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Effect of PPFM and PGRs on crop growth rate in transplanted rice under moisture stress condition

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Abstract

Field investigations were conducted in the Wetland Farm, Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore during *rabi* and summer seasons of 2016-17 and 2017-18 to assessing the performance of growth regulating compounds for mitigating induced moisture stress on the growth and yield of transplanted rice. Field experiments were laid out in split plot design with three replications. The treatments comprised of inducing water stress in different growth stage *viz*., panicle initiation stage, flowering stages, both panicle initiation and flowering stages, moisture stress free control (irrigating the field with 5 cm depth of irrigation one day after disappearance of previously ponded water), respectively in main plots and foliar application of growth regulating compounds in sub plots *viz*., chlormequat chloride at 200 ppm, mepiquat chloride at 200 ppm, brassinolide at 0.1 ppm, Pink Pigmented Facultative Methylotrophs (PPFM 1%) and Control (No spray). The treatment combination of moisture stress free control with foliar spraying of PPFM (1%) recorded higher growth attributes (CGR) at flowering and harvest stages and it was on par with brassinolide (0.1 ppm).

Keywords: rice, moisture stress, growth regulating compounds and crop growth rate

Introduction

Rice is one of the greatest water user among cereal crops, consuming about 80% of the total irrigated fresh water resources in Asia. In Asia, with relatively more suitable growing conditions for rice, production has declined due to increasing water stress (Tao *et al*., 2004) [6]. Therefore, it is important to cut down water supply for rice cultivation but without affecting rice yield. Water limited condition (also referred to as drought), affecting 23 m ha of rice in India regularly (Pandey *et al.*, 2007) [5] is a condition related to insufficient soil moisture available to support average crop production. The response of plants to water stress depends on the duration and severity of the stress (Bartels and Souer, 2004) [2] and the developmental stage (Zhu *et al*., 2005) [8]. Rice is sensitive to drought stress particularly during flowering stage, resulting in severe yield losses. The physiological processes during the sensitive flowering stage, negatively affects spikelet fertility under water stress.

Plant growth regulators (PGRs) has been found to play a key role in the integration of the responses expressed by plants under stress conditions (Amzallag *et al*., 1990) [1]. Plant growth regulators are the chemical substances, when applied at low concentration, modify the growth of plants usually by stimulating or inhibiting part of the natural growth regulatory system. PGRs had been found to influence water uptake effectively under stress conditions, either by increasing membrane permeability or by increasing the internal concentration of osmotically active solutes (Holland, 1997) [3]. Plant growth regulators play an important role to minimize the negative effects by drought and improves the growth attributes and yield.

Material and Methods

Field experiments were conducted in the Wetland Farm, Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore during *rabi* and summer seasons of 2016-17 and 2017-18 to asses the performance of growth regulating compounds for mitigating induced moisture on the growth and yield of transplanted rice. Field experiments were laid out in split plot design with three replications. The treatments comprised of inducing water stress in different growth stage *viz*., moisture stress free control (M_1) (irrigating the field with 5 cm depth of irrigation one day after disappearance of previously ponded water), stress induced at panicle initiation stage (M_2), stress induced at flowering stage (M_3) and stress induced at panicle initiation and flowering stage (M_4), respectively in main plots and foliar application of growth regulating compounds in sub plots *viz.*, chlormequat chloride at 200 ppm (S_1), mepiquat chloride at 200 ppm (S_2), brassinolide at 0.1 ppm (S_3), Pink Pigmented Facultative Methylotrophs (PPFM1%) (S_4) and control (No spray) (S_5). The medium duration rice variety

(CO (R) 50) was used during *rabi* season and short duration variety (CO (R) 51) was used during summer season. Moisture stress was imposed during panicle initiation, flowering stages and both the stages by withholding irrigation in 10 days. The selected growth regulating compounds were sprayed one day after the imposition of water stress in the in the respective phenophase in both the seasons.

Results and Discussion

Crop growth rate

Crop growth rate (CGR) is a function of daily intercepted radiation, radiation use efficiency and leaf area index. Crop growth rate is representing photosynthetic efficiency of a plant, which depends upon the dry matter production of rice crop (Table 1, 2, 3 and 4).

