

Salicylic acid: To assuage salinity stress at the early seedling stage of rice

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Article history: Received: 27 Dec., 2021 Revised: 14 May, 2022 Accepted: 21 June, 2022

Citation: Raghu N, B Niharika, K Ravi, A Sowmya, A Kaliaperumal, N Subbarayen and R Thirunavukkarasu. 2022. Salicylic acid: To assuage salinity stress at the early seedling stage of rice. *Journal of Cereal Research* **14 (Spl-1):** 163-167. <http://doi.org/10.25174/2582-2675/2022/122890>

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Agriculture production is highly vulnerable to biotic and abiotic stresses. Abiotic stress is one of the major factors which overshadow the crop growth and productivity world-wide. Due to global warming, rise in sea levels, surplus irrigation without appropriate drainage in inlands and underlying rocks rich in detrimental salts, the area under salt stress is expanding. Salinity affects the plant growth and yield by interfering the physiological, biochemical, cellular and molecular mechanism in plants (Gupta and Huong, 2014). Rice is the major crop which is adversely affected by saline soil in its seedling and vegetative stage. Salt stress induces cellular accumulation of reactive oxygen species (ROS), which damages the biomolecules of the cell (Amor *et al.*, 2007; Mansour *et al.*, 2005).

Although several mechanical, chemical and biochemical approaches are being pursued to overcome the menace of soil salinity, exogenous application of plant growth regulators are considered most effective. Plant hormones have been shown to play a key role in abiotic stress responses (Kaya *et al.*, 2009). Exogenous application of hormones has been shown to impart abiotic stress

tolerance (Yang and Mei 2004; Azooz, 2009; Kanmani *et al.*, 2017).

Among the endogenous growth regulators, a phenol compound named salicylic acid (SA) plays major role under stress (Sakhabutdinova *et al.*, 2003). The application of SA could alleviate the adverse effects of salt stress by the regulation of physiological mechanism in rice (Hayat *et al.*, 2010). SA has a protective function which includes the development of anti-stress programs and acceleration of normalization of growth processes after removal of stress factors (Sakhabutdinova *et al.*, 2003). SA potentially generates a wide range of metabolic responses in plants that affects plant water relations. This molecule has also found to be active in reducing oxidative stress by scavenging the reactive oxygen species (El- Esawi., 2017).

With this above background the primary objective of the study was to assess whether the exogenous application of SA as seed treatment will give salinity tolerance on rice genotypes at early seedling growth stages.

In order to standardize the SA concentration required to overcome the inhibitory effect of salinity stress on early seedling growth, salinity tolerant rice genotype, FL478 and



salinity susceptible rice genotype, IR 29 were selected. The seeds of these genotypes were presoaked overnight in different concentrations of SA such as control (0ppm), 12.5, 25, 50 and 100 ppm. Then the seeds were spread in petriplates containing 150 mM NaCl and a control plate moistened with distilled water was also maintained. After 14 DAS, the growth parameters like shoot length and root length were measured. Under salinity conditions, there was a reduction in both root length and shoot length in two

the genotypes when compared with control (0mM NaCl) (Figure 1). Better root length was noticed in seeds treated with 12.5 ppm and 100 ppm of SA. But better shoot length was noticed in seeds treated with 100 ppm SA. Moreover, in root length the improvement was better in 100 ppm SA treated seeds in IR 29, the salinity susceptible genotype (Figure 1). Therefore 100ppm SA was standardized as an optimum concentration for further experiment to assess the role of salicylic acid in salinity stress tolerance.

