Environment and Ecology 40 (3C) : 1773—1778 July—September 2022
ISSN 0970-0420

Evaluation of Different Doses of Progibb 0.1% GR (Gibberellic Acid 0.1% GR) in Transplanted Rice and its Effection Succeeding Rapeseed Crop

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Received 15 September 2020, Accepted 24 January 2022, Published on 26 August 2022

ABSTRACT

Rice architecture is crucial for grain yield. India's dream of Second Green Revolution and Doubling Farmers' Income can be met with use of plant growth regulators. Gibberellins (GA) are plant growth regulators occurring naturally and involved in most phases of plant growth and development including germination, cell proliferation, flowering, sex determination, fruit set, seed development and senescence. A field experiment was conducted at the Institute of Agriculture, Visva-Bharati, West Bengal, India during 2016 and 2017 to study the effect of exogenous application of Progibb 0.1% GR (Gibberellic acid 0.1 % gr) on transplanted rice (MTU 7029) at active tillering stage and its residual effect on rapeseed (B_9). There were six treatments comprising of Gibberellic Acid 0.1% Gr applied at four different doses, 7.5 g a.i/ha, 10 g a.i/ha, 12.5 g a.i/ha, 15 g a.i/ha, Tricontanol 0.05% Gr @ 12.5 g a.i./ha and untreated control laid out in Randomised Block Design and replicated four times. The results revealed that Gibberellic Acid 0.1% Gr @ 15 g a.i/ha recorded highest plant height, crop growth rate, yield attributes and yield without having any adverse effect on succeeding crop of rapeseed. But, Gibberellic Acid 0.1% Gr @ 12.5 g a.i/ha gave better return per rupee and proved economically viable as compared to other treatments.

Keywords Economics, GA_3, Nutrient management, Plant growth regulator.

INTRODUCTION

Rice is one of the most important crops in the global food system providing energy, protein and vitamins for half of the world population (Tiwari *et al*. 2011). Rice architecture is crucial for grain yield, and is determined by plant height, leaf angle, tillering number, and panicle morphology. (Matusmoto *et al.* 2016). In

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Table 1. Characteristics of initial soil (0–15 cm depth).

Characteristics	Value
pH (1:2.5 soil:water ratio)	4.8
EC (ds/m)	0.46
Oxidizable N (kg/ha)	121
Available P (kg/ha)	15.14
Exchangeable K (kg/ha)	115
Organic carbon (%)	0.32

contrary to the first green revolution in India, where improved varieties, fertilizers and irrigation played crucial role; second green revolution needs to be in the lines of eco-friendly and environmentally sustainable ways. India's dream of Second Green Revolution and Doubling Farmers' Income can be met with use of plant growth regulators, which enhances the agronomical and physiological attributes of rice. Among all the plant growth regulators, role of gibberellins is well established in horticulture, agriculture, viticulture, ornamentals and forage crops (Rademacher 2016). Gibberellins (GA) are naturally occurring plant hormones involved in most phases of plant growth and development including germination, cell proliferation, cell elongation, bud break, flowering, sex determination, fruit set, seed development and senescence (Kaiser *et al.* 2017). Gibberellin application was very effective in increasing seed set rate and seed yield through elongation of plant height, promoting panicle and spikelet exertion, enhancing stigma exertion and longevity and receptivity (Gavino *et al.* 2008). Plants defective in both GA biosynthesis and GA signal transduction show typical phenotypes such as dwarfism ; small, dark green leaves; prolonged germination dormancy; retardation of root growth; suppression of flowering; reduced seed production; and male sterility (Yamaguchi 2008). The objective of the present study is to analyze the effect of exogenous application of gibberellin in enhancement of rice architecture, its influence in rice yield and residual effect on rapeseed.

