

## RESEARCH ARTICLE

# Enhancement of Salinity Tolerance in Green Gram (CO 8) through Plant Growth Regulators: Physiological and Biochemical Responses

Ajmal Siddique S<sup>1\*</sup>, R. Gowthami<sup>2</sup>, Indianraj N<sup>3</sup>, Bavithra Balakrishnan<sup>4</sup>, Venkatesan V G<sup>5</sup>, Kavya D<sup>6</sup>

<sup>1\*</sup>Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore-3, Tamil Nadu, India.

<sup>2</sup>Department of Crop Management, Thanthai Roever Institute of Agriculture and Rural Development, Perambalur, Tamil Nadu, India.

<sup>3</sup>Research Scholar, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal.

<sup>4</sup>Ph.D. Research Scholar - Vegetable Science, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal.

<sup>5</sup>Research scholar, Tamil Nadu Agricultural University, Coimbatore-3, Tamil Nadu, India.

<sup>6</sup>Research Scholar, Bidhan Chandra Krishi Vishwavidyalaya, Mohanpur, Nadia, west bengal.

## ABSTRACT

Green gram (*Vigna radiata*), also known as Mung bean, belongs to the Fabaceae family. Environmental stress, particularly salinity, significantly limits plant growth and productivity. Plant growth regulators (PGRs), such as NAA, kinetin, and gibberellic acid, can mitigate the effects of salinity stress. A study was conducted from April to July 2022 at the Crop Physiology Laboratory, Thanthai Roever Institute of Agriculture and Rural Development, Perambalur, Tamil Nadu, India, to examine the “Effect of plant growth regulators on green gram (CO 8) under salinity stress.” The experiment aimed to standardize NaCl levels for assessing salinity effects on seed germination and to evaluate PGR responses under salinity stress. NaCl concentrations of 75 mM, 100 mM, 150 mM, and 200 mM were tested, with 50% germination observed at 150 mM, which was standardized for subsequent trials. The study followed a Completely Randomized Design (CRD) with eight treatments: T<sub>1</sub> (Absolute Control), T<sub>2</sub> (150 mM NaCl), T<sub>3</sub> (NAA 100 ppm), T<sub>4</sub> (NAA 200 ppm), T<sub>5</sub> (Kinetin 50 ppm), T<sub>6</sub> (Kinetin 100 ppm), T<sub>7</sub> (GA<sub>3</sub> 100 ppm), and T<sub>8</sub> (GA<sub>3</sub> 200 ppm). Results showed that salinity stress reduced seedling growth, but PGR treatment improved germination, shoot and root length, dry matter production, vigour index, Stress tolerance index (%), Relative water content (%), Chlorophyll a (mg g<sup>-1</sup>), Chlorophyll b (mg g<sup>-1</sup>) & Total Chlorophyll content (mg g<sup>-1</sup>). GA<sub>3</sub> 200 ppm (T<sub>8</sub>) exhibited the highest germination (79.68 %), shoot length (17.3 cm), root length (6.4 cm), vigour index (1745), dry matter production (0.25 g), Stress tolerance index (83.09 %), Relative water content (88.44 %), Chlorophyll a (0.95 mg g<sup>-1</sup>), Chlorophyll b (0.21 mg g<sup>-1</sup>) & Total Chlorophyll content (1.22 mg g<sup>-1</sup>) demonstrating its effectiveness in mitigating salinity-induced stress.

Received: 12 Dec 2025

Revised: 10 Feb 2026

Accepted: 26 Feb 2026

**Keywords:** Green gram, Salinity stress, PGRs, NaCl, Gibberellic acid

## INTRODUCTION

Green gram (*Vigna radiata*), also called Mung bean, is a pulse crop belonging to the botanical family Fabaceae. It is a warm-season, frost-intolerant plant suitable for planting in temperate, subtropical, and

\*Corresponding author mail: [ajmalsiddiq333@gmail.com](mailto:ajmalsiddiq333@gmail.com)



Copyright: © The Author(s), 2026. Published by Madras Agricultural Students' Union in Madras Agricultural Journal (MAJ). This is an Open Access article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited by the user.

tropical regions. The optimal temperature for mung bean germination and growth is 15-18 °C. It has high adaptability to various soil types, with the best soil pH between 6.2 and 7.2. Since it is a short-day plant, long-day conditions will delay its flowering and podding.

