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Effect of foliar application of signal molecules on yield and yield attributes of rice (*Oryza sativa*.L) under salinity stress

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ABSTRACT

A field experiment was conducted at Agricultural College Farm, Bapatla during *kharif*, 2023-24 to explore the effect of foliar application of signal molecules on yield and yield attributes of rice under salinity stress. The experiment was carried out with two contrast varieties (MCM103- Salt tolerant, as a check; BPT 5204- Salt susceptible) in randomized block design with eight treatments *viz.,* MCM 103 (Check variety) - T_1, 0.25 mM/L of SNP - T_2, 0.50 mM/L of SA -T_3, 0.50 mM/L of BR -T_4, 0.25 mM/L SNP+0.50 mM/L SA -T_5, 0.25 mM/L SNP+0.50 mM/L BR -T_6, 0.25 mM/L SNP+ 0.50 mM/L SA+0.50 mM/L BR -T_7 and No spray control -T_8 in three replications. The foliar application was done at two different growth stages: before and after reproductive stages. The salt tolerant MCM 103 recorded superior performance over salt sensitive BPT 5204 on yield and yield attributes under salinity stress. The foliar application of signal molecules had positive effects on the yield and yield attributing traits *viz.,* number of spikelets per panicle, number of filled grains per panicle, spikelet fertility (%) and grain yield. Among all the foliar treatments, treatment consortia (T_7) found to be the best, significantly increased yield and was consistent with MCM 103 in the present study.

Key words: *Grain yield, Rice, Salinity stress, Signal molecules and Spikelet fertility*

Soil salinity is one of the major abiotic stresses and is the excess accumulation of salt in the soil which results in adverse impact on the crop growth and development. More than 833 million hectares of soils are currently affected by high levels of salt worldwide (FAO, 2021). In India alone 6.73 million hectares of land are degraded by salt on irrigated land (Sharma *et al.*, 2004). Approximately, greater than 10% of the agricultural crop land is impacted by salinity (FAO, 2021).

Rice is a major cereal crop grown globally and it serves as a staple food for about half of the world's population (Gross and Zhao, 2014). Asia is considered as the world's leading producer of rice and 650 million tons of rice produced on 145 million hectares of land and this amounts to 90% of the world's total rice crop (Rajakumar, 2013).

As the rice crop is sensitive to salt stress, it may tolerate a salinity of around 3 dSm^{-1}, but anything higher has been associated with significant yield loss (Gao *et al.*, 2007). Among different growth stages of rice crop, the seedling and early vegetative stages (Lutts *et al,* 1995), and later, the reproductive (booting) stage (Ismail *et al.,* 2007) are the most critical stages under salinity stress.

Plant growth regulators perform as signaling agents and aid in mitigating salt stress by initiating various physiological and developmental modification, results in increased yield (Yu *et al.*, 2020). The exogeneous application of signal molecules *viz*., Brassinosteroids(BR), Salicylic acid and Sodium(SA) Nitro prusside(SNP) provides certain advantages in mitigating the negative effects of salt stress, as well as enhancing germination, growth, development, tillering, flowering, seed yields, and quality (Egamberdieva, 2009).

Brassinosteroids are primarily polyhydroxylated, sterol-derived plant growth regulators. Under salt stress conditions, the exogenous application of BRs improved the activity of antioxidant enzymes and the Na^+ and Cl^- ion homeostasis as well as ensuing improvement in other photosynthetic related processes (Yue *et al.,* 2019) to ameliorate the adverse effects of salt stress. Sodium Nitroprusside (SNP) acts as a signaling molecule, Nitric Oxide donor. Exogenous treatment with NO results in an optimal maintenance of Na^+/K^+ ratio, mitigation of osmotic stress by increasing antioxidant enzymes activity, glucose-mediated repression of photosynthesis and also, protects the mitochondria from oxidative damage by increasing ATP synthesis that ultimately results in enhanced yield (Ali *et al.,* 2017). Salicylic Acid (SA) is a phenolic molecule, assists in helping plants to deal both biotic and abiotic stresses and is a key endogenous growth regulator (Hayat *et al.,* 2007). The exogenous application of SA plays a vital role in mitigating salinity stress by enhancing adaptive mechanisms such as regulating ion uptake and transport abiding redox homeostasis in cells and downgrades the salinity induced oxidative damage (Dolatabadian *et al.,* 2009). Therefore, this study was conducted to evaluate the effect of foliar application of signal molecules on yield and yield components of rice under salinity.

