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Effect of Moisture Stress and Growth Regulating Compounds on Root Traits, Nutrient Uptake and Yield of Transplanted Rice at Critical Stages

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ABSTRACT

Background: The field experiment was conducted in the Wetland farm, SRM College of Agricultural Sciences, Baburayanpettai during the *Sornavari* (Apri-Aug) season of 2024 to assess the impact of growth regulating compounds on root traits, nutrient uptake and yield of transplanted rice under induced moisture stress conditions.

Methods: A Field experiment was laid out in split-plot design with three replications. The treatments comprise of induced moisture stress in different crop growth stages, *viz*., Moisture stress free control (conventional irrigation), where the field was irrigated with 5 cm depth of water one day after the disappearance of previously ponded water (M_1), moisture stress at panicle initiation stage (M_2) and moisture stress at the flowering stage (M_3) in main plots and foliar application of growth regulating compounds in sub-plots *viz*., potassium silicate @ 1% (S_2), Seaweed extract @ 2% (S_3), Brassinolide @ 0.04% (S_4) and Control without foliar application of growth regulating compounds (S_1). Observations were recorded on root parameters such as root length, root volume, root dry weight and root/shoot ratio, nutrient uptake by crop (N, P and K), yield attributes (number of productive tillers m^{-2}, panicle length, number of grains $panicle^{-1}$, fertility percentage and thousand grain weight) and yield of rice under induced moisture stress.

Result: Root parameters were significantly increased under moisture stress at panicle initiation stage with foliar application of one per cent potassium silicate. The treatment combination of moisture stress free control (conventional irrigation) in conjunction with foliar spraying of one per cent potassium silicate recorded higher N, P and K uptake, yield attributes and yield of rice. The critical stages of rice *viz*., panicle initiation and flowering, are most sensitive to moisture stress and can create yield reduction. Especially moisture stress at panicle initiation stage significantly reduced nutrient uptake, yield attributes and yield when compared to flowering stage but it recorded higher root traits.

Key words: Brassinolide, Flowering stages, Growth regulating compounds, Moisture stress, Panicle initiation stages, Potassium silicate, Seaweed extract.

INTRODUCTION

Rice (*Oryza sativa* L.), often called the “Wonder cereal” is grown in different ecological zones with varying productivity. Rice is the staple food of more than half of the world’s population. The world’s cultivated area is 165.25 million hectares and annual productivity and production of 3105 kg ha^{-1} and 509.87 million tons, respectively (FAO, 2024). India is the world’s largest rice producer by area and the second largest after China. Rice is grown on 44.1 million hectares in India, accounting for 105.5 million tonnes of production per year. In Tamil Nadu 2.3 million hectares are under rice cultivation and the production was about 74 lakh tonnes (Indiastat, 2022). Moisture stress has a serious impact on rice growth and development, causing changes at the morphological, physiological, biochemical and molecular levels. Furthermore, drought causes a decline in plant growth and development, as evidenced by a decrease in plant height, root length, leaf numbers, leaf length, leaf breadth and number of tillers, as well as total dry matter. It reduces the *via*bility of pollen, resulting in fewer grains and ultimately declining the grain yield. The plants ability to respond and survive in the face of water scarcity is dependent on the plant’s overall mechanisms, which can integrate cellular responses. Water scarcity (also known as drought) affects 23 million hectares of rice in India on a regular basis and is caused by insufficient soil moisture to support average crop production (Ashraf *et al*., 2020).

Plant growth regulators (PGRs) played an important role in integrating plant responses to stress (Amzallag *et al*., 1990). Many researchers are experimenting with foliar

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application of plant growth regulating compounds in rice to reduce transpiration loss. Plant growth regulators are chemicals that, when used in low concentrations, alter plant growth by stimulating or inhibiting components of the natural growth control system. Growth regulators include growth promoters and growth inhibitors, which alter canopy structure and manifest themselves as yield. Endogenous growth regulators are important factors in plant growth and development under water stress. Considering the above, the present work was undertaken to evaluate the performance of growth regulating compounds to alle*via*te the effect of induced moisture stress in transplanted rice and to study the root parameters, nutrient uptake and yield of rice under moisture stress occurring at different phenological phases (Punniyamoorthi *et al*., 2024).

