



# Effect Of Sodium Bicarbonate Concentrations On Seed Germination Of *Amaranthus Dubius* Mart.Ex Thell. And *Hibiscus Sabdariffa* L.

M.Sridevi<sup>1</sup>, A.Satya Gowri Parvathi <sup>2\*</sup>, K.Sridevi<sup>3</sup>, B.Asha Latha<sup>4</sup>

K.Ramalakshmi <sup>5</sup> P.Binduvadana <sup>6</sup>,

1, Head of the Department Botany, SKR Government Degree College(W), Rajamahendravaram, Andhra Pradesh, India – 533103.

2,3 &4, Lecturers In Botany, SKR Government Degree College(W), Rajamahendravaram, Andhra Pradesh, India – 533103.

5&6, Students, Department of Botany, SKR Government Degree College(W), Rajamahendravaram, Andhra Pradesh, 533103.

**Abstract:** The present study was conducted to evaluate the effect of different concentrations of sodium bicarbonate ( $\text{NaHCO}_3$ ) on the seed germination of *Amaranthus dubius* Mart. ex Thell. (*Amaranthus*) and *Hibiscus sabdariffa* L. (*Hibiscus*). Seeds were subjected to seven treatments: 0 mg (control), 1 mg, 3 mg, 5 mg, 10 mg, and 15 mg of sodium bicarbonate solution. The control group exhibited 100% germination, indicating normal physiological activity in the absence of stress. However, with increasing concentrations of sodium bicarbonate, a gradual reduction in germination percentage was observed. At the highest concentration (15 mg), germination was markedly reduced, demonstrating the inhibitory effect of sodium bicarbonate on seed viability and early seedling growth. The study concludes that sodium bicarbonate induces alkaline stress, adversely affecting seed germination, with *Amaranthus* showing relatively greater tolerance compared to *Hibiscus sabdariffa*.

**Keywords:** *Amaranthus dubis*, *Hibiscus sabdariffa*, Sodium bicarbonate, Seed germination, Salinity stress.

## I. INTRODUCTION

Seed germination is a crucial phase in a plant's life cycle, determining its establishment and productivity. Environmental stresses such as salinity and alkalinity affect germination by reducing water uptake and enzyme activity. Sodium bicarbonate, a major cause of alkaline stress, influences seed physiology by altering pH balance and ion availability. *Amaranthus* and *Hibiscus* are economically important crops cultivated for their edible and medicinal value. Understanding their response to Sodium bicarbonate stress helps in selecting tolerant varieties for alkaline soils. Seed germination is a vital physiological process that determines plant establishment and crop productivity (Bewley et al., 2013). This stage is highly sensitive to abiotic stresses, particularly salinity and alkalinity, which interfere with water uptake, enzyme activation, and metabolic processes required for germination (Munns & Tester, 2008). *Amaranthus* spp. and *Hibiscus*. are economically important plants valued for their nutritional and medicinal properties, yet their responses to Sodium bicarbonate induced stress during germination are not well documented (Ali et al., 2014).

Therefore, evaluating the effect of different sodium bicarbonate concentrations on seed germination of these species is essential for identifying tolerance potential under alkaline soil conditions.

## II. REVIEW OF LITERATURE

Previous studies have clearly demonstrated that salinity and alkalinity stress adversely affect seed germination and early seedling growth in a wide range of crop plants. Salinity and alkaline conditions reduce water uptake, disturb ionic balance, and inhibit enzymatic activities essential for germination. Singh et al. (2015) reported that sodium bicarbonate significantly reduced germination percentage in spinach and okra, indicating sensitivity of these crops to alkaline stress. Similarly, Kumar and Rao (2018) observed that increasing bicarbonate concentrations delayed radicle emergence and caused a marked reduction in chlorophyll content, thereby impairing early seedling development and photosynthetic efficiency.

Chauhan et al. (2020) found that *Amaranthus* species exhibited moderate tolerance to salinity stress compared to other leafy vegetables, suggesting species-specific adaptive mechanisms under stress conditions. In contrast, studies on *Hibiscus sabdariffa* by Devi et al. (2021) revealed that alkaline environments drastically reduced root and shoot elongation, highlighting its higher sensitivity to alkaline stress. Sodium bicarbonate is a major alkaline salt present in sodic soils and induces stress by increasing soil pH and disrupting ionic balance, thereby negatively affecting seed vigor and germination rate (Yang et al., 2007).

These findings collectively indicate that alkaline stress negatively influences germination and seedling growth, with tolerance levels varying among plant species, emphasizing the importance of screening and selecting stress-tolerant varieties for cultivation in alkaline soils.

