Impact of growth regulating compounds on leaf area index in transplanted rice under moisture stress condition

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Received: 4.7.2018/Accepted: 7.7.2018

ABSTRACT

Field investigations were conducted in the Wetland Farm, Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu during rabi and summer seasons of 2016-17 and 2017-18 to assess the performance of growth regulating compounds for mitigating induced moisture stress on the growth and yield of transplanted rice. Experiments were laid out in split plot design with three replications. The treatments comprised induced water stress at different growth stages viz panicle initiation, flowering, both panicle initiation and flowering and moisture stress-free control (irrigating the field with 5 cm depth of irrigation one day after disappearance of previously-ponded water) in main plots and foliar application of growth regulating compounds in sub-plots viz chlormequat chloride 200 ppm, mepiquat chloride 200 ppm, brassinolide 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 leaf area index (LAI) at flowering and harvest and it was on par with brassinolide (0.1 ppm).

Keywords: Rice; moisture stress; growth regulating compounds; leaf area index

INTRODUCTION

Rice is one of the greatest water users among cereal crops consuming about 80 per cent of the total irrigated fresh water resources. In Asia with relatively more suitable growing conditions for rice, its production has declined due to increasing water stress (Tao et al 2004). Therefore it is important to cut down water supply for rice cultivation but without affecting yield. Water limited condition (also referred to as drought) affecting 23 Mha of rice in India regularly (Pandey et al 2007) 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) and the developmental stage (Zhu et al 2005). Rice is sensitive to drought stress particularly during flowering stage resulting in severe yield losses. The physiological processes during the sensitive flowering stage negatively affect spikelet fertility under water stress.

Plant growth regulators (PGRs) have been found to play a key role in the integration of the responses expressed by plants under stress conditions (Amzallag et al 1990). Plant growth regulators are the chemical substances when applied at low concentrations modify the growth of plants usually by stimulating or inhibiting part of the natural growth regulatory system. PGRs have 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). They play an important role in minimizing the negative effects caused by drought and improve 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, Tamil Nadu during rabi and summer seasons of 2016-17 and

2017-18 to assess the performance of growth regulating compounds for mitigating induced moisture on the growth and yield of transplanted rice. Experiments were laid out in split plot design with three replications. The treatments comprised induced water stress at different growth stages viz moisture stress-free control (irrigating the field with 5 cm depth of irrigation one day after disappearance of previously-ponded water) (M_1), stress induced at panicle initiation (PI) stage (M_2), stress induced at flowering stage (M_3) and stress induced at panicle initiation and flowering (M_4) in main plots and foliar application of growth regulating compounds in sub-plots viz chlormequat chloride 200 ppm (S_1), mepiquat chloride 200 ppm (S_2), brassinolide 0.1 ppm (S_3), pink pigmented facultative methylotrophs (PPFM 1%) (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 during summer. Moisture stress was imposed during panicle initiation, flowering and both the stages by withholding irrigation for 10 days. The growth regulating compounds were sprayed one day after the imposition of water stress in the respective phenophase during both the seasons.

RESULTS and DISCUSSION

Leaf area index (LAI)

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

With respect to moisture stress treatments, higher LAI was observed in moisture stress-free control (M_1) (4.28, 4.53, 4.67 and 4.73 for rabi 2016-17, rabi 2017-18, summer 2017 and summer 2018 respectively) at harvesting stage which was comparable with stress induced at flowering stage (M_3). Stress-free control (M_1) was significantly superior to the rest of treatments and the decreased LAI was found in stress induced at panicle initiation and flowering stages (M_4) during all the growing seasons. The increased LAI might have been brought up by favourable moisture regimes, more nutrient uptake and delayed senescence of the leaves with higher photosynthetic rate which resulted in increased LAI under one day after disappearance (DAD) of ponded water at 5 cm depth of irrigation of rice (Tables 1, 2). Lower LAI was observed with stress induced at both panicle initiation and flowering stages. This might be due to the loss of cell turgor that lead to reduced cell enlargement and transport of assimilates from the leaves to the developing sink which later caused senescence of leaves. The reduction in LAI during reproductive stage could be due to rapid decline in leaf elongation coupled with greater leaf death as observed by Holland (1997).