MATERIALS AND METHODS

A field experiment was conducted during the *kharif* season of 2016 and 2017 at Agricultural Field, Institute of Agriculture, Visva Bharati in Birbhum, West Bengal situated at 23°67´N, 87°63´E and 58.90 m above mean sea level under sub-humid, semi-arid region of West Bengal. The details of initial soil status in 0–15 cm range was analyzed taking a furrow slice following standard procedures of soil sampling and presented in Table 1. The experiment was laid out in Randomized Block Design and replicated four times with six treatment combinations. The plot size was 24 sq m. The treatments consisted of : Gibberellic Acid 0.1% Gr @ 7.5 g a.i/ha (T_1), Gibberellic Acid 0.1% Gr @ 10 g a.i/ha (T_2), Gibberellic Acid 0.1% Gr @ 12.5 g a.i/ha (T_3), Gibberellic Acid 0.1% Gr @ 15 g a.i/ha (T_4), Tricontanol 0.05 % Gr @ 12.5 g a.i./ha (T_5) and Untreated Control (T_6).

The experiment was carried out by applying treatments in the transplanted rice crop, variety 'MTU 7029' in *kharif* and analyzing the residual effect on rapeseed in the succeeding *rabi* season, variety 'B9'. All the general package practices of growing transplanted rice and rapeseed was followed. Seedlings of 25 days old was transplanted in the well puddled experimental plots.Transplanting of rice was done on

Table 2. Effect of treatments on plant height (cm) and crop growth rate (g/m^2/day) of rice during *kharif* of 2016 and 2017.

		Plant height (cm)		Crop growth rate (g/m^2/day)			
		2016	2017	2016		2017	
No.	Treatments	85 DAT	85 DAT	45-65 DAT	65-85 DAT	45-65 DAT	65-85 DAT
T_1	Gibberellic Acid 0.1% Gr @ 7.5 g	103.9	107.4	7.32	9.35	7.19	9.99
T_2	Gibberellic Acid 0.1% Gr@ 10 g	105.2	109.2	7.4	9.84	7.37	10.19
T_3	Gibberellic Acid 0.1% Gr@ 12.5 g	115.8	112.73	7.72	10.12	7.6	10.41
T_4	Gibberellic Acid 0.1% Gr@ 15 g	117.7	114.8	8.17	10.32	8.02	10.54
T_5	Tricontanol 0.05 % Gr@ 12.5 g	112.2	110.4	7.67	10.12	7.49	10.32
T_6	Untreated control	99.2	98.2	7.17	8.29	7.05	6.21
	LSD(P=0.05)	3.36	3.06	0.48	2.25	0.65	1.95

Table 3. Effect of treatments on yield attributes of rice during *kharif* of 2016 and 2017.

No.	Treatments	No. of panicles/m^2 2016	2017	No. of grains/panicle 2016	2017	Test weight (g) 2016	2017
T_1	Gibberellic Acid 0.1% Gr @ 7.5 g	490	498	184	193	22.65	22.1
T_2	Gibberellic Acid 0.1% Gr@ 10 g	502	502	195	197	22.4	22.4
T_3	Gibberellic Acid 0.1% Gr@ 12.5 g	508	505	205	207	22.72	22.63
T_4	Gibberellic Acid 0.1% Gr@ 15 g	515	510	209	210	22.9	22.85
T_5	Tricontanol 0.05 % Gr@ 12.5 g	506	509	199	201	22.53	22.42
T_6	Untreated control	490	495	180	185	21.89	21.83
	LSD(P=0.05)	2.46	4.83	7.02	5.67	NS	NS

31 July 2016 in the first season and 19 July 2017 in the second season. The doses of nutrients applied was (80 kg/ha) N, (40 kg/ha) P_2O_5 and (40 kg/ha) K_2O with row spacing of 25 cm × 10 cm for transplanted rice. One third N and all other nutrients were applied as basal. Rest N was applied in two equal splits at 30 and 50 days after transplanting (DAT). For the treatments, commercial product, Progibb 0.1% Gr (Gibberellic Acid 0.1% Gr) of M/S Sumitomo Chemical India Private Ltd was used. The plant growth regulators were exogenously sprayed in rice at active tillering stage (15 DAS) by using a Knapsack sprayer fitted with triple action cone nozzle with prescribed water volume. After the harvest of rice, rapeseed was sown as line sowing following spacing of 30 cm × 10 cm with basal application of 100 kg/ha N, 50 kg/ha P_2O_5 and 50 kg/ha K_2O.

Observations on plant height, crop growth rate, yield attributes, grain quality (length and breadth) was recorded for rice and yield was recorded for both rice and rapeseed. Crop growth rate during the period of two growth stages was determined with the following formula given by Fisher 1921.