## III. MATERIALS AND METHODS

Healthy and uniform seeds of *Amaranthus* and *Hibiscus* were used for the experiment. Sodium bicarbonate ( $\text{NaHCO}_3$ ) of analytical grade, distilled water, aluminium trays, filter paper, measuring cylinders, and a hand sprayer were used for preparing treatment solutions and maintaining moisture conditions.

The experiment was carried out in the Botany Laboratory of SKR Government Degree College (W), Rajamahendravaram, Andhra Pradesh ( $17.0056^\circ \text{N}$ ,  $81.7779^\circ \text{E}$ ). Seeds were sown in aluminium trays lined with filter paper to ensure uniform moisture conditions. Different concentrations of sodium bicarbonate ( $\text{NaHCO}_3$ ) were prepared using distilled water, namely 0 mg (control), 1 mg, 3 mg, 5 mg, 10 mg, and 15 mg per 100 mL. Each tray received daily spray applications of its respective treatment solution, while control trays were sprayed only with distilled water.

The experiment was conducted under laboratory conditions, and seed germination was observed daily for a period of 7–8 days. Germination percentage was calculated based on the number of seeds germinated relative to the total number of seeds sown in each treatment.

## IV. RESULTS

The effect of sodium bicarbonate on seed germination of *Amaranthus* and *Hibiscus* was evaluated after eight days of treatment. The results revealed a clear concentration-dependent reduction in germination percentage and seedling growth in both species. At lower concentrations, *Amaranthus* seeds exhibited comparatively higher germination rates and better seedling vigor, indicating greater tolerance to alkaline stress. Moderate germination and growth were observed in *Amaranthus* up to 10 mg sodium bicarbonate, with only slight reductions in radicle and plumule length. In contrast, *Hibiscus* exhibited pronounced sensitivity to sodium bicarbonate, with significant inhibition of germination observed beyond the 5 mg concentration. Increasing sodium bicarbonate levels resulted in delayed germination, reduced seedling length, and poor seedling establishment in *Hibiscus*. At the highest concentration tested (15 mg), germination was severely suppressed in both plant species, with germination reduced to approximately 5%. Overall, the results indicate that *Amaranthus* possesses a higher level of resistance to sodium bicarbonate-induced alkaline stress compared to *Hibiscus*.

The effect of sodium bicarbonate on seed germination and seedling growth of *Amaranthus* showed a concentration-dependent response (Table 1 & Plate-2). The control treatment (0 mg/100 mL) recorded 100% germination with healthy, green seedlings. At lower concentrations (1–3 mg), germination remained relatively high (70–95%), with only slight to moderate reductions in seedling growth. At 5 mg, seedlings appeared pale, and germination declined to 50–60%. Moderate tolerance was observed up to 10 mg, although growth became stunted and germination decreased to 20–30%. At the highest concentration tested (15 mg), only a few weak seedlings were observed, with germination reduced to 5–10%. These results confirm the relatively higher tolerance of *Amaranthus* to sodium bicarbonate stress.

In *Hibiscus*, sodium bicarbonate treatment caused a pronounced inhibitory effect on seed germination and seedling growth (Table 3& Plate-4)). The control treatment showed 100% germination with vigorous seedling growth. A slight reduction in germination and growth was observed at 1 mg. At 3 mg, root development was noticeably reduced, and germination declined to 70–80%. Significant inhibition of germination occurred beyond 5 mg, with germination decreasing to 50–60% and poor seedling growth. At 10 mg, germination was very low (20–30%), and seedling establishment was severely affected. At the highest concentration (15 mg), only 1–2 seedlings were observed, with germination reduced to 5–10%. These findings indicate that *Hibiscus* is more sensitive to sodium bicarbonate stress compared to *Amaranthus*.

The error bars in the figure-1 represent the standard error (SE) of the mean, indicating the variability among replicates. Smaller SE values observed in *Amaranthus* suggest greater consistency and tolerance to sodium bicarbonate stress, whereas relatively higher SE values in *Hibiscus* indicate greater sensitivity to alkaline stress.

**Table 1: germination percentage of Amaranth and Hibiscus**

NaHCO <sub>3</sub> (mg/100 mL)	<i>Amaranthus</i> Growth	<i>Hibiscus</i> Growth	Germination (%)
0 (Control)	Healthy, green seedlings	Vigorous seedlings	100
1mg	Slightly shorter	Slightly reduced	90–95
3mg	Moderate growth	Short roots	70-80
5mg	Pale seedlings	Reduced germination	50-60
10mg	Stunted growth	Very low germination	20-30
15mg	Few weak seedlings	1–2 seedlings only	5-10

Plate 1: Seed sowing of *Amaranthus dubius* and *Hibiscus sabdariffa* subjected to different concentrations of sodium bicarbonate.