MATERIAL AND METHODS

A field experiment was conducted in *kharif* during 2023-2024 at Agricultural College Farm, Bapatla, Andhra Pradesh. It is geographically located at 15°54′ Northern latitude, and 80°25′ Eastern longitude, with an altitude of 5.49 m above the mean sea level (MSL), which is about 8 km away from the Bay of Bengal in the Krishna Agro - Climatic Zone of Andhra Pradesh. In this investigation, two distinct varieties with varying salt tolerance were chosen. The variety, BPT 5204 is sensitive to salt, while the variety, MCM 103 exhibits higher tolerance to salt stress. The salt tolerant variety, MCM 103 was used as a check to compare the impact of signal molecules which were foliar applied on BPT 5204.

The present study was carried out in randomized block design with eight treatments *viz*., MCM 103 (Check variety) - T_1, 0.25 mM/L of SNP - T_2, 0.50 mM/L of SA -T_3, 0.50 mM/L of BR - T_4, 0.25 mM/L SNP + 0.50 mM/L SA - T_5, 0.25 mM/L SNP + 0.50 mM/L BR - T_6, 0.25 mM/L SNP + 0.50 mM/L SA + 0.50 mM/L BR - T_7 and No spray (control) - T_8 in three replications. The foliar application of different signal molecules (PGRs) namely, Brassinosteroids (BR), Salicylic acid (SA) and Sodium Nitro prusside (SNP) was done at two different growth stages (before and after reproductive stages) to know the influence on effects of salinity stress. Data on the yield and yield attributes were recorded at harvest.

The harvested panicles were threshed, cleaned and total number of grains per panicle were counted and recorded. Number of filled and unfilled grains were counted separately. Spikelet fertility was worked out using the following formula and expressed in percent. Number of filled spikelets /Total number of spikelets) × 100 At maturity, five plants from each replication were harvested, sun dried, threshed, cleaned and weight of the grains was recorded and expressed in q/ha.

RESULTS AND DISCUSSION

Number of spikelets per panicle

The data on number of spikelets per panicle under salinity stress presented in table 1 and figure 1. The number of spikelets per panicle was reduced under salinity more in susceptible BPT 5204 than the tolerant variety. All the treatments, except the foliar spray of 0.50 mM/L SA (T_3) recorded significantly maximum number of spikelets per panicle. The highest number of spikelets per panicle were recorded by the foliar spray of 0.25 mM/L SNP + 0.50 mM/L SA + 0.50 mM/L BR consortia (T_7 - 131.73) among different foliar application treatments and it was on par with the check variety, MCM 103 (T_1 – 145.47). The foliar spray of consortia (T_7) increased the number of spikelets per panicle by 27.74 % with respect to control, BPT 5204 (T_8). The present study was in consistent with the results of Prodjinoto *et al.* (2023). It is well known that the exogenous application of phytohormones changes the endogenous hormone levels and interact with each other, that ultimately led to increase in yield and its attributes. Chen *et al*. (2022) reported that the yield increased with increase in number of spikelets per panicle after the exogenous application of brassinosteroid.

Number of filled grains per panicle

The data related to the number of filled grains per panicle under salinity stress presented in table 1 and figure 2. The maximum number of filled grains per panicle was observed in the salt tolerant variety, MCM 103. All foliar spray treatments recorded significantly increased number of filled grains per panicle, except the foliar spay of 0.50 mM/L SA (T_3

Table 1 Influence of signal molecules on the number of spikelets per panicle, number of filled grains per panicle, spikelet fertility (%), and grain yield (q/ha) in rice under salinity stress

