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Effect of drought stress and its mitigating chemicals on aerobic rice (*Oryza sativa* L.) cultivation

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Abstract
Aerobic rice cultivation is a method of growing rice in well-drained, non-puddled and non-saturated soils using specifically developed varieties. It is the process of growing a crop from dry seeds put in the ground rather than transplanting seedlings from a nursery. Rice production is severely limited by drought stress during reproductive phase, which causes significant economic losses. Enhancing agricultural yield in the drought-prone rainfed areas has become necessary in consideration of the present and projected global food demand. A field experiment was conducted during summer 2022 at Tamil Nadu Agricultural University, Coimbatore, to study the effect of drought stress at reproductive stage and its growth and yield of aerobic rice. The experiment was laid out in split plot design with three replications. In main plot irrigation interval *viz*., irrigation @ IW/CPE 1.0 (M_1), withholding irrigation for 8 days from heading (M_2), with holding irrigation for 12 days from heading (M_3) was adopted. In sub plot stress mitigating chemicals *viz*., salicylic acid @ 100 ppm (S_2), sodium selenate @ 20 ppm (S_3), Pink Pigmented Facultative Methylotroph @ 1 per cent (S_4) in comparison with control no spray (S_1). The results revealed that irrigation @ IW/CPE 1.0 with foliar application of sodium selenate @ 20 ppm recorded higher grain yield (4146 kg ha^{-1}) which was followed by drought stress for 8 days from heading with foliar spray of sodium selenate @ 20 ppm recorded the grain yield of 3461 kg ha^{-1}. The application of sodium selenate @ 20 ppm at heading stage which results to mitigate the drought stress up to 8 days and the yield reduction is noticed only 16 per cent when compared to without drought stress.

Keywords: Aerobic rice, drought stress, sodium selenate, productive tillers, grain yield

1. Introduction
Aerobic rice is a system of cultivating rice without puddling, which saves water, human power and reduces the releasing of greenhouse gases as compared to conventional transplanted rice (Belder *et al.*, 2005) [3]. In comparison with cultivation of transplanted rice, the aerobic rice saves nearly half of water by reducing the water requirements for land, nursery preparation and also due to absence of standing water. Rice growth and development are significantly impacted by moisture stress, which causes pollen viability to decline, eventually leads to fewer grains and decrease in grain yield. Rice response to moisture stress depends on both its intensity and duration. During the entire reproductive cycle stress sensitivity is greater (Patnaik *et al.*, 2021) [11]. Due to drought, there was a drop of 21 per cent grain yield during the vegetative stage, 50 per cent during the flowering stage and 21 per cent during grain filling stage (Sarvestani *et al*., 2008) [13]. Therefore, there is need to adopt several mitigation strategies to alleviate the ill effects of moisture stress in rice.
Rice performed better when stress mitigating chemicals applied. Selenium can play protective role against various environmental stress including drought and salinity through strengthening the antioxidant defence mechanism particularly by activating enzymatic antioxidants (Nawaz *et al*., 2015) [10]. Salicylic acid was applied to leaves through foliar spray of 100 ppm to promote drought tolerance and improve performance in both normal and stressful conditions (Farooq *et al.*, 2009) [4]. Under moisture stress conditions, pink pigmented facultative methylotrophic (PPFM) bacteria have a wide range of beneficial effects on rice (Patnaik *et al.*, 2021) [11]. In sustainable agricultural systems, PPFMs may be used as bio-inoculants to boost plant growth and resistance to drought stress (Anandakumar, 2021) [2].

2. Materials and Methods
A field experiment was conducted during summer 2022 in the Wetlands Farm, Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore.

The experimental field is located at 77˚E longitude and 11˚N latitude with an altitude of 426.7 m above mean sea level (MSL) and it belongs to the western agro-climatic zone of Tamil Nadu. The soil is clay loam with the pH and EC of 8.5 and 0.45 ds m^{-1} respectively. Organic carbon content of the soil was 0.76 g kg^{-1} of soil. Soil was low in available nitrogen (235.2 kg ha^{-1}), high in available phosphorous (30.5 kg ha^{-1}) and available potassium (526.1 kg ha^{-1}). Field experiment was laid out in split plot design with three replication. The main plot consists of three levels of irrigation interval *viz*., irrigation @ IW/CPE 1.0 (M_1), withholding irrigation for 8 days from heading (M_2), withholding irrigation for 12 days from heading (M_3) and in sub plot consisted of foliar spray of stress mitigating chemicals *viz*., Salicylic acid (SA) @ 100 ppm (S_2), Sodium selenate (Se) @ 20 ppm (S_3) and PPFM (Pink Pigmented Facultative Methylotrophs) @ 1 per cent (S_4) and control (No spray) (S_1). Rice variety CO 53 was selected for the field experiment and seeds were manually dibbled in the well-prepared plots with a spacing of 20 x 10 cm. Polyethene sheet was placed in bunds to stop water seepage between the main fields. The experimental data was statistically analysed at critical difference 5 per cent probability level using analysis of variance (ANOVA) as suggested by Gomez and Gomez (2010) [6].

3. Results and Discussion

3.1. Number of productive tillers

Effect of drought stress on productive tillers of aerobic rice was influenced significantly. Among the irrigation interval, irrigation at IW/CPE ratio 1.0 from emergence to physiological maturity (M_1) recorded more productive tillers of 281 m^{-2}. Drought stress imposed for 8 days from heading (M_2) resulted the productive tillers of 256 m^{-2}. Drought stress imposed 12 days from heading (M_3) resulted lower productive tillers of 212 m^{-2}.

