International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(9): 108-112
Received: 15-07-2024
Accepted: 22-08-2024

Punniyamoorthi
P.G. Scholar, Department of Agronomy, SRM College of Agricultural Sciences, Vendhar Nagar, Baburayanpettai, Chengalpattu, Tamil Nadu, India

A Mohammed Ashraf
Assistant Professor (Agronomy), Department of Agronomy, SRM College of Agricultural Sciences, Vendhar Nagar, Baburayanpettai, Chengalpattu, Tamil Nadu, India

HA Archana
Assistant Professor (Agronomy), Department of Agronomy, SRM College of Agricultural Sciences, Vendhar Nagar, Baburayanpettai, Chengalpattu, Tamil Nadu, India

P Chandrasekaran
Assistant Professor (Crop Physiology), Department of Basic Sciences, SRM College of Agricultural Sciences, Vendhar Nagar, Baburayanpettai, Chengalpattu, Tamil Nadu, India

Corresponding Author:
A Mohammed Ashraf
Assistant Professor (Agronomy), Department of Agronomy, SRM College of Agricultural Sciences, Vendhar Nagar, Baburayanpettai, Chengalpattu, Tamil Nadu, India

Effect of induced moisture stress and growth regulators on physiological traits and yield of transplanted rice (*Oryza sativa* L.) at critical stages

Punniyamoorthi, A Mohammed Ashraf, HA Archana and P Chandrasekaran

DOI: https://doi.org/10.33545/2618060X.2024.v7.i9Sb.1463

Abstract
A field experiment was carried out at the wetland farm of SRM college of Agricultural Sciences, Baburayanpettai during the season *Sornavari* (April - May) 2024, to assess the performance of growth regulating compounds for mitigating moisture stress in transplanted rice. Split plot design experiments with three replications. The main plot treatments (3) comprised of Conventional Irrigation (control) (M_1), moisture stress during panicle initiation stage (M_2) and moisture stress during flowering stage (M_3). The sub-plot treatments (4) were foliar application of growth regulating compounds including Control (No spray) (S_1), potassium silicate @ 1% (S_2), seaweed extract @ 2% (S_3), brassinolide @ 0.04% (S_4). The moisture stress free control is implemented by irrigating the field with 5 cm of irrigation each day after the disappearance of previously ponded water. The experimental results revealed that as stage of rice crop is concerned, the panicle initiation stage is more sensitive to stress compared to flowering stage. The MS period of 10 days from panicle initiation significantly reduced all physiological parameters, including rice yield. This finding concluded that the treatment combination of moisture stress free control with 1% potassium silicate registered higher physiological traits and grain yield.

Keywords: Potassium silicate, seaweed extract, brassinolide, moisture stress, physiological traits

Introduction
Rice (*Oryza sativa* L.) is a wonder grain that can be grown in wide ecological zones and has an extensive range of production. Rice is the only crop that can grow in heavy rainfall areas and deltaic river belts around the world. Rice production must urgently be improved due to stagnant yield levels and rising food demand in India. Rice is the main diet for millions of people and is one of Asia's most water-intensive cereal crops, consuming more than 80% of the continent's irrigated freshwater resources. Due to increased water stress, rice yield in Asia, where growing circumstances were previously more favourable, has declined.
Moisture stress is one of the important stresses in plants and if it persists, it harms the growth, development and production. Moisture stress had a negative impact on several physiological traits in crops (Sharma and Kumar, 2014) [7]. Water is the most essential input for rice crops throughout their growth, but the panicle initiation and flowering stages are more critical and a deficit in these stages leads to a reduction in growth and yield. However, the influence of moisture stress in these two critical stages (Panicle initiation and flowering) on various physiological traits of rice remains unknown (Ashraf *et al.,* 2021) [1]. In India, water scarcity (also known as drought) affects 23 million hectares of rice on a regular basis, resulting from insufficient soil moisture to maintain average crop yield. Plant responses are influenced by the duration and severity of water stress, as well as the stage of development of the plant. In this perspective, it is vital to understand the many strategies for reducing water consumption in rice production without sacrificing yield. It is necessary to determine appropriate stress management measures in order to offset increasing water scarcity (Pandey, *et al*., 2007) [6].
Plant growth regulators (PGRs) played a key role in integrating plant stress responses (Tuteja, *et al*., 2010) [6].