MATERIALS AND METHODS

A Field experiment was conducted in Field No. A 5.6, during the *Sornavari* (Apri-Aug) season of 2024, at the Wetland Farm of SRM College of Agricultural Sciences, Baburayanpettai, Tamil Nadu, India. The experimental fields are situated in the North Eastern agro-climatic zone of Tamil Nadu at 11°N latitude and 77°E longitude at an altitude of 426.7 m above MSL (Fig 1). The weather parameters were recorded for the standard weeks of 12th to 27th during *Sornavari* 2024.There was a total rainfall of 540.7 mm received in 6 rainy days. The mean maximum and minimum temperatures were 28.13°C and 25.57°C, respectively. The mean relative humidity (RH) ranged from 42.68% (14.14 hrs) to 85.04% (7.14 hrs). Mean sunshine hours was 5.49 respectively The soil of the experimental site was clay loam in texture. The short duration rice variety CO 55 was used as test material. The field experiment was laid out in a split-plot design with three replications. The treatments consisted of inducing moisture stress in the main plots and foliar application of growth regulating compounds in the sub-plots. All the cultural practices for rice other than the treatments were followed as per the recommendations of CPG (2020).

Treatments details

Main plot: Moisture stress induced at critical growth stages

M_1: Moisture stress free control (Conventional Irrigation).
M_2: Moisture stress at the panicle Initiation stage (30 to 40 DAT).
M_3: Moisture stress at the flowering stage (55 to 65 DAT).
(Note: Moisture stress is imposed by withholding irrigation for 10 days and re-flooding on the plots after the moisture stress periods).

Sub plot: Growth regulating compounds

S_1: Control (No spray).
S_2: Foliar spray of Potassium silicate @ 1%.
S_3: Foliar spray of Seaweed extract @ 2%.
S_4: Foliar spray of Brassinolide @ 0.04%.

Conventional method of irrigation

In the conventional method, the recommended irrigation was provided upto 5 cm depth of water one day after disappearance of previously ponded water till ten days before harvest. In order to maintain a 5 cm level, a wooden peg was fixed in each plot to show the depth of standing water. The amount of water irrigated each irrigation was measured by regulating through a 'water meter' fixed at the head of the experimental field. The time required for the flow of calculated volume of water was worked out and the water was allowed to reach each plot only for a specified time to get a desired depth (5 cm) of irrigation.

Imposition of moisture stress

The conventional method of practice was followed up to before panicle initiation stage. Moisture stress was imposed in two phases *viz.,* the first one at during panicle initiation (30 to 40 DAT) and second one during flowering stage (55 to 65 DAT) by completely withdrawing water from the respective treatment plots and ceasing irrigation for the duration specified as per treatment. A 30-mm-high polythene sheet was inserted on all four sides of the plots to prevent water seepage (Fig 2). The stress was imposed

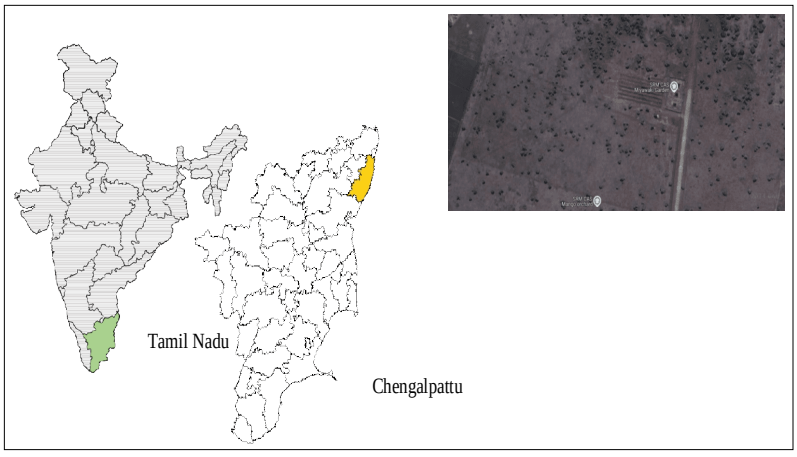


Fig 1: Location of the experimental field.

one day after the disappearance of ponded water of 5 cm depth during panicle initiation and flowering stages (Fig 3). Irrigation was resumed on the plots after the moisture stress periods. After the termination of the moisture stress period, the stressed plots were irrigated to the required depth. In both non-stressed and stressed plots, irrigation was suspended ten days before the expected time of harvest.