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \quad g/m^2/day$$

Where, W_2 and W_1 are the final and initial total dry weights of all plants per unit land area (m^2) at the time t_2 and t_1 respectively. The data was statistically analyzed using Fisher's least-significant difference (LSD) test, where the F values were significant at the $P = 0.05$ level of probability.

RESULTS AND DISCUSSION

Plant height

Application of Progibb 0.1% Gr (Gibberellic Acid 0.1% Gr) showed a significant increase in the plant height of rice at 85 DAT in all the treatments except at Gibberellic Acid 0.1% Gr @ 7.5 g a.i/ha. Treatments

Table 4. Effect of treatments on yield of rice during *kharif* of 2016 and 2017.

No.	Treatments	Grain yield t/ha 2016	2017	Straw yield t/ha 2016	2017	Harvest index 2016	2017
T_1	Gibberellic Acid 0.1% Gr @ 7.5 g	6.021	6.138	6.81	7.879	0.48	0.44
T_2	Gibberellic Acid 0.1% Gr@ 10 g	6.565	6.809	6.88	8.073	0.46	0.46
T_3	Gibberellic Acid 0.1% Gr@ 12.5 g	6.688	7.112	7.635	8.308	0.48	0.46
T_4	Gibberellic Acid 0.1% Gr@ 15 g	6.912	7.209	7.807	8.203	0.49	0.47
T_5	Tricontanol 0.05 % Gr@ 12.5 g	6.574	6.475	7.732	7.738	0.44	0.46
T_6	Untreated control	5.384	5.532	6.029	6.677	0.49	0.45
	LSD(P=0.05)	0.45	0.51	0.42	0.54	NS	NS

Table 5. Effect of treatments on rice grain quality during *kharif* of 2016 and 2017.

No.	Treatments	Grain length (mm) 2016	Grain length (mm) 2017	Grain breadth (mm) 2016	Grain breadth (mm) 2017
T_1	Gibberellic Acid 0.1% Gr @ 7.5 g	6.32	6.4	2.35	2.36
T_2	Gibberellic Acid 0.1% Gr@ 10 g	6.44	6.45	2.4	2.4
T_3	Gibberellic Acid 0.1% Gr@ 12.5 g	6.52	6.53	2.48	2.56
T_4	Gibberellic Acid 0.1% Gr@ 15 g	6.57	6.57	2.51	2.52
T_5	Tricontanol 0.05 % Gr@ 12.5 g	6.48	6.48	2.45	2.47
T_6	Untreated control	6.26	6.35	2.32	2.3
	LSD(P=0.05)	0.18	0.09	0.36	0.18

of Gibberellic Acid 0.1% Gr applied at 12.5 g a.i/ha & 15 g a.i/ha gave statistically at par results in both the years (Table 2). Whereas in 2017, Gibberellic Acid 0.1% Gr applied at 15 g a.i/ha were significantly better than treatments applied with Tricontanol 0.05 % Gr@ 12.5 g and Gibberellic Acid 0.1% Gr @ 7.5 g a.i/ha and 10 a.i/ha.

Gibberellins are naturally synthetized in young leaves. Hence, foliar application of gibberellins leads to better transportation of these hormones throughout the plant, both acropetally and basipetally (Dayan *et al.* 2012). Gavino *et al*. 2008, rightly pointed out that higher the GA_3 dosage, the taller the differences of plant height among the treatments. Variation in plant height is mainly due to effect of gibberellin and its cross-talk with other related plant growth hormones during crop growth. Miceli *et al.* 2019, also reported that the increase of GA_3 was positively related to plant height and epigeal part/root part ratio. Increase in plant height with gibberellin application had a positive impact on rice yield. Moreover, shorter stems would have a negative impact on light interception, encourage leaf diseases and make harvesting more difficult (Flintham *et al.* 1997).

Crop Growth Rate

During 45–65 DAT, 65–85 DAT, the highest value of Crop Growth Rate was recorded in Gibberellic Acid 0.1% Gr @ 15 g a.i/ha and lowest in untreated control

Table 6. Effect of treatments on economics of rice during *kharif* . Rs=Indian rupees, 1 US Dollar=Rs 73.59 (Indian rupees).