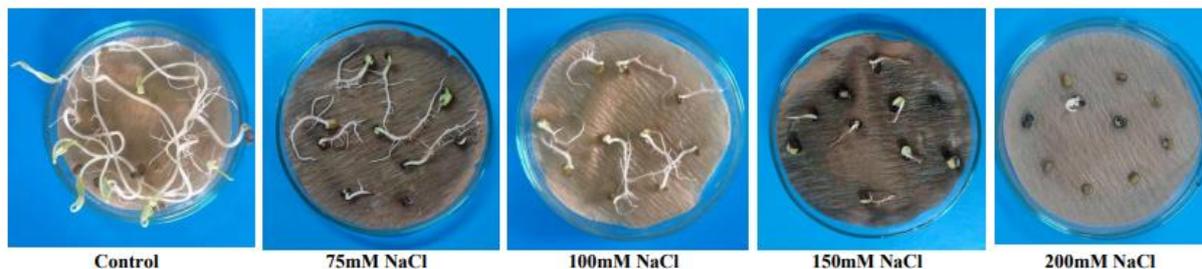
Environmental stress is a major area of scientific concern because it constrains crop productivity. Anthropogenic activities have further worsened the situation. Abiotic stresses, such as stable food crops. Salinity is one of the most important abiotic stress factors limiting plant growth and productivity (Flowers, 2004). High exogenous salt concentrations affect seed germination, induce water deficit, and cause ionic imbalance, resulting in ion toxicity and osmotic stress (Khan and Panda, 2009). According to estimates from FAQs, over 6% of the world's land is affected by salinity. Thus, salinity stress appears to be a major constraint to plant and crop productivity. Hence, our understanding of salinity impact on various aspects of plant metabolism and its tolerance strategies. Crop productivity is severely affected by salinity stress. This occurs directly due to the impact of photosynthesis, respiration, nutrient assimilation, hormonal imbalances, etc.

Plant hormones, also known as phytohormones, are small chemical messengers produced within the plant at extremely low concentrations and play a crucial role in plant growth and development by coordinating cellular activities. It controls all aspects of plant growth and development, from embryogenesis to regulation of organ size, pathogen defense, stress tolerance, and reproductive development. Unlike in animals (in which hormone production is restricted to specialized glands), each plant cell is capable of producing hormones. Phytohormones occur across the plant kingdom, including algae, where they perform functions similar to those in higher plants. Some phytohormones also occur in microorganisms, such as unicellular fungi and bacteria; however, in these cases they do not play a hormonal role and are better regarded as secondary metabolites. Auxin plays an important role in cell elongation in the shoot, apical dominance, root initiation, prevention of abscission, induction of parthenocarpy, stimulation of respiration, activation of cell division, and induction of callus formation, and induction of vascular differentiation in plants. NAA is a synthetic plant hormone in the auxin family and is an integral component in many commercial plants rooting horticultural products. It is a rooting agent and is used for the vegetative propagation of plants

from stem and leaf cuttings. It is also used for plant tissue culture. Kinetin is a cytokinin derivative that promotes cell division and plant growth. It has been shown to naturally occur in the DNA of organisms, including humans and various plants. While kinetin is used in tissue cultures to produce new plants, it is also found in cosmetic products as an anti-aging agent. Gibberellic acid, a plant hormone stimulating plant growth and development, is a tetracyclic di-terpenoid compound. GAs stimulate seed germination, trigger transitions from meristem to shoot growth, juvenile to adult leaf stage, vegetative to flowering, determine sex expression and grain development along with an interaction of different environmental factors viz., light, temperature, and water (Sivakumar *et al.*, 2018).