Time of foliar application to alleviate moisture stress

The growth regulating compounds were dissolved in water as per their concentration requirements and sprayed at 500 litres ha^{-1} in panicle initiation and flowering stages one day after the imposition of the stress in the respective critical growth stages.

Observations were recorded on root parameters such as root length, root volume, root dry weight and root/shoot ratio, nutrient uptake by crop (N, P and K), yield attributes (number of productive tillers m^{-2}, panicle length, number of grains $panicle^{-1}$, fertility percentage and thousand grain weight) and yield of rice under induced moisture stress.

RESULTS AND DISCUSSION

Root studies

In general, root length, root volume, root dry weight and root/shoot ratio varied significantly between moisture stress treatments and foliar application of growth-regulating compounds was tabulated in (Table 1,2,3 and 4). Among the moisture stress treatments, the higher root length, root volume, root dry weight and root/shoot ratio found to be in moisture stress at panicle initiation stage (M_2) at flowering and harvest stages respectively. This was comparable with moisture stress at flowering stage (M_3) at both the stages. Moisture stress free control (conventional irrigation) (M_1) recorded reduced root length, root volume, root dry weight and root/shoot ratio respectively. Foliar application of one per cent potassium silicate (S_2) registered increased root length, root volume, root dry weight and root/shoot ratio at both the stages. However, it was on par with foliar spraying of two per cent of seaweed extract (S_3) at both the stages. Poor root volume was recorded in control (no spray).

From the root studies, it could be inferred that, moisture stress at panicle initiation recorded increased root traits. This might be due to non-availability of water in the top layer of soil, the roots are forced to grow deeper to forage moisture from the deeper layers. The results were in accordance with Almaghrabi, (2012) on wheat cultivars. This might be due to optimum moisture and aerated conditions in the soil to access both oxygen and water by the roots. Similar results were reported by Thakur *et al*. (2010). In terms of foliar application of growth regulating compounds, spraying one per cent potassium silicate



Fig 2: Inserting polythene sheets on the plots to prevent water seepage.

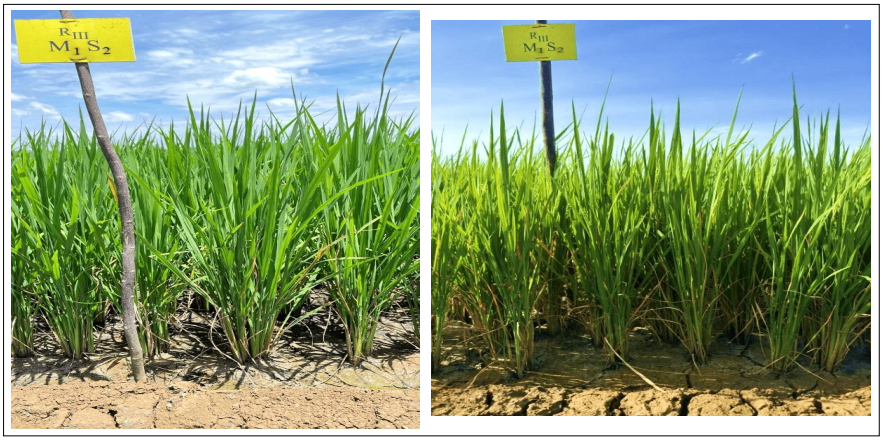


Fig 3: Moisture stress imposition at panicle initiation and flowering stage.

outperformed all other treatments. This increase could be due to silicon application, thereby improving root water uptake. Silicon is an essential nutrient for root development and water uptake under drought stress conditions. Similar findings were reported by Ashraf *et al.* (2021). There is no significant interaction effect of moisture stress treatments and foliar application of growth regulating compounds on root parameters.

Table 1: Effect of moisture stress and growth regulating compounds on root length (cm) at different growth stages of rice.

Treatment	Flowering stage				Harvest stage			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	17.0	21.5	20.2	19.5	21.5	26.7	24.9	24.4
S_2	21.5	24.9	22.7	23.0	26.4	30.4	28.1	28.3
S_3	20.9	24.8	23.1	22.9	25.6	30.2	28.4	28.1
S_4	19.8	22.8	21.2	21.3	24.6	28.2	26.4	26.4
Mean	19.8	23.5	21.8		24.5	28.9	26.9	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	0.9	1.1	2.1	2.0	1.1	1.4	2.5	2.4
CD at 5%	2.7	2.5	NS	NS	3.2	3.0	NS	NS

Table 2: Effect of moisture stress and growth regulating compounds on root volume (cc $hill^{-1}$) at different growth stages of rice.

