Sahel Journal of Life Sciences FUDMA (SAJOLS)
March 2025 Vol. 3(1): 314-318
ISSN: 3027-0456 (Print)
ISSN: 1595-5915(Online)
DOI: https://doi.org/10.33003/sajols-2025-0301-38

Research Article

Effect of Salinity on Germination of Three Varieties of Soybean (*Glycine max*) in Sudan-Sahelian Nigeria

***Muhammad Adamu Aliyu, Adashu Tanko Gani and Abubakar M. Kundiri**

Department of Soil Science and Land Resources Management, Faculty of Agriculture Federal University Wukari, Taraba State, Nigeria
****Corresponding Author's email***: aliyum440@fuwukari.edu.ng

ABSTRACT

This study examined the effect of salinity on the germination of three soybean (*Glycine max*) varieties to determine the salinity level most detrimental to germination and identify the most tolerant variety the research was carry out 2014. A pot experiment was conducted using four sodium chloride (NaCl) concentrations (0.00, 3.0, 4.5, and 6.0 g per 3 kg of soil) and three soybean varieties (TGX 1904-6F, TGX 1951, and TGX 1448-2E) arranged in a completely randomized design with three replications. Germination percentage (%) and rate significantly decreased with increasing NaCl concentration. However, no significant differences were observed among the varieties in terms of germination performance. The interaction between NaCl concentration and variety revealed that all varieties experienced reduced germination under higher salinity levels. These findings suggest that soybean germination is highly sensitive to salinity, regardless of variety.

Keywords: Germination; Nutrient uptake; Sandy loam; Saline Water; Soya-bean Seed

Citation: Aliyu, M.A., Gani, A.T. & Kundiri, A.M. (2025). Effect of Salinity on Germination of Three Varieties of Soybean (*Glycine max*) in Sudan-Sahelian Nigeria. *Sahel Journal of Life Sciences FUDMA*, 3(1): 314-318. DOI: https://doi.org/10.33003/sajols-2025-0301-38

INTRODUCTION

Soil salinity is a critical factor limiting agricultural productivity, particularly in regions with irregular rainfall patterns and poor soil drainage, such as the Sudan-Sahelian zone of Nigeria. High salt concentrations can significantly impact seed germination by causing osmotic stress, ion toxicity, and metabolic imbalances, which reduce seedling emergence and establishment. Given that soybean is an essential crop for food security, livestock feed, and soil fertility improvement, understanding its germination response to saline conditions is crucial for optimizing its production in affected regions.

In direct sowing and transplanting systems, the first exposure of crops to salinity stress typically occurs during the germination stage, making this phase particularly critical for overall plant establishment (Ibrahim and Kazzim, 2008). Salinity-induced reduction in osmotic potential can lead to lower water uptake, nutrient deficiencies, and stunted growth (Grant, 1995; Folorunso et al., 2004). Furthermore, research has indicated that increasing salinity from 0 to 180M NaCl can reduce germination rates by 50% in species of the *Phaseolus* genus (Bayuelos et al., 2002). Soybean exhibits symptoms such as leaf chlorosis, stunted growth, and biomass reduction when grown in saline conditions, primarily due to chloride-induced toxicity (Abel and Mackenzie, 1964). Despite the significance of soybean cultivation in Nigeria, there is limited research on the effects of salinity on germination and early growth in this region. This study aims to investigate the germination response of different soybean varieties to salinity, assess their tolerance levels, and identify varieties that can thrive in saline-prone environments.

MATERIAL AND METHODS

Study Area

The experiment was conducted in a screen house at the Faculty of Agriculture, University of Maiduguri, Nigeria. Maiduguri is located at 11°05' North latitude and 30°05' East longitude (3BSBLS, 2004). The area has an annual rainfall of approximately

625 mm and an average temperature of 32°C. The relative humidity varies between 40% (dry season) and 60% (rainy season), with an evaporation rate of about 1600 mm per year (Umar et al., 2006). The soil is classified as typic ustipsamment (Rayar, 1984) and is predominantly sandy loam with low water and nutrient retention capacity.