Table 1. Effect of induced water stress and growth regulating compounds on leaf area index at harvesting stage during rabi season

Treatment	Leaf area index									
	Rabi 2016-17					Rabi 2017-18				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	4.18	3.68	3.21	2.68	3.44	4.43	3.93	3.46	2.93	3.69
S_2	4.25	3.75	3.37	2.59	3.49	4.50	4.00	3.62	2.84	3.74
S_3	4.35	4.22	3.91	2.84	3.83	4.60	4.47	4.16	3.09	4.08
S_4	4.46	4.35	3.85	3.12	3.95	4.71	4.60	4.10	3.37	4.20
S_5	4.17	3.33	2.75	2.48	3.18	4.42	3.58	3.00	2.73	3.43
Mean	4.28	3.87	3.42	2.74		4.53	4.12	3.67	2.99	

	Rabi 2016-17				Rabi 2017-18			
	M	S	M at S	S at M	M	S	M at S	S at M
SEd	0.06	0.05	0.11	0.11	0.08	0.06	0.14	0.13
$CD_{0.05}$	0.14	0.11	0.23	0.21	0.19	0.13	0.3	0.26

M: Moisture stress, S: Treatment

Table 2. Effect of induced moisture stress and growth regulating compounds on leaf area index at harvesting stage during summer season

Treatment	Leaf area index									
	Summer 2017					Summer 2018				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	4.58	4.06	3.58	3.05	3.82	4.63	4.13	3.66	3.13	3.89
S_2	4.64	4.14	3.75	2.97	3.88	4.70	4.20	3.82	3.04	3.94
S_3	4.75	4.60	4.29	3.24	4.22	4.80	4.67	4.36	3.29	4.28
S_4	4.84	4.75	4.21	3.51	4.33	4.91	4.80	4.30	3.57	4.40
S_5	4.56	3.72	3.14	2.88	3.57	4.62	3.78	3.20	2.93	3.63
Mean	4.67	4.25	3.79	3.13		4.73	4.32	3.87	3.19	

	Summer 2017				Summer 2018			
	M	S	M at S	S at M	M	S	M at S	S at M
SEd	0.06	0.07	0.13	0.13	0.05	0.08	0.13	0.13
$CD_{0.05}$	0.15	0.14	0.28	0.27	0.14	0.13	0.28	0.27

M: Moisture stress, S: Treatment

With regard to the sub-plot treatments 1 per cent of PPFM (S_4) recorded higher LAI during rabi 2016-17, rabi 2017-18, summer 2017 and summer 2018 (3.95, 4.20, 4.33 and 4.40 respectively) at harvesting stage and it was comparable with 0.1 ppm of brassinolide (S_3). However LAI was least in control (S_5). This might be due to their positive role in cell division and cell elongation resulting in increased LAI. Growth regulators play an important role in increasing the number of leaves, leaf elongation, chlorophyll content, leaf area and net assimilation rate thus lead in increase in total dry matter production (Li et al 2009).

Moisture stress treatments and foliar application of growth regulating compounds had significant interaction with each other on LAI at harvest stage during all the growing seasons. The treatment combination of moisture stress-free control along with 1 per cent of PPFM (M_1S_4) registered higher LAI at harvest stage. However it was on par with 0.1 ppm of brassinolide (M_1S_3). Stress induced at PI and flowering stages with control (M_4S_5) produced lower LAI. Application of PPFM and brassinolide exerted positive influence in maintaining higher LAI with special reference to the stressed environment. The PPFM-mediated hormonal activity might be attributable for the increase in leaf area and other growth parameters. Lower LAI recorded under stress induced at PI and flowering stages along with control might have resulted in lower recovery of the crop thereby causing reduction in the grain yield (Thangamani 2005).

Thus the foliar application of PPFM (1%) (*Methylobacterium* sp) was 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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