## MATERIALS AND METHODS

The experiment was carried out to determine the effect of plant growth regulators that mitigate the effects of salinity in green gram (CO 8). The research was conducted as a laboratory study at the Crop Physiology laboratory, Department of Crop Management, Thanthai Roever Institute of Agriculture and Rural Development, Perambalur, Tamil Nadu, India, to study the "Effect of plant growth regulators on green gram (CO 8) under salinity stress". The experiment was laid out under a completely randomized block design with eight treatments and three replications. The seeds of green gram (CO 8) were placed in petriplates. The petridishes for the experiment were sterilized using 0.01 per cent  $HgCl_2$  and 70 per cent ethanol, and finally repeated washing with distilled water. The salinity was imposed using NaCl at concentrations of 75 mM, 100 mM, 150 mM, and 200 mM. Among these NaCl concentrations, no seed germination occurred at 200 mM. At 75 mM and 100 mM, almost all the seeds germinated, along with the control. However, only 50 per cent of the seeds germinated at 150 mM NaCl compared to the control (Fig. 1). Hence, 150 mM NaCl was standardized for the experiment to evaluate the effect of plant growth regulators in mitigating salinity stress in green gram. Seeds were soaked in  $T_3$ : NAA 100 ppm,  $T_4$ : NAA 200 ppm,  $T_5$ : kinetin 50 ppm,  $T_6$ : kinetin 100 ppm,  $T_7$ :  $GA_3$  100 ppm and  $T_8$ :  $GA_3$  200 ppm. After that, the seeds were dried in the shade for 4 hours. These treated seeds were later placed on a germination sheet in each petri plate separately, with untreated seeds in the control and absolute control. The germination paper was moistened at regular intervals with a 150 mM NaCl solution



**Fig. 1. Effect of Standardized NaCl on seedling growth of green gram CO 8**

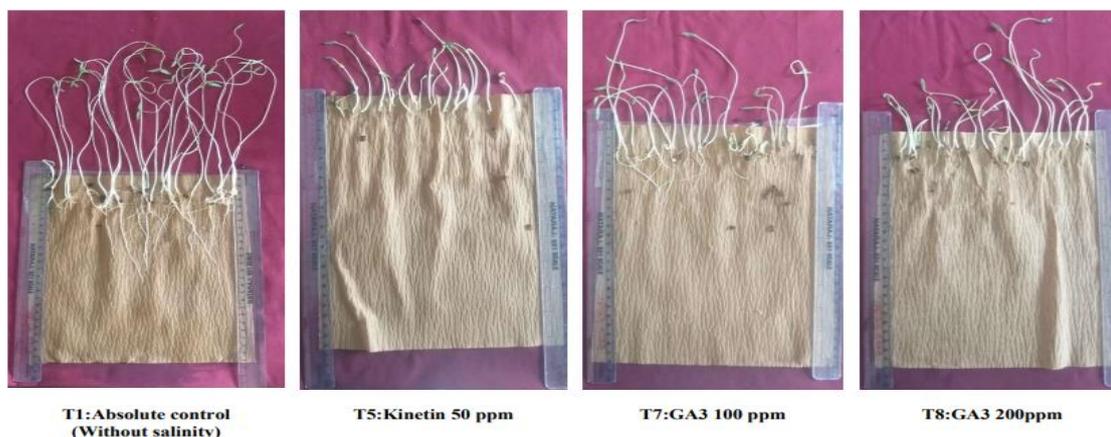
for salinity and with water for the absolute control. The petri plates were kept in the laboratory at room temperature. The seeds were allowed to germinate by pouring approximately 10 ml of 150 mM NaCl solution once every 3 days. Distilled water was used to maintain absolute control. Germination percentage was recorded every 24-hour interval up to 7 days. Seeds were considered germinated when the radicle length reached at least 2 mm. Finally, germination was recorded on the 7<sup>th</sup> day, and the number of seeds germinated was expressed as a percentage. Root and shoot lengths were measured 7 days after sowing and expressed in cm. For total dry matter production, 10 seedlings from each treatment were randomly selected and placed in a hot-air oven at 80 °C for 48 hours, then weighed to determine total dry weight. The seed vigour index was calculated using the following formula proposed by AbdulBaki and Anderson (1973). Stress tolerance index of the seeds was calculated using the following formula proposed by Dhopte and Livera-Munoz (1989). The contents of chlorophyll ‘a’, ‘b’, and total chlorophyll were estimated by adopting the procedure of Arnon (1949), and the content was expressed as mg g<sup>-1</sup> of fresh weight. The relative water content (RWC) was estimated according to Barrs and