Experimental Design and Treatments

A completely randomized design (CRD) was employed, and four salinity levels (0 g, 3.0 g, 4.5 g, and 6.0 g NaCl per 3 kg soil) and three soybean varieties (TGX1904-6F, TGX1951, TGX1448-2E), resulting 12 treatments that combined, each replicated three times.

Soybean seeds were placed on moist filter paper in Petri dishes, and germination percentage was recorded every two days over a 10 -day's period, adhering to International Seed Testing Association (ISTA, 1985) guidelines.

Germination Parameters Measured

The following parameters were recorded:

Germination Percentage = (Number of germinated seeds / Total seeds) × 100

Mean Germination Time (MGT) = Σ (ni × ti) / Σ ni

Where **ni** = Number of seeds germinated on day **ti**

Germination Rate Index (GRI) = Σ (G/t), where **G** is the number of seeds germinated per day **t**

Root and Shoot Length (cm) (measured with a ruler at the end of the experiment)

Seedling Vigour Index (SVI) = Germination % × Mean root length (cm)

Data Analysis

All collected data from both experiments were analyzed using analysis of variance (ANOVA) in **Statistix 8.0** software.

RESULTS AND DISCUSSION

Effects of Sodium Chloride on Germination

Salinity significantly ($p \leq 0.01$) affected germination, with a notable decline as salt concentration increased. The highest germination percentage (78%) was recorded in the control, while the highest salt treatment (6.0g/3kg soil) completely inhibited germination (0%). This confirms previous studies that attribute reduced germination to lower soil water potential, which limits water absorption by seeds.

This trend continues through to the 8DAS, where control had highest germination percentage of 86% and the lowest 0.0% with the highest salinity treatment. This result implies that salinity adversely affects seed germination. The result obtained in this work is consistent with earlier findings that germination is higher in non-saline than saline condition (Khan *et al.*, 2000). Essa (2002) also observed significantly reduction in germination percentage in soybean with increasing salinity levels.

Effects of Sodium Chloride on Plant Height

Plant height declined significantly with increasing salinity levels. The reduction is likely due to restricted nutrient uptake, increased osmotic stress, and toxic effects of accumulated sodium chloride. No significant varietal differences ($p \leq 0.01$) were observed in plant height, contrasting with some reports that indicate genetic differences in salinity tolerance among Phaseolus species.

Salinity induced reduction in plant growth has been reported in tomato (*Lycopersicumesculantum*) seedlings (Hajar *et al.,* 2006), similar result was obtained by Yakubu *et al.,* (2010) in millet. The effect of salinity on growth of plant might be due to interference with nutrient absorption; and physiological water stress created by high salt concentration in the root zone (Shukla and Makhi, 1985 and Folorunso *et al.,* 2005). It may be due to toxic effect of sodium chloride used as well as unbalanced nutrient uptake by the seedling (Jamil *et al.,* 2006).

Effects of Sodium Chloride on Number of Leaves

Salinity stress led to a decrease in leaf number. This could be attributed to the degradation of chlorophyll and damage to chloroplast structures. While some studies report no significant differences in canopy yield under salinity, others support the observed decline in leaf production.

Similarly, Dolatabadian *et al.,* (2011) found no significant differences in the responses of soybean varieties to salinity. Also, the result from this study is in disagreement with those of Yakubu *et al.,* (2010) who reported significant differences in the responses of millet varieties to salinity.

Effects of Sodium Chloride on Stem Diameter and Root Length

Both stem diameter and root length decreased significantly ($p<0.01$) with increasing salt content. Root length was highest in the control (25.4 cm) and completely inhibited in the highest salt treatment (6.0g/3kg soil). The reduction in root growth may be due to transpiration salt flux, leading to toxic ion accumulation in plant tissues.