Plant growth regulators are both chemical and natural compounds that, when used at low concentrations, alter plant growth by activating or inhibiting a portion of the plant's natural growth regulation system (Prajapati, *et al*., 2015) [3] Growth promoters and retardants are both growth regulators that alter the canopy structure and their expression in the form of yield. PGRs have been found to efficiently regulate water absorption during stressful situations by increasing membrane permeability or increasing the internal concentration of osmotically active solute. By sealing the loop, growth regulators could enhance water use efficiency by closing the stomata. They also boosted the above-ground biomass of the roots and may have an impact on the buildup of antioxidants that protect plants from stress (Zarei, *et al*., 2022) [4].

Material and Methods

Field experiments were conducted in the Wetland farm, Department of Farm Management, SRM College of Agricultural Sciences, Baburayanpettai during *Sornavari* (April - May) season of 2024. The aim was to study the effect of growth regulating compounds for mitigating moisture stress at critical stages in transplanted Rice. Field experiments were laid out in split-plot design with three replications. The test crop were used is medium duration rice variety CO (R) 55. The treatments consisted of inducing moisture stress in the main plots and foliar spray of growth regulating compounds in the sub-plots. The treatments comprised of inducing water stress at critical stages *viz*., moisture stress free control (irrigating the field with 5 cm depth of irrigation one day after disappearance of previously ponded water), stress induced at panicle initiation stage and stress induced at flowering stage, respectively in main plots and foliar application of growth regulating compounds in sub plots *viz*., Control (No spray), potassium silicate @ 1%, seaweed extract @ 1% and brassinolide @ 0.04%. The selected growth regulating compounds were sprayed one day after the imposition of water stress in the in the respective phenophase.

The relative water content (RWC) was estimated using the formula given by Barrs and Weatherley (1962). The proline content was estimated by acid ninhydrinprotocol given by Bates *et al*. (1973) and expressed in $\mu g\ g^{-1}$. Chlorophyll content of leaves was recorded as described by Peng *et al.* (1996) using the chlorophyll meter (SPAD-502, Soil Plant analysis Development Section, Minolta Camera Co. Ltd., Japan). The data recorded were statistically analyzed for split design using the Analysis of Variance (ANOVA) at a 5% level of significance using R Studio version 4.2.2. The Treatment differences that were non-significant were denoted by "NS".

Results and Discussion

Physiological parameters

Moisture stress and foliar application of growth regulating compounds did not have any significant influence on physiological parameters 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 were imposed only at the panicle initiation and flowering stage.

Chlorophyll index

Total chlorophyll content of the plant influenced the photosynthetic rate and thereby altered the biomass production and yield. The drought-induced alterations in leaf chlorophyll content could be due to impaired biosynthesis or accelerated pigment degradation. Higher value of chlorophyll index (SPAD) was noticed with moisture stress free control. On the other hand, lesser chlorophyll index was observed with moisture stress at panicle initiation stage. This might be due to moisture stress reduced the chlorophyll content in leaves and led to suppression of crop productivity through CO_2 assimilation as was reported by Jahan *et al*. (2014) [11]. Moisture stress caused a distinct decline in the chlorophyll 'a', chlorophyll 'b' and the total chlorophyll content. The decrease in chlorophyll under drought stress was mainly due to the damage of chloroplasts caused by active oxygen species. Conversely, under moisture stress conditions there would be degradation in pigment composition, which induced decrease in chlorophyll content (Khairi *et al*., 2015).

Among the foliar application of growth regulating compounds, increased chlorophyll index (SPAD) were observed with 1% potassium silicate, which was followed by seaweed extract @ 2%. The improvement in chlorophyll content under drought could be attributed to decreased activity of the chlorophyll degrading enzyme chlorophyllase or increase in the chlorophyll content as phytochromes interact with gibberellins. The results are in accordance Misratia *et al*. (2013) in rice.

