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Crop growth rate (CGR), root length, panicle length and grain yield of rice (*Oryza sativa* L.) as influenced by gibberellic acid

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Abstract
Field investigations were carried out at the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University during early samba (2013) and thaladi (2014) to study the crop growth rate, root length, panicle length and grain yield of rice (*Oryza sativa* L.) as influenced by gibberellic acid. The experiments comprised of seven treatments *viz*., T_1 - Gibberellic acid @ 5 g ha^{-1}, T_2 - Gibberellic acid @ 10 g ha^{-1}, T_3 - Gibberellic acid @ 15 g ha^{-1}, T_4 - Gibberellic acid @ 20 g ha^{-1}, T_5 - Gibberellic acid @ 25 g ha^{-1}, T_6 - Triacontanol 0.05% EC @ 250 ml ha^{-1} and T_7 - Control. The treatments were conducted in randomized block design (RBD) and replicated thrice. Rice variety BPT 5204 was used as test variety in both the seasons of study. The crop growth rate (CGR), root length, number of tillers m^{-2} and panicle length were strikingly impressive by Gibberellic acid @ 25 g ha^{-1} in both seasons. Among the different treatments, Gibberellic acid @ 25 g ha^{-1} recorded the higher grain yield. This was followed by Gibberellic acid @ 20 g ha^{-1}. Triacontanol 0.05% EC @ 250 ml ha^{-1} and Gibberellic acid @ 10 g ha^{-1} were next in order and were on par in their values. The lowest grain yield was recorded in control (no foliar spray). Based on the above experimental results, it could be concluded that cultivation of rice with foliar application of Gibberellic acid @ 25 g ha^{-1} significantly registered higher crop growth rate (CGR), tillers number m^{-2}, root and panicle length and grain yield. The dosage of Gibberellic acid @ 25 g ha^{-1} was found to be an agronomically sound and ecologically safe practice for augmenting higher productivity of rice.

Keywords: Rice, foliar application, gibberellic acid, triacontanol, panicle length and grain yield

Introduction
Rice (*Oryza sativa*), one of the most important food grain crops in the world, forms the staple diet of 2.7 billion people. It occupies 150 million hectare and producing 537 million tonnes with the average productivity of 3.83 tonnes/ha. Its cultivation is of immense important to food security of Asia, where more than 90% of the global rice is produced and consumed. Due to the increasing consumption of rice as a source of calorie and reducing the cultivated area in the world, use of new technologies and approaches in rice cultivation is important. Achieving a sustainable increase in rice production can improve global food security and contribute to poverty alleviation. In India, rice is grown in an area of 44.10 million hectares with the production of 107 million tonnes and the productivity is 3.58 t ha^{-1}.The reason for such low yield is mainly associated with cultural technologies (Sharief *et al.*, 2006). Use of plant growth regulators (PGR's) might be a useful alternative to increase crop production. Recently, there has been global realization of the important role of PGR's in increasing crop yield. The most widely available plant growth regulator is GA_3 or gibberellic acid, which induces stem and internode elongation, seed germination, enzyme production during germination and fruit setting and growth (Davies, 1995) [2]. Gibberellic acid is an important growth regulator that may have many uses to modify the growth, yield and yield contributing characters of plant (Rafeekher *et al.*, 2002) [11]. The GA3 application promoted maximum increase in CGR, fresh weight and dry weight of roots, growth character, panicle length grain yield than NAA and control (Garg and Kumar, 2012). But research on application of Gibberellic acid on rice crop for improvement of growth and yield is very meager. Considering the above facts, field experiments were conducted to study the Influence of gibberellic acid on crop growth rate, root and panicle length and grain yield of rice.

Materials and Methods
Field experiments were conducted at the Experimental Farm, Department of Agronomy, Annamalai University, Annamalai Nagar during early samba (First season) 2013 and thaladi (second season) 2014 to evaluate the influence of Gibberellic acid on Crop growth rate, root and panicle length and grain yield of rice.