The decrease in both stem diameter and root length is consistent with the findings of Neves *et al.*, (2005) who reported that increasing salt concentration reduces the number and length of roots as well as the stem diameter of soybean. The reduction in root length and stem diameter could be attributed to translocation of salt into the root and shoots as a result of transpiration flux required for the maintenance of the plant status and unregulated transpiration that causes toxic levels of the ions in the shoots (Yeo, 1998). Also, the reduction may be due to water stress following the lowering of the water potentials by salt, which consequently reduces the physiological and biochemical processes affecting seedling growth (Braccini *et al.*, 1996).

Effects of Sodium Chloride on Fresh and Dry Weight of Root and Shoot

The fresh and dry weight of soybean roots and shoots significantly decreased with increasing salinity levels. The highest biomass was recorded in the control, while the lowest occurred in the highest salt treatment. The reduction in yield may be attributed to Na+ toxicity, reduced water uptake, and osmotic stress, aligning with previous findings on salinity-induced yield reduction in soybean and rice.

Dolatabadian *et al.* (2011) reported that the soybean had a reduction in their fresh weight because of the proportional increase in Na^+ concentration, which could imply that an ionic effect was being manifested. They also assumed that in addition to toxic effect of NaCl, higher concentration of salt reduces the water potential in the medium, which hinders water absorption and thus reduces plant growth. Sagi *et al.* (1997) also observed adverse effects of salinity stress on shoot and root growth. The decline in plant biomass in this and other studies could be due to excessive accumulation of NaCl in the chloroplast of soybean, which adversely affects growth rate and electron transport activities for photosynthesis (Kirst, 1989) and inhibits PS11 activity (Kao *et al.,* 2003). In general, the decrease in fresh and dry yield of soybean with salinity is consistent with the report of Ali *et al.,* (2004) that both yield and yield component of rice genotypes grown in saline condition decreases with the increasing salinity but some genotypes showed better salinity tolerance than others.

These results confirm that increasing salinity levels negatively impact both the germination and early growth of soybean varieties. While varietal differences exist, they were not statistically significant ($p \leq 0.01$), indicating a generally adverse effect of salinity across all tested varieties.

Table 1: Effects of Sodium Chloride on Germination percentage of Soybean (*Glycine max*.)

TREATMENTS	4DAS	6DAS	8DAS
Salt Level			
Control	77.77^a	81.46^a	86.17^a
3.0g	9.26^b	12.96^b	18.52^b
4.5g	3.70^b	14.81	16.72^b
6.0g	0.00^b	0.00^b	0.00^b
SE	4.83	6.81	6.95
LSD (p≤0.01)	14.16	19.99	20.38
Varieties			
TGX 1904 -6F	18.05^a	20.82^a	26.39^a
TGX 1951	24.99^a	34.71^a	36.39^a
TGX 1448 -2E	25.00^a	26.39^a	27.78^a
Mean	22.68	27.31	30.10
SE	4.18	5.90	6.02
LSD	NS	NS	NS

Table 2: Effects of Sodium Chloride on plant height (cm) of soybean (*Glycine max*.)

Treatment salt level	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS
Control	13.09	19.05	26.29	35.37	43.09	49.32
3.0g	3.25	3.31	4.81	6.27	7. 48	8.51
4.5g	2.67	4.65	5.52	8.19	10.29	10.92
6.0g	0.00	0.00	0.00	0.00	0.00	0.00
SE	1.09	1.62	2.20	3.03	3.78	4.15
LSD(p<0.01)	3.20	4.74	6. 46	8.88	11.08	12.16
Variety						
TGX 1904-6F	4.18	7.04	9.30	12.85	16.36	18.86
TGX 1951	5.73	8.86	11. 45	15.63	18.63	20.06
TGX114-2E	4.35	4.56	6.32	8.89	11.17	12.64
Mean	4.75	6.75	9.16	12. 46	15.22	17.19
SE	0.9	1.39	1.91	2.62	3.27	3.59
LSD	NS	NS	NS	NS	NS	NS

Table 3: Effects of Sodium Chloride on number of Leaves of soybean (*Glycinemax*.)