Proline content

Distinct variation of tissue proline content was observed in different moisture stress treatments and foliar application of growth regulating compounds. With regard to different moisture stress treatments, increased proline content was found to be associated with moisture stress at panicle initiation stage and lower proline content with moisture stress free control . Singh *et al*. (2008) mentioned that proline was a non-protein amino acid that formed in plant tissues when subjected to moisture stress and rapidly metabolized upon recovery from drought. This indicated the specific role of accumulated free proline in plant tissues which acted as an osmolyte produced under moisture stress and played significant role in drought adaptation of plants.

Among the foliar spraying of growth regulating compounds, one per cent of potassium silicate was significantly superior to all the other treatments. However, it was comparable with seaweed extract @ 2%. This might be due to the fact that growth regulating compounds especially salicylic acid reduced the impact of stress leading to high level of proline accumulation. However, the proline content was higher than absolute control in all the growth regulating compounds treatments. Our results are in agreement with the findings that, proline acted as a compatible solute and a protective agent for cytoplasmic enzymes and structures. The rice genotypes exhibiting high proline accumulation had a marked effect on the ability to maintain water status consequently delayed tissue death and leaf senescence in rice under moisture stress (Uyprasert *et al*., 2004) [12].

Relative water content

Relative water content (RWC) represented the ability of the crop to retain tissue water status under moisture stress and this was one of the most important indicators of plant water stress. RWC of leaves was higher in the initial stages of leaf development and declined as the dry matter accumulated and leaf matured. According to different moisture stress treatments, higher relative water content was noticed with moisture stress free control, which was followed by moisture stress at flowering stage. Increased RWC indicated better growth and development, which in turn depended on leaf area. Rapid early growth and maintenance of RWC at reasonably higher level during reproductive phase greatly influenced the yield under moisture stress conditions. Moreover, lower relative water content was observed with moisture stress at panicle initiation stage. Decrease in soil water content increased soil water tension (*i.e*., decreased soil water potential) and rice roots experienced difficulty in absorbing water thereby reducing the plant water content. This influenced the ability of the plant to recover from stress and consequently affected yield and yield stability. Similar finding was also observed by Khairi *et al*. (2015).

Foliar application of one percent potassium silicate maintained a high relative water content status in the leaf cells under moisture stress condition. However, this was on par with foliar spraying of seaweed extract @ 2%. This might be due to the osmotic adjustment as reported by Dastan et. al. (2011). Applying silica might increase IAA and GA3 formation while reduced ABA formation.

Grain and straw yield

Rice grain yield is the product of number of filled grains per unit area under a given environment wherein the individual grain weight is primarily decided by the genetic make-up, a varietal character. Increased grain and straw yields were observed to be associated with moisture stress free treatment (one day after disappearance of ponded water at 5 cm depth of irrigation). This might be attributed to more productive tillers, number of grain panicle^{-1} with high fertility percentage. Also, rotational irrigation (wetting and drying) of the fields allowed for good aeration of the soil and better root growth and development, increased nutrient availability throughout the crop growth and reduced the weed growth which resulted in improved yield components and consequently, increased rice yield. The results are in line with the findings of Ceesay *et al*. (2006) and Uphoff (2009) [9] who reported that, cycles of repeated wetting and drying were found to be beneficial to rice plant growth through increased nutrient availability leading ultimately to increased grain and straw yields. Moisture stress period during panicle initiation stage was more detrimental on rice yield than flowering stage.

Regarding foliar application of growth regulating compounds, increased grain and straw yields were noticed under one per cent of potassium silicate. However, this was on par with foliar spraying of seaweed extract @ 2%. This might be due to the application of silicon to upland paddy enhanced the sturdiness in plant and helps to grow erect without lodging. The erectness exposed the plant to sunlight and enhanced the photosynthetic activity and assimilation of organic constituents. These assimilates promotes the growth and development of crop, as well as reduce the incidence of pest and disease. The crop grows vigorously and utilized the nutrient and moisture from soil which are turn into the economic yield of upland paddy. This might be the reason for increasing the grain yield of upland paddy. These results are in conformity with the findings of Singh *et al*. (2007) and Aarekar (2014) [10].