Plate 2: Seed Germination and Early Seedling Growth of *Amaranthus dubius* and *Hibiscus sabdariffa* under Sodium Bicarbonate Treatments



Plate 3: *Amaranthus* seed germination under  $\text{NaHCO}_3$  concentrations (after 8 days).

Plate 4: *Hibiscus* seed germination under  $\text{NaHCO}_3$  concentrations (after 8 days)

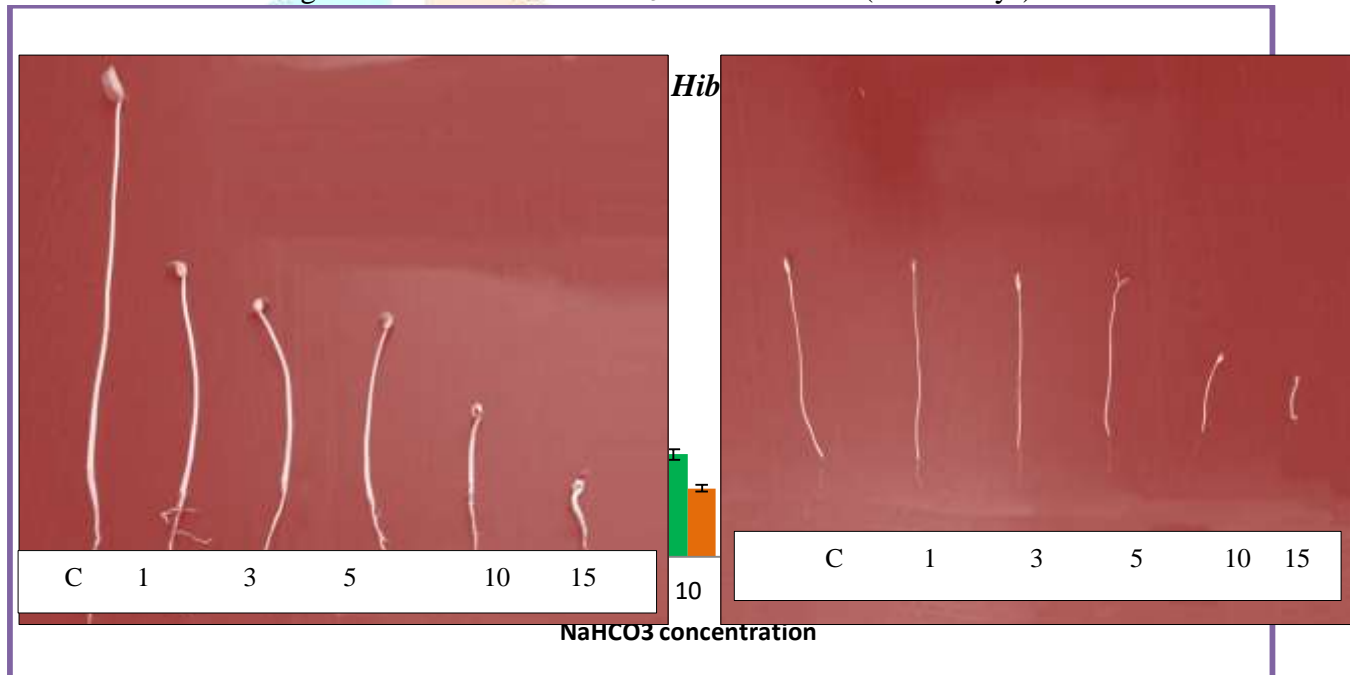


Fig. 1. Germination (%) of *Amaranthus* and *Hibiscus* under different sodium bicarbonate concentrations. Error bars represent the standard error (SE) of the mean.

## Discussion

The present study confirms that increasing sodium bicarbonate concentrations significantly inhibit seed germination, as observed in other species subjected to alkaline stress (Mustard; *Brassica campestris* L.) where higher sodium bicarbonate reduced germination and seedling growth (Anuradha and Ashish Tejasvi 2023).

Alkaline stress has been shown to disrupt water uptake and ionic balance, decreasing germination rates under high pH conditions (Amnah S. Alshahwan et al., 2024). Differential tolerance among species reflects inherent physiological adaptability; some halophytes maintain germination under moderate alkali stress (Rui Zhang 2024), Liu et al., 2010). Alkaline stress has been reported to cause delayed germination and reduced seedling growth in several crop species (Zhu, 2001). These findings emphasize that alkaline stress effects are species-specific and confirm that *Amaranthus* shows relatively higher resistance than *Hibiscus*.