Treatment salt level	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS
Control	5.86a	8.51a	10.67a	14.18a	18.04a	23.32a
3.0g	1.83b	1.94b	2. 44b	3.39b	3.94b	3.92b
4.5g	1.33bc	2.09b	3.39b	3.75b	3.65b	4.31b
6.0g	0.00c	0.00b	0.00b	0.00b	0.00b	0.00b
SE	0.55	0.99	1.33	1.59	1.72	1.79
LSD(p<0.01)	1.62	2.93	3.91	4.67	5.03	5.27
Variety						
TGX 1904-6F	1.86a	3.82a	4.09a	5.64a	7.07a	7.62ab
TGX 1951	2.76a	4.36a	5.39a	7.02a	8.04a	10.58a
TGX114-2E	2.14	1.83	2.89	3.32	4.11	5. 46a
Mean	2.25	3.34	4.13	5.33	6. 41	7.89
SE	0. 48	0.86	1.56	1.38	1. 49	1.55
LSD	NS	NS	NS	NS	NS	NS

Table 4: Effects of Sodium Chloride on stem diameter and root length of soybean (*Glycine max*.)

Treatment salt level	1WAS	2WAS	3WAS	4WAS	5WAS	6WAS	ROOT LENGTH
Control	0.99a	1.07a	1.21a	1.37a	1.47a	1.63a	25.44a
3.0g	0.49b	0.24b	0.26bc	0.28b	0.31bc	0.32b	5.67b
4.5g	0.32bc	0.34b	0.39b	0.42b	0. 47b	0.47b	5.56b
6.0g	0.00c	0.00b	0.00c	0.00b	0.00c	0.00b	0.00b
SE	0.14	0.12	0.13	0.14	0.16	0.16	2.63
LSD(p<0.01)	0.40	0.34	0.38	0.42	0.46	0.48	7.70
Variety							
TGX 1904-6F	0.40a	0.43a	0.49a	0.57a	0.62a	0.65a	10.83a
TGX 1951	0.49a	0.56a	0.61a	0.66a	0.71a	0.77a	10.33a
TGX114-2E	0.51a	0.25b	0.29a	0.33a	0.36b	0.39a	6.33a
Mean	0.45	0.41	0.47	0.52	0.56	0.61	9.12
SE	0.12	0.10	0.11	0.12	0.13	0.4	2.27
LSD	NS	NS	NS	NS	NS	NS	NS

Table 6: Effects of Sodium Chloride on fresh and dry weight of root and shoot of soybean (*Glycine max*.)

TREATMENT	RFW	SFW	RDW	SDW
Salt level				
Control	7.39a	21.71a	4.64a	13.98a
3.0g	0.86b	3.02b	0.63b	2.08b
4.5g	0.62b	1.89b	0.51b	1.22b
6.0g	0.00b	0.00b	0.00b	0.00b
SE	0.57	1.56	0.32	0.94
LSD(p≤0.01)	1.66	4.58	0.95	0.82
Variety				
TGX1904 – 6F	1.74a	5.64a	1.23a	3.68a
TGX1951	2.73a	8.46a	1.86a	5.30a
TGX1448 – 2E	2.18a	5.87a	1.26a	3.98a
Mean	2.22	6.66	1.45	4.32
SE	0.49	1.35	0.28	0.81
LSD	NS	NS	NS	NS

CONCLUSION

The study confirmed that salinity negatively impacts soybean germination and growth, leading to reduced emergence, shorter plants, fewer leaves, decreased stem diameter, shorter roots, and lower biomass accumulation. These effects were observed across all tested varieties, with no statistically significant differences.

