg/ha (145.70) was statistically at par with the treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha. Significantly highest Number of panicle per hill was observed with treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha (10.10) and the treatment with GA_3 @ 25 ppm + B_2 @ 2 kg/ha (9.80) was statistically at par with the treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha. Significantly highest Test weight (g) was observed with treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha (29.33 g) and the treatment with GA_3 @ 25 ppm + B_2 @ 2 kg/ha (27.33 g)

was statistically at par with the treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha. The application of growth regulators significantly increased yield components (Tiwari *et al*, 2011). kg/ha. Significantly highest Test weight (g) was observed with treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha (29.33 g) and the treatment with GA_3 @ 25 ppm + B_2 @ 2 kg/ha (27.33 g) was statistically at par with the treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha. The application of growth regulators significantly increased yield components (Tiwari *et al*, 2011).

Table 2: Effect of plant growth regulators and boron level on yield attributes of rice.

Treatments	Panicle length(cm)	Panicle per meter square	No of panicle per hill	No of grains per panicle	Test weight(gm)
GA_3 25 ppm + B_1 1 kg/ha	31.40	616.30	9.60	137.90	28.33
GA_3 25 ppm + B_2 2 kg/ha	31.90	642.30	9.80	145.70	28.00
GA_3 25 ppm + B_3 3 kg/ha	32.60	692.00	10.10	158.10	29.33
IAA 50 ppm + B_1 1 kg/ha	29.80	375.70	7.70	110.30	26.00
IAA 50 ppm + B_2 2 kg/ha	30.40	518.00	8.70	112.00	26.67
IAA 50 ppm + B_3 3 kg/ha	30.80	579.00	9.10	123.80	27.43
NAA 75 ppm + B_1 1 kg/ha	30.20	434.00	7.90	104.50	26.67
NAA 75 ppm + B_2 2 kg/ha	30.70	537.00	9.00	119.20	27.00
NAA 75 ppm + B_3 3 kg/ha	31.10	589.30	9.30	126.50	27.33
F-test	S	S	S	S	S
S.Em (±)	0.27	24.91	0.21	4.37	0.48
CD (5%)	0.82	74.68	0.64	13.10	1.43

Yield

The observation regarding yield *viz.*, Grain yield (t/ha), Stover yield (t/ha) and Harvest index (%) are shown in table 3. Significantly highest Grain yield (3.60 t/ha) and Stover yield (4.10 t/ha) was observed with treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha. Treatment with GA_3 @ 25 ppm + B_2 @ 2 kg/ha in terms of grain yield (3.50 t/ha) and stover yield (4.0 t\ha) was statistically at par with the treatment GA_3 @ 25 ppm + B_3 @ 3 kg/ha. GA3 application was found very effective in increase seed set rate and seed yield (Gavino *et al*, 2008). Application of B, when used alone as well as when applied in combination, resulted in significantly higher grain and straw yields than the control. The beneficial effect of B on enhancement of crop yield has been reported by (Sharma (1995), Christos Dordas (2006) and Raghuveer Rao *et al*., (2013). Significantly highest Harvest index was observed with treatment GA_3 @ 25 ppm + B_1 @ 1 kg/ha (48.61%).

Table 3: Effect of plant growth regulators and boron levels on yield of rice.

Treatments	Grain yield(t/ha)	Straw yield(t/ha)	Harvest index (%)
GA_3 25 ppm + B_1 1 kg/ha	3.50	3.70	48.61
GA_3 25 ppm + B_2 2 kg/ha	3.40	4.00	45.94
GA_3 25 ppm + B_3 3 kg/ha	3.60	4.10	46.75
IAA 50 ppm + B_1 1 kg/ha	2.20	3.00	42.30
IAA 50 ppm + B_2 2 kg/ha	2.40	3.20	42.85
IAA 50 ppm + B_3 3 kg/ha	2.90	3.50	45.31
NAA 75 ppm + $B_1$1 kg/ha	2.20	3.00	42.30
NAA 75 ppm + $B_2$2 kg/ha	2.60	3.30	44.06
NAA 75 ppm + $B_3$3 kg/ha	3.20	3.50	47.76
F- test	S	S	S
S.Em (±)	0.11	0.09	0.96
CD (5%)	0.33	0.28	2.89

Conclusion

From the above results, it was concluded that application of GA_3 25 ppm + B_3 3 kg/ha was found to be best by obtaining highest growth, yield attributes and yield. It was found more productive when compared to other treatments.

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