Weatherley (1962) and calculated using the following formula, expressed as per cent. The data on various parameters were analyzed statistically using AGRES software. Wherever the treatment differences were found significant, critical differences were calculated at the 5% probability level, and the values were furnished. The treatment differences that were not significant were denoted as “NS”.

**RESULTS AND DISCUSSION**

**Germination percentage (%)**

When the seeds are exposed to salinity stress, the germination percentage was reduced compared to the absolute control. A significant difference was observed among all treatments with respect to seed germination (Fig. 2). Absolute control (T<sub>1</sub>) showed the highest germination percentage (92.26 %), and the control (T<sub>2</sub>) showed the lowest germination percentage (48.21 %). Seed treatment with PGRs resulted in a significant increase in germination percentage. Among the PGRs, the GA<sub>3</sub> 200 ppm (T<sub>8</sub>) treatment showed the highest germination percentage (79.68 %), followed by GA<sub>3</sub> 100 ppm (T<sub>7</sub>) (76.27 %) and Kinetin 100 ppm (T<sub>6</sub>) (72.21 %). However, the lowest germination percentage was observed in the NAA 200 ppm (T<sub>4</sub>) treatment



**Fig. 2. Effect of plant growth regulators on seedling growth of green gram CO 8 under salinity**

(59.78 %) (Table 1). It may be due to GA<sub>3</sub> at 200 ppm (T<sub>8</sub>) inducing seed germination by inhibiting abscisic acid in the seed. GA<sub>3</sub> is known to play an essential role in seed germination (Fahad et al., 2015). A similar result was reported by Khan and Panda (2008), who stated that GA<sub>3</sub> increased germination percentage in caper plants under salinity.

**Shoot length (cm)**

Significant differences were observed across all treatments in shoot length. The absolute control (T<sub>1</sub>) recorded the highest shoot length (23.87 cm), and the control (T<sub>2</sub>) recorded the lowest shoot length (4.49 cm). The result confirmed that salinity reduces shoot length. The PGR treatments showed a positive response against salinity. GA3 200 ppm (T<sub>8</sub>) had the most prominent result (17.3 cm), followed by GA<sub>3</sub> 100 ppm (T<sub>7</sub>) (17.3 cm), Kinetic 50 ppm (T<sub>5</sub>) (9.3 cm). The lowest shoot length was recorded by NAA 200 ppm (T<sub>4</sub>) (5.4 cm) (Table 1).