Induced moisture stress and foliar application of growth regulating compounds did not have any significant influence on crop growth rate of rice at active tillering and panicle initiation stages. This was mainly due to the fact that the treatments such as moisture stress and growth regulating compounds are imposed only after the panicle initiation stage, until that all agronomic practices were followed similarly for all the treatments.

Moisture stress free control (M_1) (one day after disappearance of ponded water at 5 cm depth of irrigation) registered higher crop growth rate at panicle initiation to flowering (17.50 and 18.18 g m^{-2} day^{-1} during *rabi* 2016-17 and 2017-18, respectively; 18.66 and 19.60 g m^{-2} day^{-1} during summer 2017 and 2018, respectively). At flowering to harvest stages (9.48 and 10.76 g m^{-2} day^{-1} during *rabi* 2016-17 and 2017-18, respectively; 10.99 and 12.09 g m^{-2} day^{-1} during summer 2017 and 2018, respectively. Lower crop growth rate was recorded under stress induced at PI and flowering stage (M_4). This could be attributed to the higher tiller number which resulted in more leaf number leading to higher leaf area index and leaf area index. Water saving irrigation influenced the soil aeration which facilitated more number of tillers and subsequently higher photosynthetic rate for increased leaf area index as well as leaf area index was stated by Holland (1997) [3].

With regard to the foliar application of growth regulating compounds, PPFM (1%) was significantly superior to all the other treatments. Higher crop growth rate was noticed under PPFM (1%) during *rabi* 2016-17, 2017-18; summer 2017 and 2018 (16.10, 17.13, 17.61 and 17.76 g m^{-2} day^{-1}, respectively) at panicle initiation to flowering stages. However, which was on par with foliar spraying of 0.1 ppm of brassinolide (S_3). At flowering to harvest stages (9.23 and 10.35 g m^{-2} day^{-1} during *rabi* 2016-17 and 2017-18, respectively; 10.74 and 11.76 g m^{-2} day^{-1} during summer 2017 and 2018, respectively. Lesser crop growth rate was observed under control (S_5) at both the year of experiments. This might be due to the result of increased leaf area index. CGR had positive association with leaf area index. Growth regulators were helped to accumulate considerable amount of photo assimilates in various sinks leading to higher crop growth rate (Li *et al.*, 2008).

Interaction effect between induced moisture stress treatments and growth regulating compounds was noticed only at panicle initiation to flowering and flowering to harvesting stages of summer season crop not in *rabi* season. During all the growing seasons, the treatment combination of stress free control along with PPFM at 1 per cent (M_1S_4) recorded higher crop growth rate. This might be due to application of PPFM and brassinolide exerted positive influence in maintaining higher CGR with special reference to the stressed environment. The PPFM mediated hormonal activity might be attributable for the increase in leaf area, crop growth rate and other growth parameters. Lower CGR recorded under stress induced at PI and flowering stage along with control, which might have resulted in lower recovery of the crop and thereby causing reduction in the grain yield (Thangamani, 2005) [7].

Table 1: Effect of induced moisture stress and growth regulating compounds on crop growth rate (g m^{-2} day^{-1}) of *rabi* rice 2016-17

Treatment	Panicle initiation to Flowering						Flowering to Grain filling				
	M_1	M_2	M_1	M_1	Mean		M_1	M_2	M_3	M_4	Mean
S_1	16.75	13.09	14.85	11.09	13.94	S_1	9.05	8.58	8.03	7.16	8.21
S_2	16.88	13.69	14.99	10.75	14.08	S_2	9.13	8.67	8.30	7.28	8.35
S_3	18.15	15.66	17.73	12.87	16.10	S_3	10.00	9.61	8.90	7.78	9.07
S_4	17.24	15.59	16.76	11.56	15.29	S_4	9.90	9.90	8.45	8.69	9.23
S_5	16.72	11.34	13.52	10.34	12.98	S_5	9.32	7.80	6.96	6.84	7.73
Mean	17.15	13.87	14.85	11.09		Mean	9.48	8.91	8.13	7.55	
	M	S	M at S	S at M			M	S	M at S	S at M	
SEd	0.20	0.21	0.42	0.41			0.13	0.14	0.28	0.28	
CD (p=0.05)	0.49	0.42	0.89	0.84			0.31	0.14	0.28	0.28	