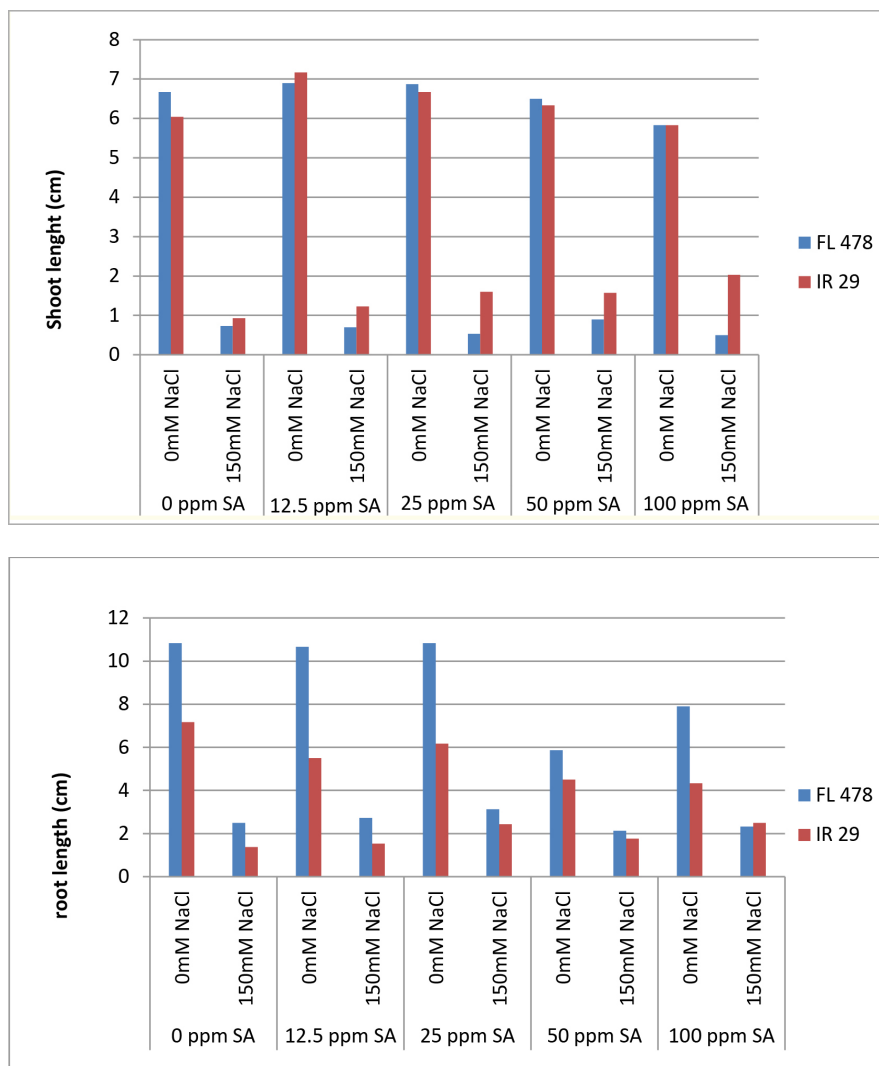


Figure 1: Standardization of Salicylic acid concentration for seed treatment with two genotypes (FL478 – Salt tolerant and IR 29 – Salt susceptible genotypes)

To study the effect of salicylic acid in alleviating salinity stress, growth and biochemical parameters of seven genotypes FL 478, ADT 45, ADT 46, ADT 50, CR 1009, KKL(R)1, and IW Ponni were selected and treated with 100 ppm SA overnight and sown under saline condition(150 mM NaCl) and also under control condition. The selected

genotypes were grown in inclined plate method (Punjabi and Basu, 1982) with some modifications, to assess the role of SA in reducing the salinity stress effect on the growth parameters. The root to shoot ratio (length basis), one of the important physiological trait for abiotic stress tolerance (Thomas *et al.*, 2020) of the seedlings were derived from



Salicylic acid treated (100 ppm) and untreated (0 ppm) from control and salinity condition. Under control condition the mean root to shoot ratio has reduced from 1.78 to 1.77 at 100 ppm SA. Whereas, under salinity stress, the mean value has significantly increased from 1.8 to 2.83 when treated with SA at 100 ppm (Table 1). The root to shoot ratio on length basis of FL 478 which is a salt tolerant genotype increases from 2.46 to 2.50 when seeds

were treated with 100 ppm SA under Salinity stress and similar trend was recorded in genotypes ADT 45, ADT 46, ADT 50, KKL (R) 1 and IW PONNI with 100 ppm SA treatment. Root to shoot ratio on length basis increased under salinity condition when seeds are treated with 100 ppm SA than the non treated seeds indicating that, when seeds are treated with SA, the tolerance towards salinity get enhanced.