Treatment	Flowering stage				Harvest stage			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	36.2	44.3	40.9	40.5	34.9	42.9	40.1	39.3
S_2	43.9	51.1	46.4	47.1	42.3	49.8	44.8	45.6
S_3	42.1	45.9	43.1	43.7	40.6	44.6	42.1	42.4
S_4	41.9	46.1	42.5	43.5	40.3	44.3	41.6	42.1
Mean	41.0	46.9	43.2		39.5	45.4	42.1	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	1.9	2.3	4.0	3.9	1.6	2.1	3.6	3.5
CD at 5%	5.4	4.8	NS	NS	4.3	4.3	NS	NS

Table 3: Effect of moisture stress and growth regulating compounds on root dry weight (g $hill^{-1}$) at different growth stages of rice.

Treatment	Flowering stage				Harvest stage			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	4.28	8.29	6.79	6.45	3.08	5.82	4.79	4.56
S_2	7.84	9.96	8.19	8.66	5.26	10.90	8.43	8.20
S_3	6.23	8.33	7.55	7.37	5.13	9.59	6.72	7.14
S_4	5.88	8.29	7.27	7.15	4.47	7.57	6.28	6.11
Mean	6.02	8.72	7.45		4.48	8.47	6.55	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	0.38	0.66	1.15	1.07	0.71	0.67	1.17	1.24
CD at 5%	1.07	1.40	NS	NS	1.98	1.42	NS	NS

Table 4: Effect of moisture stress and growth regulating compounds on root shoot ratio at different growth stages of rice.

	Flowering stage				Harvest stage			
Treatment	0.12	0.26	0.18	0.18	0.21	0.23	0.22	0.22
S_1	0.30	1.10	0.64	0.68	0.20	0.40	0.38	0.32
S_2	0.29	0.41	0.36	0.35	0.23	0.38	0.30	0.30
S_3	0.24	0.38	0.29	0.30	0.20	0.32	0.21	0.24
S_4	0.24	0.53	0.37		0.21	0.33	0.28	
Mean	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
	0.12	0.10	0.13	0.14	0.03	0.02	0.04	0.05
SEd	0.22	0.20	NS	NS	0.08	0.05	NS	NS
CD at 5%	0.12	0.26	0.18	0.18	0.21	0.23	0.22	0.22

Yield components

Rice yield components such as number of panicles, panicle length, number of grains panicle^{-1} and fertility percentage increased in stress free control (one day after ponded water disappeared at 5 cm depth of irrigation) was tabulated in (Table 5 and 6). As a result, the variation in yield parameters could be linked to changes in LAI, CGR, dry matter production and LAD. Better aeration and a more extensive root system, combined with optimal mobility and absorption of inorganic N, increased the uptake of all other nutrients and contributed to favourable growth characteristics, which resulted in higher yield components. This is in agreement with the findings of Veeraputhiran *et al.* (2010) and Ashraf and Ragavan (2024). Moisture stress at panicle initiation stage recorded a lesser number of filled grains than other treatments tested for stress mitigation. The reduction in the number of productive tillers was more due to moisture stress at vegetative stage than the stress at reproductive stage. This was in accordance with the findings of Wopereis *et al*. (1996) that moisture stress at vegetative stage reduced tiller numbers. Distinctly increased yield components *viz.,* more number of grains panicle^{-1} and fertility percentage were registered under foliar spraying of one per cent potassium silicate. However, it was on par with foliar spraying of seaweed extract @ 2%. The application of silicon significantly increased the yield components of rice *viz*., the number of panicles, panicle length, number of grains panicle^{-1} and fertility percentage. This could be due to increased photosynthetic activity, improved carbohydrate assimilation, or increased nutrient availability as a result of silicon application. Silicon plays an important role in plant metabolic activity by facilitating the uptake of other essential nutrients. Similar findings were also reported by Patil *et al.* (2018).