No.	Treatments	Cost of production (₹)	Gross return (₹)	Net profit (₹)	Return per rupee
T_1	Gibberellic Acid 0.1% Gr @ 7.5 g	41155	126248	85092.8	2.07
T_2	Gibberellic Acid 0.1% Gr@ 10 g	42905	135421	92515.8	2.15
T_3	Gibberellic Acid 0.1% Gr@ 12.5 g	44655	142558	97903	2.19
T_4	Gibberellic Acid 0.1% Gr@ 15 g	46405	145570	99165.2	2.13
T_5	Tricontanol 0.05 % Gr@ 12.5 g	50905	135195	84289.6	1.66
T_6	Untreated control	35905	112860	76955.3	2.14

in both the years. In 2016 and 2017, crop growth rate of treatments with Gibberellic Acid 0.1% Gr @ 15 g a.i/ha and Gibberellic Acid 0.1% Gr @ 10 g a.i/ha were statistically at par between 45–65 DAT duration. Between 65-85 DAT, rice crop treated with Gibberellic Acid 0.1% Gr @ 15 g a.i/ha recorded 24.49% and 69.73% higher crop growth rate than untreated control treatment in 2016 and 2017 respectively (Table 2). Similar results of enhancing seedling development by application of GA_3 in cereal crops like rice, maize and wheat was also reviewed by Rademacher 2016. Miceli *et al.* 2019 observed in their work on lettuce that GA_3 showed a visibly greater growth rate than those grown without exogenous gibberellic acid. Total dry weight also increased significantly only in the plants grown with GA_3 application but to a greater extent than fresh weight. Gibberellin enhanced rice architecture which in turn improved the crop growth.

Yield attributes

Observations of yield attributes is summarized in Table 3. During both the years of trial, the number of panicles/m^2 was significantly highest in treatment,

Table 7. Effect of treatments on yield of rapeseed during *rabi* of 2016 and 2017. q= quintal, 1 q= 100 kg.

No.	Treatment	Yield (q/ha) 2016-17	2017-18
T_1	Gibberellic Acid 0.1% Gr @ 7.5 g	1175	1154
T_2	Gibberellic Acid 0.1% Gr@ 10 g	1179	1162
T_3	Gibberellic Acid 0.1% Gr@ 12.5 g	1172	1165
T_4	Gibberellic Acid 0.1% Gr@ 15 g	1181	1174
T_5	Tricontanol 0.05% Gr@ 12.5 g	1176	1166
T_6	Untreated control	1174	1169
	LSD(P=0.05)	19.5	17.3

Gibberellic Acid 0.1% Gr @ 15 g a.i/ha than all other treatments and untreated control. No significant difference in number of panicles/m^2 was seen between Gibberellic Acid 0.1% Gr @ 7.5 g and untreated control. Number of grains per panicle was significantly higher in both the years in Gibberellic Acid 0.1% Gr @ 15 g a.i/ha than all other treatments viz. Tricontanol 0.05 % Gr@ 12.5 g and Gibberellic Acid 0.1% Gr @ 7.5 g a.i/ha and 10 a.i/ha and untreated control. Better development of floral organ, stamen and anther formation played important role in production of filled grain and in return better yield. Increased application of GA had a positive impact on leaf number, water and nutrient use efficiency (Miceli *et al.* 2019). Contribution of leaf to panicle and yield is very important. The median contribution ratio of panicle to yield in hybrid rice seed production was 36% and the application of GAs was a more important factor for significantly increasing the out-crossing rate and increasing seed yield in hybrid rice seed production (Zheng *et al.* 2018). In rice, application of GA_3 helps the breeders as it increases the emergence of female panicles (male sterile line) from the leaf sheath, hence improving the ability to accept the pollen from male plant (fertile line) (Gavino *et al.* 2008). However, number of grains per panicle in rice plots treated with Gibberellic Acid 0.1% Gr @ 15 g a.i/ha had results at par with Gibberellic Acid 0.1% Gr @ 12.5 g a.i/ha in both the years. There was no observed statistical difference between the treatments in varietal character like test weight in both the years studied.