Table 2: Effect of induced moisture stress and growth regulating compounds on crop growth rate (g m^{-2} day^{-1}) of *rabi* rice 2017-18

Treatment	Panicle initiation to Flowering						Flowering to Grain filling				
	M_1	M_2	M_3	M_4	Mean		M_1	M_2	M_3	M_4	Mean
S_1	17.78	14.12	15.88	12.12	14.97	S_1	10.33	9.86	9.31	8.44	9.49
S_2	17.91	14.72	16.02	11.78	15.11	S_2	10.41	9.95	9.58	8.56	9.63
S_3	18.27	16.62	17.79	12.59	16.32	S_3	11.28	10.89	10.18	9.06	10.35
S_4	19.18	16.69	18.76	13.90	17.13	S_4	11.18	11.18	9.73	9.97	10.51
S_5	17.75	12.37	14.55	11.37	14.01	S_5	10.60	9.08	8.24	8.12	9.01
Mean	18.18	14.90	16.60	12.35			10.76	10.19	9.41	8.83	
	M	S	M at S	Sat M			M	S	M at S	S at M	
SEd	0.24	0.23	0.47	0.45			0.15	0.15	0.31	0.30	
CD (p=0.05)	0.58	0.46	1.01	0.93			0.36	0.31	0.65	0.61	

Table 3: Effect of induced moisture stress and growth regulating compounds on crop growth rate (g m^{-2} day^{-1}) of summer rice 2017

Treatment	Panicle initiation to Flowering						Flowering to Grain filling				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**		**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
S_1	18.26	14.60	16.36	12.60	15.45	S_1	10.56	10.09	9.54	8.67	9.72
S_2	18.39	15.20	16.50	12.26	15.59	S_2	10.64	10.18	9.81	8.79	9.86
S_3	18.75	17.10	18.27	14.07	17.05	S_3	11.51	11.12	10.41	9.29	10.58
S_4	19.66	17.17	19.24	14.38	17.61	S_4	11.41	11.41	9.96	10.2	10.74
S_5	18.23	11.52	15.03	11.85	14.16	S_5	10.83	9.31	8.47	8.35	9.24
Mean	18.66	15.12	17.08	13.03			10.99	10.42	9.64	9.06	
	M	S	M at S	Sat M			M	S	M at S	S at M	
SEd	0.23	0.26	0.52	0.53			0.19	0.14	0.32	0.29	
CD (p=0.05)	0.57	0.54	NS	NS			0.47	0.29	NS	NS	

Table 4: Effect of induced moisture stress and growth regulating compounds on crop growth rate (g m^{-2} day^{-1}) of summer rice 2018

Treatment	Panicle initiation to Flowering						Flowering to Grain filling				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**		**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
S_1	19.28	15.42	17.08	13.32	16.27	S_1	11.58	11.11	10.56	9.69	10.74
S_2	19.31	16.12	17.32	13.08	16.46	S_2	11.66	11.20	10.83	9.81	10.88
S_3	20.48	18.19	19.86	15.3	18.46	S_3	12.53	12.14	11.43	10.31	11.60
S_4	19.77	17.92	19.09	14.09	17.72	S_4	12.43	12.43	10.98	11.22	11.76
S_5	19.15	13.77	15.95	12.87	15.44	S_5	11.85	10.33	9.49	9.37	10.26
Mean	19.60	16.28	17.86	13.73			12.01	11.44	10.66	10.08	
	M	S	M at S	Sat M			M	S	M at S	S at M	
SEd	0.32	0.41	0.8	0.82			0.22	0.19	0.40	0.38	
CD (p=0.05)	0.78	0.83	NS	NS			0.54	0.38	NS	NS	

Conclusion

From the experimental results, foliar application of PPFM (1%) (*Methylobacterium* sp.) is found to be highly effective than brassinolide (0.1 ppm) in sustaining the productivity through mitigating the ill-effects under water stress condition of rice and was proved to be economically feasible.

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