Grain and straw yield

Rice grain yield is the number of filled grains per unit area in a given environment, with individual grain weight determined primarily by genetic makeup, a varietal character. The number of filled grains per unit area is calculated by multiplying the number of panicles (productive tillers) per unit area by the number of filled spikelets per panicle. Filled grains per panicle are the result of a coordinated effort between the number of differentiated spikelets in a panicle, current photosynthates and translocated reserves from the stem and leaves. Moisture stress free treatment resulted in increased grain and straw yields (one day after the ponded water disappeared at a 5 cm irrigation depth) was tabulated in (Table 7). This could be attributed to more productive tillers, a larger number of grain panicles and a higher fertility percentage. Furthermore, rotational irrigation (wetting and drying) of the fields promoted for adequate soil aeration and root growth and development, increased nutrient availability throughout crop growth and reduced weed growth, all of which resulted in improved yield

Table 5: Effect of moisture stress and growth regulating compounds on productive tillers m^{-2}, filled grains panicle^{-1} and Filled grain (%) at harvest stage of rice.

Treatment	No. of productive tillers m^{-2}				No. of filled grains panicle^{-1}				Filled grain (%)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	370	333	320	341	201	155	174	176	85.0	79.8	82.5	82.4
S_2	438	392	417	415	224	198	201	207	91.9	85.3	88.2	88.4
S_3	408	372	379	386	212	179	193	194	88.8	82.3	84.9	85.3
S_4	383	367	376	375	211	173	188	190	88.2	82.0	84.7	84.9
Mean	399	366	373		212	176	189		884	82.3	85.0	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	4.0	4.3	8.6	8.5	1.9	1.7	3.6	3.4	1.1	1.0	2.1	2.0
CD at 5%	9.8	8.7	18.3	17.3	4.7	3.4	7.7	6.9	2.8	2.1	NS	NS

Table 6: Effect of moisture stress and growth regulating compounds on panicle length (cm), panicle weight (g), 1000 grain weight (g) at harvest stage of rice.

Treatment	No. of productive tillers m^{-2}				No. of filled grains panicle^{-1}				Filled grain (%)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	26.55	20.33	24.70	23.86	3.91	3.50	3.83	3.74	14.65	12.70	13.68	13.68
S_2	30.04	26.81	27.28	28.04	4.83	4.14	4.35	4.44	16.79	14.84	15.81	15.81
S_3	27.43	25.21	25.68	26.11	4.50	4.02	4.14	4.22	16.08	14.13	15.10	15.10
S_4	27.23	24.61	25.28	25.70	4.46	3.94	4.07	4.16	15.37	13.41	14.39	14.39
Mean	27.81	24.24	25.73		4.42	3.90	4.10		15.72	13.77	14.75	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	0.94	1.35	2.35	2.24	0.14	0.22	0.39	0.37	0.51	0.72	1.26	1.20
CD at 5%	2.62	2.85	NS	NS	0.39	0.48	NS	NS	1.43	1.52	NS	NS

components and higher rice yield. The findings are consistent with those of Ceesay *et al*. (2006) and Uphoff (2006), who found the cycles of repeated wetting and drying improved rice plant growth by increasing nutrient availability, resulting in higher grain and straw yields. Moisture stress during panicle initiation had a greater negative impact on rice yield than during flowering.

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 could be due to the fact that applying silicon to upland paddy increased plant sturdiness and allowed it to grow erect without lodging. The plant's erect position exposed it to sunlight, which increased photosynthetic activity and organic constituent assimilation. These assimilates promote crop growth and development while also reducing the incidence of pest and disease. The crop grows vigorously and utilizes nutrients and moisture from the soil, resulting in an economic yield of rice. The findings are in conformity with those of Patil *et al.* (2018). Moisture stress and foliar application of growth regulating compounds had a significant difference on grain and straw yield. The treatment combination of moisture stress free control (conventional irrigation) with foliar application of 1% potassium silicate resulted in increased grain yield. This was followed by moisture stress free control 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. Straw yield increased significantly with the foliar application of silicon levels. This could be attributed to silicon's role in increasing photosynthetic activity, water and nutrient utilization efficiency. This ultimately results in improved vegetative growth. Higher straw yield was primarily linked to increased plant height and number of tillers per hill. The accumulation of silicon in plant parts reduces lodging and improves resistance to biotic and abiotic stress. All of these factors may have contributed to a higher straw yield. Similar findings were reported by Singh *et al.* (2008).