The inhibitory effects of  $\text{NaHCO}_3$  are likely due to elevated pH, sodium toxicity, and osmotic stress, which impair water uptake, enzymatic activity, and nutrient availability, especially iron, calcium, and magnesium,

crucial for chlorophyll synthesis and cell elongation (Li et al., 2010; Munns & Tester, 2008; Yang et al., 2009; Zhang et al., 2012).

## Conclusions

The present study concludes that sodium bicarbonate-induced alkaline stress significantly inhibits seed germination and early seedling growth in both *Amaranthus* and *Hibiscus*. While the control treatment showed 100% germination, a drastic reduction to approximately 5% germination was observed at the highest concentration tested (15 mg), indicating the severe inhibitory effect of alkaline conditions. Among the two species studied, *Amaranthus* exhibited comparatively higher tolerance to sodium bicarbonate stress than *Hibiscus*.

These findings demonstrate that alkaline stress can adversely affect crop establishment and early growth, thereby emphasizing the importance of selecting and cultivating alkaline-tolerant plant varieties for sustainable agriculture in alkaline soils.

## References

1. Ali, Q., Ashraf, M., & Athar, H. R. (2014). Seed germination and seedling growth responses of plants under salt and alkaline stress. *International Journal of Agriculture and Biology*, **16**, 401–406.
2. Amnah S. Alshahwan, Mohammed N. Alyemeni, Mona S. Alwahibi, Nadi Award AI – Harbi, Nadi Award Al-Harbi, Salem Mesfir AI Qahtani, Abdulah Alakalbi Qahtani, November 2024, 103444, Volume 36, Issue 10. *Journal of King Saud University - Science*.
3. Anuradha and Ashish Tejasvi (2023). Effects of Sodium Bicarbonate Stress on Seed Germination and Seedling Growth of Mustard (*Brassica campestris* L.) (open access).
4. Bewley, J. D., Bradford, K. J., Hilhorst, H. W. M., & Nonogaki, H. (2013). *Seeds: Physiology of development, germination and dormancy* (3rd ed.). Springer, New York.
5. Chauhan, N. et al. (2020). Germination behavior of *Amaranthus* under saline conditions. *Asian Journal of Plant Science*, **19**(3): 240–246
6. Devi, K. et al. (2021). Impact of alkaline stress on growth and physiology of *Hibiscus sabdariffa* L. *Plant Archives*, **21**(1): 173–178.
7. Kumar, P. & Rao, S. (2018). Physiological responses of crop plants to bicarbonate-induced salinity. *Indian Journal of Botany*, **92**(4): 211–218.
8. Li, J., Pu, L., Zhu, M., Zhang, R., Xiang, Y., & Xu, Y. (2010). Effect of alkaline stress on growth and nutrient uptake of plants. *Journal of Plant Nutrition*, **33**, 172–186.
9. Liu, J., Guo, W., Shi, D., & Zhang, C. (2010). Effects of alkaline stress on seed germination and seedling growth of crops. *Journal of Agronomy and Crop Science*, **196**(5), 340–347. <https://doi.org/10.1111/j.1439-037X.2010.00425.x>.
10. Munns, R., & Tester, M. (2008). Mechanisms of salinity tolerance. *Annual Review of Plant Biology*, **59**, 651–681. <https://doi.org/10.1146/annurev.arplant.59.032607.092911>.
11. Rui Zhang, Huizhen Zhang, Lai Wang & Youling Zeng. Effect of salt-alkali stress on seed germination of the halophyte *Halostachys caspica* 13. Published: 08 June 2024 *Scientific Reports* volume 14, Article number: 13199 (2024).
12. Singh, R. et al. (2015). Effect of bicarbonate stress on seed germination and seedling growth in spinach and okra. *Journal of Plant Stress Research*, **10**(2): 45–49.
13. Yang, C., Chong, J., Kim, C., Li, C., Shi, D., & Wang, D. (2009). Osmotic adjustment and ion balance traits under alkaline stress. *Plant and Soil*, **315**, 83–95.
14. Yang, C., Chong, J., Li, C., Kim, C., Shi, D., & Wang, D. (2007). Osmotic adjustment and ion balance traits of an alkaline-resistant halophyte under salt stress. *Plant Science*, **173**(2), 184–190. <https://doi.org/10.1016/j.plantsci.2007.05.010>.
15. Zhang, H., Wang, J., & Shi, D. (2012). Effects of bicarbonate stress on nutrient availability and photosynthesis. *Plant Physiology and Biochemistry*, **56**, 1–7.
16. Zhu, J. K. (2001). Plant salt tolerance. *Trends in Plant Science*, **6**(2), 66–71. [https://doi.org/10.1016/S1360-1385\(00\)01838-0](https://doi.org/10.1016/S1360-1385(00)01838-0).