**Root length (cm)**

The root length (Table 1) was affected more pronouncedly by salinity than shoot length. Significant differences were observed across all treatments in root length. The maximum root length was observed in the absolute control (T<sub>1</sub>) (8.54 cm), and the minimum root length was measured in kinetin 50 ppm (T<sub>5</sub>) (1.9 cm). The results support the idea that salinity causes a negative relationship with root length. However, the PGR treatments showed positive effects against salinity. Among the treatments, GA3 200 ppm

(T<sub>8</sub>) (6.4 cm), GA<sub>3</sub> 100 ppm (T<sub>7</sub>) (4.5 cm), and NAA 100 ppm (T<sub>3</sub>) (2.52 cm) showed negative effects against salinity. Among the treatments, kinetin 50ppm (T<sub>5</sub>) (1.9 cm), NAA 200ppm (T<sub>4</sub>) (1.15 cm), and kinetin 100 ppm (T<sub>6</sub>) (2.7 cm). The root length of control (T<sub>2</sub>) is 2.52 cm, which was on par with kinetin 100ppm (T<sub>6</sub>) (2.7 cm) and control (T<sub>2</sub>) (2.15 cm) (Table 1).

**Vigour index**

The vigour index results exhibited significant variation among the treatments. The highest vigour index was recorded in absolute control (T<sub>1</sub>) (2989), and the lowest vigour index was recorded by control (T<sub>2</sub>) (320). Among the treatments used, GA3 200 ppm (T<sub>8</sub>) recorded the highest vigour index (1745), followed by GA<sub>3</sub> 100 ppm (T<sub>7</sub>) (1670) and kinetin 100 ppm (T<sub>6</sub>) (809). Significantly lowest vigour index was observed in NAA 200 ppm (T<sub>4</sub>) (510) (Table 1). This might be due to increased germination percentage; shoot and root length were recorded under the GA<sub>3</sub> treatment.

**Total dry matter production (g)**

The data (Table 2) on total dry matter production showed a significant difference between the treatments. The highest total dry matter production was observed in the absolute control (T<sub>1</sub>) (0.35 g), and the control (T<sub>2</sub>) recorded the lowest value (0.09 g), indicating that total dry matter production decreased under salinity stress. Among the ameliorants used, GA<sub>3</sub> at 200 ppm (T<sub>8</sub>) showed the highest value (0.25 g). The treatments NAA 200 ppm (T<sub>4</sub>) showed the minimum value (0.12 g)

**Table 1. Effect of PGRs on germination percentage (%), Shoot length (cm), Root length (cm), Vigour index, and Total dry matter production (g) of green gram under Salinity**

S. No	Treatment details	Germination percentage (%)	Shoot length (cm)	Root length (cm)	Vigour index	Total dry matter production (g)
1	T <sub>1</sub> : Absolute control	92.21	23.87	8.54	2989	0.35
2	T <sub>2</sub> : 150 mM NaCl	48.12	4.49	2.15	320	0.09
3	T <sub>3</sub> : NAA 100 ppm	59.78	7.3	2.52	658	0.15
4	T <sub>4</sub> : NAA 200 ppm	64.45	5.4	1.15	510	0.12
5	T <sub>5</sub> : Kinetin 50 ppm	67.86	9.3	1.9	608	0.16
6	T <sub>6</sub> : Kinetin 100 ppm	72.26	6.4	2.7	809	0.18
7	T <sub>7</sub> : GA3 100 ppm	76.27	15.5	4.52	1670	0.21
8	T <sub>8</sub> : GA3 200ppm	79.68	17.3	6.4	1745	0.25
	Mean	70.08	11.20	3.74	1164	0.19
	SE.d	3.07	0.31	0.13	17	0.0046
	CD (P=0.05)	6.51	0.65	0.27	36	0.0097



**Stress tolerance index (%)**

The results (Table 2) showed the significant differences in the tolerant potential among the treatments. The highest stress tolerance index was noticed in GA<sub>3</sub> 200 ppm (T<sub>8</sub>) treatment (83.09 %), followed by GA<sub>3</sub> 100 ppm (T<sub>7</sub>) (79.54 %), kinetin 100ppm (T<sub>6</sub>) (38.54 %) treatments; the lowest stress tolerance index was recorded by NAA 200 ppm (T<sub>4</sub>) (24.31 %). This increment may be due to GA<sub>3</sub> at 200 ppm (T<sub>8</sub>) induced germination, vigour index, and shoot and root length under a saline environment.