Table 1: Effect of drought stress and mitigating chemicals on yield attributes of aerobic rice

Number of productive tillers m^{-2}				
	M1	**M2**	**M3**	**Mean**
S1	263	241	204	236
S2	274	261	211	248
S3	315	277	225	273
S4	272	244	208	242
Mean	281	256	212	
	M	S	M X S	S X M
SEd	4.0	3.1	6.2	5.4
CD (5%)	11.3	6.5	14.8	11.3

M_1: Irrigation @ IW/CPE = 1.0, M_2: With holding irrigation for 8 days from heading, M_3: With holding irrigation for 12 days from heading, S_1: No spray, S_2: salicylic acid @ 100 ppm, S_3: Sodium Selenate @ 20ppm, S_4: PPFM @ 1%.

The productive tillers significantly differ with application of stress mitigating chemicals. Application of sodium selenate @ 20 ppm (S_3) at heading stage resulted more productive tillers of 273 m^{-2}. Germ *et al.*, (2005) [5] reported that the applications of selenium at low concentrations have beneficial effects and increases plants abilities to fight the drought stress. Foliar application of selenium resulted in a significant increase in tillers development in rice (Monisha *et al.*, 2021) [9]. This was followed by the application of salicylic acid @ 100 ppm (S_2) resulted the productive tillers of 248 m^{-2} which was comparable with PPFM (Pink Pigmented Facultative Methylotrophs) @ 1 per cent (S_4) with productive tillers of 242 m^{-2}. The lowest productive tillers were recorded in No spray (S_1) resulted 236 m^{-2}. Deficit irrigation greatly reduced the yield due to entire yield related traits like number of productive tillers and grains count and size (Hussain *et al*., 2016) [7]. The interaction effect had significant with irrigation interval and stress mitigating chemicals. Higher productive tillers were recorded in irrigation at IW/CPE ratio 1.0 with application of sodium selenate @ 20 ppm the productive tillers resulted of 315 m^{-2}. The lowest productive tillers were recorded in withholding irrigation for 12 days from heading with no spray resulted 204 m^{-2}.

3.2. Grain yield

Grain yield of aerobic rice was significantly influenced by drought stress and its mitigating chemicals. Among the irrigation interval, irrigation at IW/CPE ratio 1.0 from emergence to physiological maturity (M_1) recorded higher grain yield of 3831 kg ha^{-1}. Drought stress imposed for 8 days from heading (M_2) resulted the grain yield of 3320 kg ha^{-1}. Drought stress imposed 12 days from heading(M_3) resulted lower grain yield of 2892 kg ha^{-1}. The grain yield differed significantly with application of stress mitigating chemicals. Application of Sodium selenate @ 20 ppm (S_3) at heading stage resulted higher grain yield of 3591 kg ha^{-1}. This was followed by the application of Salicylic acid @ 100 ppm (S_2) resulted the grain yield of 3397 kg ha^{-1} which was comparable with PPFM (Pink Pigmented Facultative Methylotrophs) @ 1 per cent (S_4) spray with a yield of 3280 kg ha^{-1}. The lowest yield was recorded in no spray (S_1) resulted yield of 3123 kg ha^{-1}.

Table 2: Effect of drought stress and mitigating chemicals on grain yield (kg ha^{-1}) of aerobic rice

Grain yield (kg ha^{-1})				
	M_1	**M_2**	**M_3**	**Mean**
S_1	3593	3081	2696	3123
S_2	3867	3395	2929	3397
S_3	4146	3461	3167	3591
S_4	3720	3344	2775	3280
Mean	3831	3320	2892	
	M	S	M X S	S X M
SEd	37	29	57	50
CD (5%)	103	61	137	106

M_1: Irrigation @ IW/CPE = 1.0, M_2: With holding irrigation for 8 days from heading, M_3: With holding irrigation for 12 days from heading, S_1: No spray, S_2: salicylic acid @ 100 ppm, S_3: sodium selenate @ 20ppm, S_4: PPFM @ 1%.

The interaction effect had significant with irrigation interval and application of stress mitigating chemicals. Higher grain yield was recorded in irrigation at IW/CPE ratio 1.0 with application of Sodium selenate (M_1S_3) recorded the grain yield of 4146 kg ha^{-1}. This may be due to application of Sodium selenate as a foliar spray. Selenium significantly increased activities of the antioxidant defence system, which reduced the oxidative stress and increased growth traits, relative water content, photosynthetic efficiency and yield (Rady *et al.*, 2020) [12]. Selenium spraying increased the 1000 grain weight and grain yield (Mohtashami *et al.*, 2020) [8]. The lowest grain yield was recorded in withholding irrigation for 12 days from heading with no spray resulted 2696 kg ha^{-1}**.** This was due to water deficit condition significantly reduced seed weight and yield (Zahoor *et al.*, 2020) [14]. The flowering

stage was the most sensitive one exhibiting more adverse effects on all the physiological and agronomic parameters (Akram *et al*., 2013) [1].

4. Conclusion

Drought stress was the most important problem faced by majority of the farmers especially in aerobic rice cultivation. The induced drought stress in aerobic rice at heading stage had drastically reduced the tiller production and grain yield. Based on the experimental study the results revealed that foliar application of sodium selenate at 20 ppm to mitigate the ill effects of drought stress resulting in a significant increase in productive tillers, which in turn increased rice grain yield in aerobic rice cultivation. In the nutshell, the application of sodium selenate @ 20 ppm at heading stage which results to mitigate the drought stress up to 8 days and the yield reduction is noticed only16 per cent when compared to without drought stress.

5. References

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