Nutrient uptake

Nutrient uptake being a product of nutrient concentration and dry matter production, it increased with the age of crop. Higher N, P and K uptake under moisture stress free conditions was due to increased nutrient solubilisation, improved root activity, improved aeration and increased DMP levels, which led to increased nutrient absorption was tabulated in (Table 8). Similar findings were reported by Ashraf *et al*. (2021). Moisture stress at panicle initiation stage registered reduced uptake of N, P and K. Under water stress conditions, the total nutrient content of the plants was significantly reduced at harvest stage. Moisture stress is thought to slow nutrient uptake by interfering with the three major processes that allow ions to come into contact with the roots. Assessing the plant's nutrient status could help determine the extent to which moisture stress inhibits nutrient uptake (Marais and Wiersma, 1975) and (Ashraf and Ragavan, 2019).

Table 7: Effect of moisture stress and growth regulating compounds on grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index (%) of rice.

Treat	Grain yield (kg ha^{-1})				Straw yield (kg ha^{-1})				Harvest Index (%)			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	4,916	4,270	4,680	4,622	6,486	5,294	5,758	5,846	44.00	42.40	42.70	43.03
S_2	6,076	4,889	5,581	5,515	7,510	5,576	6,821	6,635	44.90	43.80	43.90	44.20
S_3	5,567	4,532	5,172	5,090	6,849	5,547	6,364	6,253	44.70	43.70	43.80	44.00
S_4	5,271	4,335	4,896	4,834	6,789	5,334	6,183	6,102	44.20	43.40	43.60	43.73
Mean	5,457	4,506	5,082		6,908	5,437	6,281		44.45	43.32	43.50	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**Mat S**	**Sat M**
SEd	69	79	157	158	67	80	159	161	0.6	0.5	1.0	0.9
CD at 5%	170	161	333	321	165	164	335	327	NS	NS	NS	NS

Table 8: Effect of moisture stress and growth regulating compounds on nitrogen, phosphorus, potassium uptake (kg ha^{-1}) at harvest stage of rice.

Treat	Nitrogen uptake				Phosphorus uptake				Potassium uptake			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	92.73	79.22	85.97	85.97	21.77	19.06	20.42	20.42	140.16	125.85	133.00	133.00
S_2	105.32	91.81	98.56	98.57	24.28	21.57	22.92	22.92	153.50	139.20	146.35	146.35
S_3	101.14	87.63	94.38	94.38	23.44	20.74	22.09	22.09	149.06	134.75	141.90	141.90
S_4	96.93	83.42	90.17	90.17	22.61	19.90	21.25	21.25	144.59	130.28	137.44	137.44
Mean	99.03	85.52	92.27		23.02	20.32	21.67		146.83	132.52	139.67	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	3.59	4.29	7.42	7.36	0.73	0.84	1.46	1.48	3.82	4.51	7.89	7.78
CD at 5%	9.96	9.01	NS	NS	2.00	1.78	NS	NS	10.55	9.53	NS	NS

Among the foliar application of growth regulating compounds, one per cent potassium silicate recorded increased nutrient uptake (N, P and K) and it was on par with foliar spraying of seaweed extract @ 2%. This could be due to improved crop stand, better root growth, the synergistic effect of silicon and a favourable physical environment that allowed rice to absorb nutrients more effectively. Due to the application of silicon, an increase in nitrogen, phosphorus and potassium uptake by rice was reported by Aarekar (2014) and Ashraf *et al*. (2024).

CONCLUSION

As a result, moisture stress and foliar application of growth regulating compounds had significant effect on nutrient uptake by crop (N, P and K), yield attributes (number of productive tillers m^{-2}, panicle length, number of grains $panicle^{-1}$, fertility percentage and thousand grain weight) and yield of transplanted rice. As stage of rice crop is concerned, the panicle initiation stage is more susceptible to stress than the flowering stage. Moisture stress applied during the panicle initiation stage had a negative impact on rice yield and nutrient uptake than the moisture stress at flowering stage but higher in root traits. This suggests that adequate moisture is more important in the panicle stage. Foliar application of growth regulating compounds proved to be highly effective in mitigating moisture stress rice with higher productivity. This clearly indicated that potassium silicate could be suggested when the crop is likely to undergo moisture stress at any critical stages as inferred from the study. Hence, it could be concluded that the treatment combination of moisture stress free control (conventional irrigation) with 1% potassium silicate registered recorded higher N, P and K uptake, yield attributes and yield of rice.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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