**Chlorophyll content**

The salinity treatments reduced the chlorophyll content compared to control. A significant difference was observed in all treatments with respect to chlorophyll extent. GA<sub>3</sub> 200 ppm (T<sub>8</sub>) obtained the highest chlorophyll content (1.090 mg g<sup>-1</sup>). Seed treatment with PGRs resulted in a significant increase in chlorophyll content. Among the PGRs, the highest chlorophyll content was observed in seed treatment with kinetin at 100 ppm (T<sub>6</sub>) (1.22 mg g<sup>-1</sup>), followed by GA<sub>3</sub> at 50 ppm (T<sub>7</sub>) (1.09 mg g<sup>-1</sup>). However, the lowest chlorophyll content was observed in the NAA 100 ppm (T<sub>3</sub>) treatment (0.43 mg g<sup>-1</sup>), followed by the NAA 200 ppm (T<sub>4</sub>) treatment (0.69 mg g<sup>-1</sup>). Chlorophyll content of the absolute control (T<sub>1</sub>) is (0.90 mg g<sup>-1</sup>) (Table 2). Kinetin improves chlorophyll content, similar to Cengiz's response. Pakar *et al.* (2016) reported that foliar application of kinetin improved chlorophyll levels in salt-stressed plants.

**Relative water content**

Significant differences were observed across all treatments in relative water content. The GA<sub>3</sub> 200 ppm (T<sub>8</sub>) treatment showed the highest RWC (88.44%). The control (T<sub>2</sub>) had the lowest RWC (61.85%). Among the PGRs, RWC increased significantly. The highest RWC was observed in seed treatment with GA<sub>3</sub> 200 ppm (T<sub>8</sub>), followed by kinetin 100 ppm (T<sub>6</sub>) (82.33 %) and GA<sub>3</sub> 100 ppm (T<sub>7</sub>) (80.70 %). The lowest RWC in treatments is NAA 100 ppm (T<sub>3</sub>) (68.43 %), followed by NAA 200 ppm (T<sub>4</sub>) (72.12 %). The absolute control (T<sub>2</sub>) RWC is (82.10 %) (Table 2).

**Abbreviations**

- °C : Degree Celsius
- % : Per cent
- CD : Critical Difference
- cm : Centimetre
- CO : Coimbatore
- DNA : Deoxyribonucleic Acid
- et al.* : Co-workers
- GA<sub>3</sub> : Gibberellic Acid
- g : Gram
- Hgcl<sub>2</sub> : Mercuric chloride
- mg g<sup>-1</sup> : Milligram per gram
- mM : millimolar
- mm : Millimetre
- NAA : Naphthalene Acetic Acid
- NaCl : Sodium Chloride
- NS : Non-Significant
- PGR : Plant growth regulator
- pH : Negative logarithm of hydrogen ion
- ppm : Parts per million
- RWC : Relative water content
- Std : Standard

**Table 2. Effect of PGRs on Stress tolerance index (%), Relative water content (%), Chlorophyll a (mg/g), Chlorophyll b (mg/g) & Total Chlorophyll content (mg/g) of green gram under Salinity**

S. No	Treatment details	Stress tolerance index (%)	Relative water content (%)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll content (mg/g)
1	T <sub>1</sub> : Absolute control		82.10	0.72	0.18	0.90
2	T <sub>2</sub> : 150 mM NaCl	15.22	61.85	0.11	0.05	0.16
3	T <sub>3</sub> : NAA 100 ppm	31.31	68.43	0.34	0.09	0.43
4	T <sub>4</sub> : NAA 200 ppm	24.31	72.12	0.58	0.12	0.69
5	T <sub>5</sub> : Kinetin 50 ppm	28.95	77.57	0.66	0.15	0.82
6	T <sub>6</sub> : Kinetin 100 ppm	38.54	82.33	0.95	0.28	1.22
7	T <sub>7</sub> : GA3 100 ppm	79.54	80.70	0.65	0.11	0.76
8	T <sub>8</sub> : GA3 200ppm	83.09	88.44	0.88	0.21	1.09
	Mean	42.99	76.69	0.61	0.15	0.76
	SE.d	2.70	4.25	0.022	0.007	0.03
	CD (P=0.05)	5.78	9.01	0.048	0.016	0.06