Table 1. Root to shoot ratio (length basis) of rice genotypes under salinity conditions with and without Salicylic acid treatment in inclined plate method

Genotypes	0mMNaCl		150mMNaCl	
	0 ppm SA	100 ppm SA	0 ppm SA	100 ppm SA
	RL/SL	RL/SL	RL/SL	RL/SL
FL 478	1. 72	1. 56	2. 46	2. 50
ADT 45	1. 88	1. 64	1. 85	2. 23
ADT 46	1. 36	1. 73	0. 38	2. 98
ADT 50	2. 32	1. 93	0. 43	2. 75
CR 1009	1. 61	1. 89	2. 34	1. 87
KKL(R) 1	1. 76	1. 56	2. 98	3. 01
IW PONNI	1. 84	2. 11	2. 13	4. 46
Mean	1. 78	1. 77	1. 8	2. 83
CD _{0.05}				
GENOTYPE	0. 48			
NaCl	0. 26			
SA	0. 68			
G*NaCl	0. 26			
G*SA	0. 68			
NaCl*SA	0. 37			
G*NaCl*SA	0. 97			

It indicated that exogenous SA application on rice plants lead to an increase in salt tolerance. Similar results were recorded in rice by Jini and Joseph (2017). Likewise, SA treatment has been reported to enhances the growth of barley (El- Tayeb, 2005), wheat (Tammam *et al.*, 2008), sunflower (Noreen *et al.*, 2009), mungbean (Khan *et al.*, 2012) under salt stress. SA treatment increases the growth of radicle cells by both the division and expansion of meristem cells (Boukraa *et al.*, 2013). The interaction between salinity and SA possibly induces the genes encoding salt resistance and acts on germination by increasing the physiological activity and mobilization of the reserved material necessary for the growth (Szalai *et al.*, 2005).

Different abiotic stresses like heat, drought, salinity, and heavy metal affect the process of photosynthesis directly

and indirectly. The direct and indirect effects include a reduced activity of photosynthesis enzymes, decrease in CO₂ assimilation rate, degradation of chlorophyll content, etc (Swami *et al.*, 2021). When the biochemical parameters like total chlorophyll and carotenoids were quantified (Aron, 1949), both showed increased trend when seeds were treated with 100ppm SA under salinity and normal condition (Fig. 2). SA treatments, increased pigments content of the plants under control and salinity condition. Ghassemi-Golezani and Lotfi (2015) reported that exogenous application of salicylic acid showed an increase in Chlorophyll a, b and carotenoids content under normal field condition. Similarly, there was an increase in photosynthetic pigments on treatment with SA in corn (Khan *et al.*, 2003) and in soybean (Zhou *et al.*, 1999).



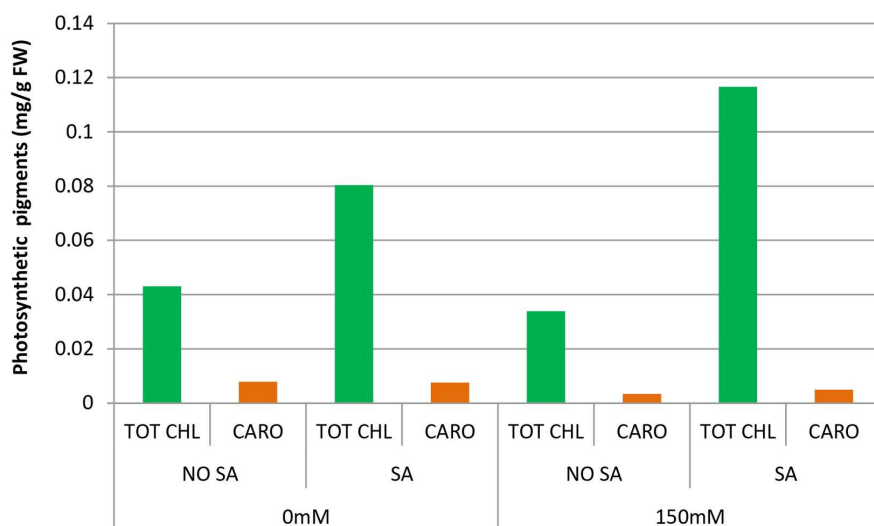


Figure 2: Effects of 100 ppm salicylic acid (SA) on Photosynthetic pigments of rice varieties for salt tolerance during early seedling growth.

Summary

SA has the ability to overcome the inhibitory effects of salinity at seedling stage of rice. Presoaking in 100ppm salicylic acid showed an increase in root to shoot ratio and photosynthetic pigments, which might have increased the hardiness of seedling to thrive under saline condition.

Declarations/ disclosures

Compliance with ethical standards

NA

Author Contribution

S.Nadaradjan and Ramanadane Tconceptualized and designed the experiments. Nalishma Raghu, Niharika B, Karpagaraj R, Sowmya A, Arulnidhi K performed experiment. Manuscript was drafted by S Nadaradjan and Nalishma Raghu.

Conflict of Interest

Authors declare that they have no conflict of interest.

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