Moisture stress and foliar application of growth regulating compounds had significant interaction with each other on grain and straw yield. The treatment combination of moisture stress free control with one per cent potassium silicate registered increased grain yield. However, it was on par with foliar spraying of seaweed extract @ 2%. Foliar stress mitigating compounds such as potassium silicate could manipulate the grain and straw yields more favourable under moisture stressed conditions. There was significant increase in the straw yield with increased levels of silicon. This might be due to role of silicon in improvement of photosynthetic activity, water and nutrient use efficiency. That ultimately results into better vegetative growth. The accumulation of silicon in plant parts reduces its lodging and enhanced resistance against biotic and abiotic stress. All these factors ultimately might have resulted into higher grain and straw yield. Similar findings had also reported by Singh *et al*.(2007) and Aarekar (2014) [10].

Table 1: Effect of moisture stress and growth regulating compounds on chlorophyll index at different growth of rice

Treatments	Flowering				Maturity			
	M_1	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
S_1	27.96	32.07	30.92	30.32	27.01	30.10	29.27	28.79
S_2	32.08	38.57	35.37	35.34	31.22	36.69	33.82	33.91
S_3	30.39	35.69	34.61	33.56	30.12	34.41	33.66	32.73
S_4	30.15	35.38	34.04	33.19	29.88	34.10	33.18	32.39
Mean	30.15	35.43	33.74		29.79	33.82	32.49	
	M	S	M at S	S at S M	M	S	M at S	S at M
SEd	1.43	1.64	2.84	2.85	1.15	1.74	3.02	2.86
CD(P=0.05)	3.97	3.45	NS	NS	3.21	3.66	NS	NS

Table 2: Effect of moisture stress and growth regulating compounds on relative moisture content (%) at different growth stages of rice

Treatments	Flowering				Maturity			
	M_1	**M_2**	**M_3**	**Mean**	**M_1**	**M_2**	**M_3**	**Mean**
S_1	50.01	92.01	58.26	66.75	49.25	57.90	56.77	54.64
S_2	105.59	114.65	105.62	108.62	77.36	113.31	85.60	92.09
S_3	75.15	102.46	80.44	86.01	61.43	90.33	68.27	73.34
S_4	51.75	96.26	59.59	69.20	59.33	67.93	63.19	63.48
Mean	70.62	101.34	75.98		61.84	82.36	68.46	
	M	S	M at S	S at M	M	S	M at S	S at M
SEd	7.66	9.72	16.8	16.4	5.55	7.72	13.4	12.8
CD(P=0.05)	21.29	20.42	NS	NS	15.43	16.23	NS	NS

Table 3: Effect of moisture stress and growth regulating compounds on proline content (μ mol g^{-1}) at different growth of rice

Treatments	Flowering				Maturity			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	1.50	4.99	3.47	3.32	2.35	5.18	4.54	4.02
S_2	5.31	6.09	5.65	5.68	6.46	7.90	7.31	7.22
S_3	4.86	5.67	5.30	5.28	5.17	7.45	6.42	6.34
S_4	3.37	5.48	4.76	4.53	4.71	6.63	6.00	5.78
Mean	3.76	5.56	4.79		4.67	6.79	6.07	
	M	S	M at S	M at S	M	S	M at S	M at S
SEd	0.41	0.40	0.6	0.7	0.54	0.65	1.12	1.13
CD(P=0.05)	1.14	0.84	NS	NS	1.50	1.37	NS	NS

Table 5: Effect of moisture stress and growth regulating compounds on grain yield (kg ha^{-1}) & straw yield (kg ha^{-1})