Salinity stress significantly reduces germination and early growth of soybean varieties in Sudan-Sahelian Nigeria. The study highlights the adverse effects of increased NaCl concentrations, emphasizing the need for effective salinity management practices in soybean cultivation.

Adoption of salt-tolerant soybean varieties for cultivation in saline-prone areas. Implementation of irrigation and soil management practices to mitigate the impact of salinity. Further research on genetic and physiological mechanisms of soybean response to salinity for improved breeding strategies.

REFERENCES

Abel, G.H. and MacKenzie. A. J. (1964). Salt tolerance of soybean varieties (*Glycine*e max (L.) Merill) during germination and later growth. *Crop Sci*., **4**: 157-161.

Ali, Y., Z. Aslam, Ashraf, M.Y. and Tahir, G. R. (2004). Effect of salinity on chlorophyll concentration, leaf area, yield and yield components of rice genotypes grown under saline environment. *International J. Environmental Sci. and Technol*., **1(3)**: 221-225.

Bayuelo-Jim'nez, J.S., Craig, R. and Lynch, J. P. (2002). Salinity tolerance of phaseolus species during germination and early seedling growth. *Crop Sci*., **42**: 1584-1594.

Essa, T. A. (2002). Effect of salinity stress on growth and nutrient composition of three soybean (*Glycinee max* (L.) Merrill) cultivars.*J. Agro & Crop Sci.,* **188**:86-93.

Folorunso, O.A., Chiroma, A. M. and Abdullahi, D. (2005). Influence NaCl salinity on soil properties and early growth of groundnut (Arachis hypogaea L.) *Environtropica*, **2**:91-99.

Grant, R. F. (1995). Salinity, water use and yield of maize: Testing the mathematical model ecosystem. *Plant Soil*, **172**:309-322.

Ibrahim, M., J. and Kazzim U. D. 2008.Selection of cotton (Gossypiumhirsutum L.) genotypes against NaCl stress. *Soil and Environment,* **26(1)**:59-63.

Jamil, M., Lee, D.B., Jung, K. Y., Ashraf, M., Lee, S. C. and Rha, E. S. (2006). Effect of salt (NaCl) stress on germination and early seedling growth of four vegetables species. *J. Cent. Eur. Agric*., **7**:273-282.

Khan, M. A., Ungar, I. A. and Showalter, A. M. (2000). *Soil Sci. Plant Anal*., **31**: 2763–2774.

Kirst G.O (1989). Salinity tolerance of eukaryotic marine algae plant. *Mol .Bio*. **40**(21-53).

Koa, W. Y., Tsai, T, Shin, C. N. (2003). Photosynthetic gas exchange And chlorophyll fluorescence of three wild soybean in response to Nacl treatments, *Photosynthetical*, **41:** 415-419.

Sagi, M., Davrat, A., Kipnis, T. and Lips, H. (1997). Ionic Balance, Biomass Production and Organic Nitrogen as Affected by Salinity and Nitrogen Source in Annual Rye-grass. *J. Plant Nutr*. **20:** 1291-1316.

Shukla, U.C. and Mukhi, A. K. (1985). Amelioration role of zinc on maize growth under salt affected soil conditions. *Plant Soil*, **87**:423-432.

Nerves, L. S., Waldeen, R.P. and Teare, I. D. (2005). Rapid determination of free proline for water stress studies. *Plant and Soil*, **39**:205-207.

Yakubu, H., Usman, H. and Chiroma, A.M. (2010). Screening of Sorghum Varieties for Salt tolerance in a sandy loam soil of Borno State, Nigeria. *Nigerian J. Exp. and Appl. Biol*., **7(1):** 49-54.

Yeo, A. R. (1998). Molecular biology of salt tolerance in the context of whole plant physiology, *J. Exp.Bot, Cambridge*, **49**(**323**): 915-929.