Materials and Methods

Field experiments were conducted at the Experimental Farm, Department of Agronomy, Annamalai University, Annamalai Nagar during early samba (First season) 2013 and thaladi (second season) 2014 to evaluate the influence of Gibberellic acid on Crop growth rate, root and panicle length and grain yield of rice. The first crop received a rainfall of 1014.9 mm, distributed over 41 rainy days. The second crop received a rainfall of 225.6 mm, distributed over 9 rainy days. A long duration rice variety BPT 5204 is selected for the study. The experiments were laid out in randomized block design with three replications. The treatment details are *viz.*, - Gibberellic acid @ 5 g ha^{-1} - (T $_1$), Gibberellic acid @ 10 g ha^{-1} - (T $_2$), Gibberellic acid @ 15 g ha^{-1} - (T $_3$), Gibberellic acid @ 20 g ha^{-1} - (T $_4$), Gibberellic acid @ 25 g ha^{-1} - (T $_5$), Triacontanol 0.05% EC @ 250 ml ha^{-1} - (T $_6$) and Control (T $_7$). Gibberellic acid is recommended for foliar application as a diluted spray solution at different concentration according to treatments and the solution was taken for spraying for an area of one hectare. Triacontanol is also another recommended for foliar application as a dissolved and diluted spray solution @ 25ml in 1 litre of water and the solution was taken for spraying for an area of one hectare. Both Gibberellic acid and Triacontanol were uniformly sprayed using hand sprayer (Knapsack) in the evening hours on 20 days after planting. Gibberellic acid was supplied through Progibb 40% WSG. A fertilizer schedule of 150 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1} was followed. The entire dose of P_2O_5, half dose of N and K_2O was applied as basal. Remaining with half the dose of N and K_2O was top dressed in the equal splits at maximum tillering and panicle primodium initiation stages. Thirty days old paddy seedlings were planted @ 2 seedling hill^{-1} with a spacing of 20 ×15 cm to accommodate a plant population of 33 seedlings m^{-2}. The experimental plots were harvested leaving the border rows to avoid border effect. Grains were separated by hand threshing, cleaned and sun dried to bring the moisture content to 14 per cent and the weight of grain was recorded. Five sample plants in each plot were selected at random and peg marked permanently for recording biometric observations.

Crop growth rate (CGR)

Crop growth rate (CGR) expresses the gain in dry matter production of the crop per unit land area per unit time and is expressed as gram per meter square per day (gm m^{-2} day^{-1}). It is calculated according to the formula given by Watson (1952).

$$CGR = \frac{W_2 - W1}{t_2 - t1} \text{ (g m}^{-2}\text{ day}^{-1}\text{)}$$

Where, W1 and W2 were the dry weight of the aerial plant per unit area gained at time t_1 and t_2 respectively. CGR were calculated at 30, 50 DAT and harvest stages.

Statistical analysis

The experiment data were statistically analysed as suggested by Panse and Sukhatme (1978) [9]. For significant results, the critical difference was worked out at 5 per cent probability level to draw statistical conclusions. The treatment differences that were non-significant at five per cent were denoted as NS.

Results and Discussion

Crop growth rate (CGR)

Crop growth rate was recorded at 30, 50 DAT and at harvest stage. The higher crop growth rate of 36.38, 21.53 and 3.34 g m^{-2} day^{-1} during first season and 33.38, 20.25 and 3.25 g m^{-2} day^{-1} during second season at 30, 50 DAT and at harvest, respectively was recorded under Gibberellic acid @ 25 g ha^{-1} (T_5) and was significantly superior over other treatments. This treatment was followed by Gibberellic acid @ 20 g ha^{-1} (T_4). Several studies indicated that crop growth rate (CGR) measured at different growth stages as an estimate of net canopy photosynthesis. The application of GA_3 had significant effect on crop growth rate in crops recorded at different stages (Ramesh and Ramprasad, 2013) [12]. Growth rate of plant has significant relation with GA_3 application because most plants were healthy and vigorous which may help the plants to absorb water and light more efficiently that may have resulted higher CGR. Similar results were observed by Rauf and Sadaqat (2007) [13]. Plant growth regulator significantly increased all physiological parameters in comparison to that of control (Meera and Poonam, 2010) [8]. Besides, Gibberellin promotes growth by stimulating cells for quick division, as well as elongation resulting in higher growth rate might be the reason behind higher CGR in this treatment. The treatments T_6 and T_2 were on par with each other and ranked next. The least crop growth rate of 22.70, 13.76 and 1.22 g m^{-2} day^{-1} during first season and 21.08, 13.25 and 1.20 g m^{-2} day^{-1} during second season respectively were recorded at 30, 50 DAT and at harvest, in treatment T_7 (control).

Growth and yield characters

In both the years, there was perceptible difference observed in rice growth character due to effect of Gibberellic acid. Among the various treatment tested, Foliar application of Gibberellic acid @ 25 g ha^{-1} (T_5) significantly registered the highest root length of 23.86 and 23.08 cm, tillers number of 428.05 and 414.36 m^{-2} and panicle length of 21.47 and 21.16 cm (Table 2) during first and second season, respectively. Improvement in growth and yield character under GA_3 application compared to the control was observed. This might be ascribed to more efficient utilization of food for reproductive growth, higher photosynthetic efficiency and enhanced source to sink relationship of the plant, reduced respiration, enhanced translocation and accumulation of sugars and other metabolites which leads to registered higher root and panicle length. These results are in conformity with the findings of khadija *et al*. (2013) [6]. Besides, GA_3 stimulated rapid cell division and elongation in plant stems and roots observed in a number of crops. The results were in line with those of Bagatharia and Chanda (1998) [1]. Panicle length determined the number of grains/plant is an important agronomic trait for grain yield and is dynamic and adjustable. GA_3 hormones play important role in increasing the panicle length in many crops. Similar views were also reported by Liu *et al.* (2012) [7]. The least values of root length of 16.31 and 15.48 cm, tillers number of 252.00 and 243.25 m^{-2} and panicle length of 11.95 and 12.12 cm (Table 2) during first and second season, respectively were registered under control (T_7).