Treatments	Grain yield				Straw yield			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	6,495	4,689	5,150	5,445	8,449	5,676	6,570	6,898
S_2	6,902	5,194	6,468	6,188	9,010	6,851	8,356	8,072
S_3	6,790	4,973	6,138	5,967	8,856	6,529	7,779	7,721
S_4	6,629	4,932	5,497	5,686	8,613	6,439	7,088	7,380
Mean	6,704	4,947	5,813		8,732	6,374	7,448	
	M	S	M at S	M at S	M	S	M at S	M at S
SEd	287	262	454	487	371	348	603	641
CD(P=0.05)	796	551	954	1136	1031	732	1267	1492

Fig 1: Inserting polythene sheets on all four sides of the plots to prevent water seepage

Fig 2: General view of experimental field

Conclusion

Results revealed that moisture stress free control.. This finding concluded that that the treatment combination of moisture stress free control with 1% potassium silicate registered recorded higher physiological traits and significantly increased grain and straw yield. This combination led to better performance than the other treatments and it were effective in mitigating the moisture stress in attaining the maximum crop productivity when crop suffered moisture stress at critical stages. Extended period of moisture stress for 10 days either during panicle initiation stage or during flowering stage recorded much lower physiological traits and yield values. Moisture stress period during panicle initiation stage was more detrimental on rice yield than flowering stage.

Acknowledgement

Department of Agronomy, SRM College of Agricultural Sciences, SRM Institute of Science and Technology, Chengalpattu, Baburayanpettai - 603 201, Tamil Nadu, India

References

1. Ashraf MA, Ragavan T, Begam NS. Superabsorbent polymers (SAPs) hydrogel: Water-saving technology for increasing agriculture productivity in drought-prone areas: A review. Agricultural Reviews. 2021;42(2):183-189. DOI: 10.18805/ag.R-2023.
2. Tuteja N, Gill SS, Trivedi PK, Asif MH, Nath P. Plant growth regulators and their role in stress tolerance. Plant Stress. 2010;4:1-18.
3. Prajapati S, Jamkar T, Singh OP, Raypuriya N, Mandloi R, Jain PK. Plant growth regulators in vegetable production: An overview. Plant Archives. 2015;15:619-626.
4. Zarei T. Balancing water deficit stress with plant growth-promoting rhizobacteria: A case study in maize. Rhizosphere. 2022;24:100621.
5. Lanceras JC, Pantuwan G, Jongdee B, Toojinda T. Quantitative trait loci associated with drought tolerance at reproductive stage in rice. Plant Physiology. 2004;135:384-399.
6. Pandey S, Bhandari H, Hardy B. Economic costs of drought and rice farmers coping mechanisms: A cross-country comparative analysis. Manila: International Rice Research Institute; c2007 .p. 203.
7. Sharma KD, Kumar A. Identification of physiological and yield related traits of wheat (*Triticum aestivum* L.). Journal of Agrometeorology. 2014;16(1):78-84.
8. Thakur AK, Uphoff N, Antony E. An assessment of physiological effects of system of rice intensification (SRI) practices compared with recommended rice cultivation practices in India. Experimental Agriculture. 2010;46(1):77-98.
9. Uphoff N, Anas I, Rupela OP, Thakur AK, Thiyagarajan TM. Learning about positive plant-microbial interactions from the system of rice intensification (SRI). Aspects of Applied Biology. 2009;98:29-54.
10. Aarekar SA, Pawar RB, Kulkarni RV, Pharande AL. Effect of silicon on yield, nutrient uptake by paddy plant and soil properties. Journal of Agrometeorology. 2014;16(1):65-70.
11. Jahan MS, Wang Y, Shu S, Zhong M, Chen Z, Wu J, Guo S. Exogenous salicylic acid increases the heat tolerance in tomato (*Solanum lycopersicum* L.) by enhancing photosynthesis efficiency and improving antioxidant defense system through scavenging of reactive oxygen species. Scientia Horticulturae. 2019;247:421-429.
12. Uyprasert S, Toojinda T, Udomprasert N, Tragoonrung S, Vanavichit A. Proline accumulation and rooting pattern in rice in response to water deficit under rainfed lowlands. Science Asia. 2004;30:301-11.