Yield

During both the years, the highest rice grain yield was obtained in Gibberellic Acid 0.1% Gr @ 15 g a.i/ha followed by Gibberellic Acid 0.1% Gr @ 12.5 g a.i/ha (Table 4). Treatment applied with Gibberellic Acid 0.1% Gr @ 15 g a.i/ha was significantly highest than other treatments applied with Tricontanol 0.05 % Gr@ 12.5 g and Gibberellic Acid 0.1% Gr @ 7.5 g a.i/ha and 10 a.i/ha and untreated control. Gibberellic Acid 0.1% Gr @ 15 g a.i/ha increased rice yield by 28.38% in 2016 and 30.03% in 2017 as compared to untreated control. Increase of grain yield by 50.52% over control was also observed by Elankavi *et al.* (2009). Straw yield in treatment Gibberellic Acid 0.1% Gr @ 15 g a.i/ha was at par with Gibberellic Acid 0.1% Gr @ 12.5 g a.i/ha in both the years, which was significantly higher than untreated control. Increase in biological yield with application of gibberellin was also recorded by (Tiwari *et al*. 2011). Application of GA resulted in increased photosynthetic activity, better translocation of photosynthates, better uptake and use of mineral nutrients and thus resulting in increased yield (Khan *et al.* 2002). No significant differences in harvest index was observed. Highest harvest index was observed in treatment, Gibberellic Acid 0.1% Gr @ 15 g a.i/ha, which was mainly due to higher grain yield and straw yield.

Rice grain quality

During both the years of trial, the grain size in terms of grain length and grain breadth improved significantly over control, by the application of Progibb 0.1% Gr (Gibberellic Acid 0.1% Gr) (Table 5). In case of grain breadth and length, all the three treatments Gibberellic Acid 0.1% Gr @ 15 g a.i/ha, Gibberellic Acid 0.1% Gr @ 12.5 g a.i/ha and Tricontanol 0.05 % Gr @ 12.5 g were statistically at par during both the years of trial. Rice grain length significantly improved with application of Gibberellic Acid 0.1% Gr @ 15 g a.i/ha as compared to untreated control.

Economics

For calculating the economics of the crop, mean yield data of both years was taken to compare effectiveness of the treatments. Weight of commercial product used for application of treatments was calculated. For estimating net return per rupee investment, net returns were divided by cost of cultivation (Sujatha *et al.* 2011). Highest net return was recorded for Progibb 0.1% Gr (Gibberellic Acid 0.1% Gr @ 15 g a.i/ha) while the lowest was for the untreated control plots. But, if we look at data of return per rupee invested it was T_3 (Gibberellic Acid 0.1% Gr @ 12.5 g a.i/ha) which gave the best result (Table 6). Treatments treated with Tricontanol 0.05 % Gr @ 12.5 g gave least return per rupee which was even lesser than untreated control plots. Gibberellic Acid 0.1% Gr @ 12.5 g a.i/ha proved to be most economically viable one for the crop which was 27.22% more than untreated control and even better than Gibberellic Acid 0.1% Gr @ 15 g a.i/ha. Tricontanol 0.05 % Gr @ 12.5 g a.i./ha was economically not feasible mainly due to its low yield as well as higher cost of commercial product available in market.

Residual effect on succeeding crop

The study (Table 7) revealed that there was no adverse effect of Progibb 0.1% Gr (Gibberellic Acid 0.1% Gr) at any dose on growth and development of succeeding *rabi* crop, Rapeseed. Progibb 0.1% Gr (Gibberellic Acid 0.1% Gr) did not had any adverse effect on germination of rapeseed in the succeeding seasons.

CONCLUSION

Gibberellic acid application was very effective in increasing assimilation of photosynthates, better nutrient use efficiency, leaf number, dry weight, number of panicles per sq. m and hence, seed yield through mobilization of reserve food materials to sink and spikelet exertion, enhancing stigma exertion, longevity and receptivity. Hence, application of Progibb 0.1% Gr (Gibberellic Acid 0.1% Gr) proves its potentiality in increasing rice quality and yield without having any adverse effect on succeeding crop.

ACKNOWLEDGEMENT

The authors acknowledge M/S Sumitomo Chemical India Private Ltd. for providing the chemicals required for the experiment.

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