	Treatments	Number of spikelets /panicle	Number of filled grains per panicle	Spikelet Fertility (%)	Grain yield (q/ha)
T_1:	MCM 103 (Check variety)	151.12	145.47	85.36	61.9
T_2:	0.25 mM/L of SNP	117.8	117.73	77.26	54.83
T_3:	0.50 mM/L of SA	109.93	109.53	76.42	54.41
T_4:	0.50 mM/L of BR	121.73	118.67	78.18	55.23
T_5:	0.25 mM/L SNP + 0.50 mM/L SA	123.4	119.4	79.93	56.44
T_6:	0.25 mM/L SNP + 0.50 mM/L BR	128.2	124.67	80.02	56.55
T_7:	0.25 mM/L SNP + 0.50 mM/L SA + 0.50 mM/L BR	140.28	131.73	80.54	57.28
T_8:	No spray (control)	100.07	103.13	69.24	47.4
	SEm±	**3.62**	**2.49**	**2.26**	**2.19**
	CD (p = 0.05)	**10.98**	**7.55**	**6.84**	**6.63**
	CV (%)	**5.05**	**3.58**	**4.99**	**6.82**

Fig 1 Effect of signal molecules on the Number of Spikelets per panicle

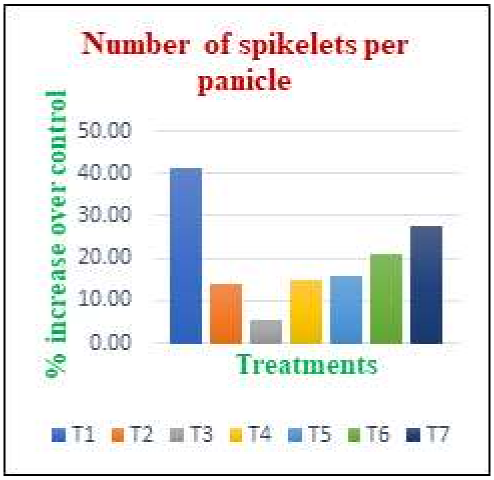
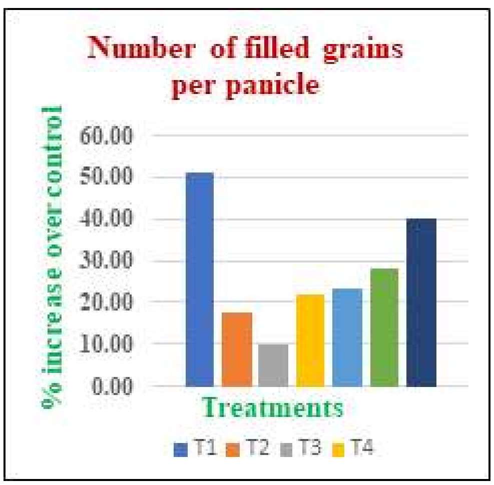


Fig 2 Effect of signal molecules on number of filled grains per panicle



- 109.93). But the foliar application of 0.25 mM/L SNP + 0.50 mM/L SA + 0.50 mM/L BR (T_7 - 140.28) recorded the higher number of filled grains per panicle among different foliar application treatments and it was on par with the check variety, MCM 103 (T_1 - 151.12). In the check variety, MCM 103 (T_1), the filled grains per panicle was increased by 51.0 % over the susceptible variety, BPT 5204 (T_8) and the foliar spray of 0.25 mM/L SNP + 0.50 mM/L SA + 0.50 mM/L BR (T_7) increased the filled grains per panicle by 40.2 % over the control, BPT 5204 (T_8). The present study is in accordance with Misratia *et al.* (2015) who reported that the salinity stress reduced the filled grains percentage in the salt sensitive variety more than that of the salt tolerant variety. Chen *et al.* (2022) and Imran *et al.* (2023)