## CONCLUSION

Salinity stress significantly reduced germination percentage, shoot and root length, vigor index, total dry matter production (TDMP), Stress tolerance index (%), Relative water content (%), & Total Chlorophyll content ( $\text{mg g}^{-1}$ ) in green gram. The study standardized 150 mM NaCl as the optimal salinity level for evaluating plant growth regulator (PGR) treatments. Among the treatments, GA<sub>3</sub> 200 ppm (T<sub>8</sub>) showed the highest effectiveness, increasing germination by 31.56 %, shoot length by 46 %, root length by 46 %, vigor index by 70 %, TDMP by 87 %, and stress tolerance index (70 %) compared to the saline control. GA<sub>3</sub> 100 ppm (T<sub>7</sub>) was the second-best treatment, showing considerable improvements in growth parameters. Kinetin 100 ppm (T<sub>6</sub>) enhanced chlorophyll content under stress. These findings suggest that GA<sub>3</sub> 200 ppm is the most effective treatment for mitigating salinity-induced damage, with GA<sub>3</sub> 100 ppm as a suitable alternative.

### Funding and Acknowledgment:

The results presented in this paper are a part of project work done for the completion of the undergraduate degree programme supported by Thanthai Roever Institute of Agriculture and Rural Development, Perambalur, Tamil Nadu.

### Ethics Statement:

Ethical approval was not required for this study, as it did not involve human participants, animals, or sensitive data.

### Originality and Plagiarism:

All authors confirm that this manuscript is an original work and has not been submitted for publication elsewhere. All sources of previously published material, including figures and tables, have been properly cited and referenced. The manuscript is free from plagiarism, and the authors have ensured that the data presented are accurate and representative of the research findings. No part of this manuscript has been reused without appropriate citations, including self-citations.

### Consent for Publication:

All authors have read and approved the final manuscript. The authors give their consent for the manuscript to be published in the Madras Agricultural Journal. The authors confirm that all necessary permissions for publication, including ethical approvals and data sharing, have been obtained. There are no conflicts of interest to declare.

### Competing Interests:

The authors declare no competing interests.

### Data Availability:

No

### Author Contributions:

AAjmal Siddique S contributed to preliminary analysis, writing the original draft and participated in manuscript writing and editing. R. Gowthami designed the research methodology, contributed to project administration, and supervised the project. Indianraj N performed data curation and statistical analysis. Bavithra Balakrishnan contributed to refining the technical content of the manuscript. Venkatesan V G and Kavya D contributed to data compilation, preliminary analysis, literature support and critical review of the manuscript prior to submission.

## REFERENCES

- Abdul-Baki, A. A. and J. D. Anderson. 1973. Vigor determination in soybean seed by multiple criteria 1. *Crop Science*, 13: 630-633. <https://doi.org/10.2135/cropsci1973.0011183X001300060013x>
- Colebrook, E. H., Thomas, S. G., Phillips, A. L. and P. Hedden. 2014. The role of gibberellin responses to abiotic stress. *Journal of Experimental Biology*, 217: 67-75. <https://doi.org/10.1242/jeb.089938>
- Fahad, Shah, Hussain, Saddam, Matloob, Amar, Khan, Faheem Ahmed, Khaliq, Abdul, Saud, Shah, Hassan, Shah, Shan, Darakh, Khan, Fahad, Ullah, Najeeb, Faiq, Muhammad, Khan, Muhammad Rafiullah, Tareen, Afrasiab Khan, Khan, Aziz, Ullah, Abid, Ullah, Nasr, and Huang, Ianliang. (2015). Phytohormones and plant responses to salinity stress: a review. *Plant growth regulation*, 75(2): 391-404. <https://doi.org/10.1007/s10725-014-0013-y>
- Flowers, T. J. 2004. Improving crop salt tolerance. *Journal of Experimental Botany*, 55: 307-319. <https://doi.org/10.1093/jxb/erh003>
- Guo, Y., Jiang, Q., Hu, Z., Sun, X., Fan, S. and H. Zhang. 2018. Function of the auxin-responsive gene TaSAUR75 under salt and drought stress. *The Crop Journal*, 6: 181-190. <https://doi.org/10.1016/j.cj.2017.08.005>
- Khan, A., Tan, D. K. Y., Afridi, M. Z. et al. 2017. Nitrogen fertility and abiotic stresses management in