Grain yield

Foliar nutrient management practices significantly influenced the grain yield of rice in both the seasons. Among the treatments, Gibberellic acid @ 25 g ha^{-1} (T_5) significantly registered the higher grain yield of 5530 and 5390 kg ha^{-1} during first and second season, respectively. The grain yield recorded in this treatment was 27 and 25 per cent higher than control (T_7) in first and second season, respectively. This might be attributed to higher biomass production at early stages of crop growth through increased utilization of nutrients, leading to higher LAI and photosynthetic rate (Elankavi *et al.*, 2009) [3] resulting in better performance as evident by number of tillers m^{-2} and panicle length which leads to registered maximum grain yield of rice (Emongnor, 2007) [4]. The present findings are in agreement with the findings Pepi Nursiawathi (2014). This treatment was followed by Gibberellic acid @ 20 g ha^{-1} (T_4), Triacontanol 0.05% EC @ 250 ml ha^{-1} (T_6) and Gibberellic acid @ 10 g ha^{-1} (T_2) were on par with each other and ranked next. The treatment T_7 (control) registered the lowest grain yield of 4050 and 3950 kg ha^{-1} during first and second season, respectively.

Table 1: Effect of Gibberellic acid on crop growth rate

Treatments	Crop growth rate ($gm^{-2}day^{-1}$)					
	30 DAT		50 DAT		Harvest	
	First season	Second season	First season	Second season	First season	Second season
T_1	26.80	23.80	14.50	14.25	2.09	1.80
T_2	29.68	26.05	16.45	16.25	2.42	2.34
T_3	32.47	29.50	19.25	17.90	2.93	2.96
T_4	34.15	31.68	20.50	18.90	3.14	3.19
T_5	36.38	33.85	21.53	20.25	3.34	3.25
T_6	30.75	27.85	17.90	16.80	2.66	2.50
T_7	22.70	21.08	13.25	13.76	1.22	1.20
SEd	0.73	0.84	0.66	0.43	0.11	0.19
CD (p=0.05)	1.57	1.75	1.46	0.96	0.26	0.42

Treatment details - Gibberellic acid @ 5 g ha^{-1} - (T_1), Gibberellic acid @ 10 g ha^{-1}-(T_2), Gibberellic acid @ 15 g ha^{-1} - (T_3), Gibberellic acid @ 20 g ha^{-1} - (T_4), Gibberellic acid @ 25 g ha^{-1} - (T_5), Triacontanol 0.05% EC @ 250 ml ha^{-1} - (T_6) and Control (T_7).

Table 2: Effect of Gibberellic acid on root length, number of tillers m^{-2}, panicle length (cm) and grain yield in rice

Treatments	Root length (cm)		Number of tillers m^{-2}		Panicle length (cm)		Grain yield (kg ha^{-1})	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
T_1	19.38	18.64	282.80	276.85	15.65	14.36	42.14	41.21
T_2	20.31	19.45	311.85	306.95	16.88	16.76	42.44	41.87
T_3	21.84	20.81	369.60	364.57	19.02	19.14	42.62	42.15
T_4	22.81	22.49	403.90	402.50	20.11	20.29	43.05	42.68
T_5	23.86	23.08	428.05	414.36	21.47	21.16	43.29	42.88
T_6	20.88	19.99	337.05	329.70	17.88	17.80	42.23	41.56
T_7	16.31	15.48	252.00	243.25	11.95	12.12	40.58	40.03
SEd	0.37	0.33	8.46	7.83	0.44	0.48	0.11	0.10
CD (p=0.05)	0.83	0.74	18.23	16.91	1.04	1.14	0.29	0.27

Treatment details - Gibberellic acid @ 5 g ha^{-1} - (T_1), Gibberellic acid @ 10 g ha^{-1}-(T_2), Gibberellic acid @ 15 g ha^{-1} - (T_3), Gibberellic acid @ 20 g ha^{-1} - (T_4), Gibberellic acid @ 25 g ha^{-1} - (T_5), Triacontanol 0.05% EC @ 250 ml ha^{-1} - (T_6) and Control (T_7).

Conclusion

Foliar spraying with different concentration of Gibberellic acid on 20 DAT was very effective chemicals for increasing crop growth rate, root length, panicle length and grain yield of rice. The dosage of Gibberellic acid @ 25 g ha^{-1} was found most effective treatment for grain production and could be recommended for farmers of coastal areas of Tamil Nadu for *early samba* and *thaladi* season to achieve higher production in rice.

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