Fig 3 Effect of signal molecules on the spikelet fertility percentage

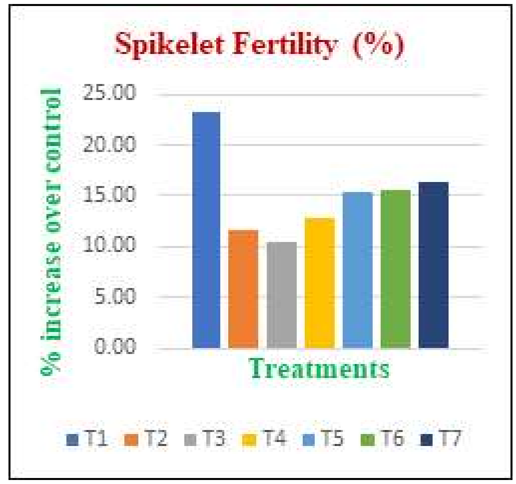
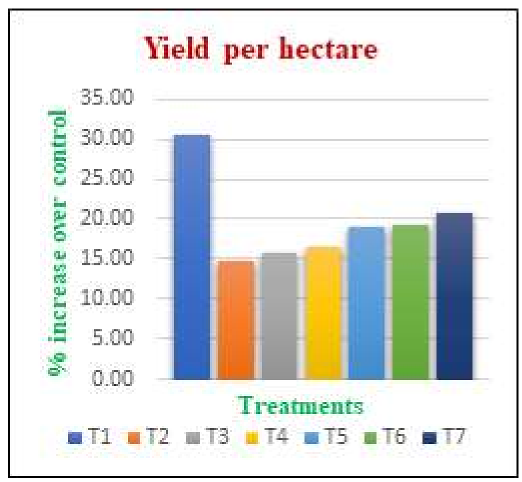


Fig 4 Effect of signal molecules on the Yield per hectare



reported that exogenous application of brassinolide and SNP increased the filled grains percentage under abiotic stress.

Spikelet fertility percentage

The data regarding to the spikelet fertility percentage under salinity stress presented in table 1 and figure 3. The drastic reduction in the spikelet fertility % was observed in the BPT 5204 (T_8- 69.24%) under salinity stress. But the foliar spray of 0.25 mM/L SNP + 0.50 mM/L SA + 0.50 mM/L BR consortia (T_7 – 80.54%) recorded the highest spikelet fertility percentage among different foliar application treatments, followed by foliar spray of 0.25 mM/L SNP + 0.50 mM/L SA (T_5 - 79.93%) and 0.25 mM/L SNP + 0.50 mM/L BR (T_6 - 80.02%) and they were on par with check variety, MCM 103 (T_1 – 85.36%). The foliar spray of consortia (T_7) increased the spikelet fertility (%) by 16.32 % over the control, BPT 5204 (T_8).

Rice panicle sterility is prevalent in plants exposed to high saline conditions, leading to a significant reduction in rice yield. Insufficient supply of carbohydrates to the growing panicle has been identified as the cause of failure in spikelet development (Murty and Murty, 1982). The findings of the present study are in accordance with the results of Li *et al.* (2023) who observed a significant decline in the spikelet fertility due to saline stress. Chen *et al.* (2022) and Okasha (2018) reported that brassinosteroids and salicylic acid treatments positively influenced the number of filled grains in rice respectively, under salinity stress conditions.

Yield per hectare (q/ha)

The data on the yield per hectare under salinity stress presented in table 1 and figure 4. The reduction in yield was observed in the BPT 5204 compared to MCM103. But the foliar application of consortia (T_7 - 57.28 q/ha) recorded the highest yield among different foliar application treatments, followed by 0.25 mM/L SNP + 0.50 mM/L SA (T_5 - 56.44 q/ha) and 0.25 mM/L SNP + 0.50 mM/L BR (T_6 – 56.55 q/ha) and were on par with the check variety, MCM 103 (T_1 – 57.28 q/ha). The foliar spray of consortia (T_7) increased the yield by 20.83 % over the control, BPT 5204 (T_8).

Grain yield is determined by the ability of the source to furnish assimilates during the ripening period and the capacity of the sink to accumulate the imported assimilates (Emongor 2007). Similar result work also reported by Prodjinoto *et al*. (2023). The studies of Dabariya and Bagdi, (2019) concluded that the exogenous application of BR increased the grain yield by mitigating the salt stress effectively in wheat and barley, respectively. The application of SA through seed priming and foliar spray had a positive impact on grain yield under salt stress (Okasha, 2018).

CONCLUSION

In rice salinity stress led to a decrease in yield characteristics and ultimately overall yield. The foliar application of signal molecules improved the yield through the mitigation of salinity stress. The present study demonstrated that the foliar application of 0.25 mM/L SNP + 0.50 mM/L SA + 0.50 mM/L BR consortia significantly increased the yield among all foliar treatments and it was found to be the best. It can be concluded that the plant growth regulators, as a signal molecule could serve as valuable tools in enhancing grain yield under salinity stress.

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