- cotton crop: a review. *Environmental Science and Pollution Research*, 24: 14551-14566. <https://doi.org/10.1007/s11356-017-8920-x>
- Khan, M. H., and Panda, S. K. (2008). Alterations in root lipid peroxidation and antioxidative responses in two rice cultivars under NaCl-salinity stress. *Acta Physiologiae Plantarum*, 30(1): 81-89. <https://doi.org/10.1007/s11738-007-0093-7>
- Ngara, R., Ndimba, R., Borch-Jensen, J., Jensen, O. N. and B. Ndimba. 2012. Identification and profiling of salinity stress-responsive proteins in Sorghum bicolor seedlings. *Journal of Proteomics*, 75(13): 4139-4150. <https://doi.org/10.1016/j.jprot.2012.05.038>
- Pakar, N. Pirasteh-Anosheh, H. Emam, Y. and Pessarakli, M. 2016. Barley growth, yield, antioxidant enzymes, and ion accumulation affected by PGRs under salinity stress conditions. *Journal of Plant Nutrition*. 39(10):1372–1379. <https://doi.org/10.1080/01904167.2016.1143498>
- Panda, S. K. and M. H. Khan. 2009. Growth, oxidative damage and antioxidant responses in greengram (*Vigna radiata* L.) under short-term salinity stress and its recovery. *Journal of Agronomy and Crop Science*, 195(6): 442-454. <https://doi.org/10.1111/j.1439-037X.2009.00371.x>
- Prakash, M. 2017. Effect of salinity on germination and seedling growth of green gram varieties. *International Journal of Plant Sciences (Muzaffarnagar)*, 12(1): 79-84. <https://doi.org/10.15740/HAS/IJPS/12.1/79-84>
- Ryu, H. and Y. G. Cho. 2015. Plant hormones in salt stress tolerance. *Journal of Plant Biology*, 58: 147-155. <https://doi.org/10.1007/s12374-015-0103-z>
- Sivakumar, R. and S. J. Priya. 2021. PGRs and nutrient consortium effect on water relations, photosynthesis, catalase enzyme and yield of blackgram under salinity stress. *Legume Research: An International Journal*, 44(4): 413-418. <https://doi.org/10.18805/LR-4118>
- Turan, M. A., Turkmen, N. and N. Taban. 2007. Effect of NaCl on stomatal resistance and proline, chlorophyll, Na, Cl and K concentrations of lentil plants. *Journal of Agronomy*, 6(2): 378-381. <https://doi.org/10.3923/ja.2007.378.381>
- Werner, T. and T. Schmülling. 2009. Cytokinin action in plant development. *Current Opinion in Plant Biology*, 12(5): 527-538. <https://doi.org/10.1016/j.pbi.2009.07.002>
- Zhu, G., An, L., Jiao, X., Chen, X., Zhou, G. and N. McLaughlin. 2019. Effects of gibberellic acid on water uptake and germination of sweet sorghum seeds under salinity stress. *Chilean Journal of Agricultural Research*, 79: 415-424. <https://doi.org/10.4067/S0718-58392019000300415>