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RESEARCH ARTICLE

# RESPONSE OF LANDRACE SOYBEAN ACCESSIONS (*GLYCINE MAX.*) TO DIFFERENT SOIL SALINITY LEVELS.

**Agbowuro Gbenga Oluwayomi[a*], Olamiriki Esther Funmi[b], Aluko Mathew[c], Alabi Bolaji Toyin[d]**

[a] *Department of Biosciences and Biotech., University of Medical Sciences, Ondo-City, Nigeria.*
[b] *Department of Crop, Horticulture and Landscape Design, Ekiti State University, Ado-Ekiti Nigeria.*
[c] *Department of Soil and Land Resources Management, Federal University, Oye-Ekiti.*
[d] *Department of Agric. Sci. and Tech., Bamidele Olumilua University of Sci., Educ. and Tech., Ikere-Ekiti Nigeri.*
**Corresponding Author E-mail: gagbowuro@unimed.edu.ng*



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**ABSTRACT**

Salinity remains a major abiotic threat to crop production. The growth and yield performance of five soybean accessions exposed to different salinity levels was evaluated in a pot experiment between July to December 2023 and August to December 2023 at the Screen House of Teaching and Research Station, Ekiti State University, Ado-Ekiti, Nigeria. The experiment was laid out in a Completely Randomized Design with two factors (accessions and salinity levels) with three replications. The factors were five soybean accessions and five salinity levels (0.64, 2.5, 5.0, 7.5, and 10.0 dS/m). Results obtained indicated that seed emergence percentage, plant height, the number of leaves per plant, number of pods per plant, pod weight (g), and grain yield at 12 percent moisture content were significantly (P>0.05) affected by soil salinity at all levels of treatment and the accessions were significantly different to each other. As the soil salinity concentration increases, the performance of the soybean agronomic traits studied reduces. However, the accessions collected Kujama and Zaria performed better compared to other studied accessions across the salinity levels. The results confirmed the detrimental effects of soil salinity on soybean, and improvement towards salt tolerance can begin with accession from Kujama and Zaria.

**KEYWORDS**

Accessions, Agronomic traits, Improvement, Salinity, Soybean

## 1. INTRODUCTION

Soybean (*Glycine max.*) is a leguminous crop that is popularly grown and consumed globally (Pajo et al., 2018). According to ACET, Nigeria is the leading producer and consumer of soybeans across sub-Saharan Africa (ACET, 2013). It is a well-recognized crop in the Guinea savanna agroecological zone of Nigeria with about half of the farmer's households in the region cultivating the crop along with other stable food crops (Franke and De Wolf, 2011). Soybean gives an average of 40% protein content, and the seeds of the crop also contain almost 29% oil which is 85% unsaturated without cholesterol on a dry matter basis (www.soystats.com). The products of the crop are used as a source of fuel and raw materials for the pharmaceutical industries anti-cancerous medicine production, and food industries (Ko et al., 2013). Moreover, a group researcher reported that soybean improves the soil by fixing atmospheric nitrogen to the soil. Due to such numerous agricultural and economic benefits from the crop, its cultivation in Nigeria is expanding across the nation (Sulieman et al., 2015). The seed yield per hectare of soybean is low in the farmer's field compared to what is obtained in research stations in Nigeria, this makes the demand surpass supply (Sadiq, et al., 2020). The low yield in the farmer's field could be a result of its sensitivity to various abiotic and biotic stresses (Kawuki et al., 2003b; Silveria et al., 2003). Soil salinity is one of the several stresses limiting soybean seed yield.

Martinez-Beltran and Manzur, reported that about 831 million hectares of arable land are saline globally and this has resulted in crop productivity losses to the estimated tune of about US $12 to 27.3 billion (Martinez-Beltran and Manzur, 2005; Qadir et al., 2014). Moreover, some researchers predicted that 50% of the world's arable land will be saline by the year 2050 (Wang et al., 2003). This will adversely affect food production sustainability and agricultural profitability globally. Identifying and developing crop species that can adapt and produce optimally in saline soil conditions is of paramount importance to advert the problem of global food shortage as predicted due to soil salinity. The cultivation of soybeans has been recorded on saline soil in so many parts of the world (Scanlon et al., 2005). Some researchers reported that soybeans are moderately tolerant to soil salinity with a threshold level of 5.0 dS/m (Maas and Hoffman, 1977; Kamkar et al., 2014). A group researcher had a report that contradicted that of (Maas and Hoffman, 1977; Katerji et al., 2000). A group researcher reported a lower threshold value of 2.0 dS/m for soybean (Katerji et al., 2000).

The major ions present in saline soils are sodium and chloride, and chloride is phytotoxic in nature (Rengasamy, 2010). The response of plants to this phytotoxic chloride varies based on the differences in the species and accessions (Xu et al., 2000). The minimum concentration of chloride level in the soil that will exhibit phytotoxic effects on soybeans has not been ascertained as different authors suggested different threshold values for the crop (Dabuxilatu, 2005a). High soil salinity reduces water potentials and induces ionic stress, and this brings about secondary oxidative stress in plants.

Accumulation of toxic salts in the plant leaf apoplast brings about dehydration and turgor loss, thus the rate of photosynthesis is drastically reduced, and the death of leaf cells and tissues may eventually occur, thus

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yield will be reduced (Marschner, 1995). Accumulation of sodium and chloride ions also causes ionic imbalance as the uptake of soil mineral nutrients like potassium ions, calcium ions, and magnesium ions will be reduced and the deficiencies of the mineral nutrients will appear (Munns, 2002). It is of paramount importance to study the performance of prominent landrace soybean accessions under different soil salinity, as salinity has become one of the major abiotic stresses affecting crop productivity. This work aims to evaluate the performances of prominent landrace soybean accessions at different salinity levels and to also ascertain whether the soil salinity level at soybeans will perform optimally.

## 2. Materials and Methods

The research was carried out at the Screen House of Teaching and Research Station, Ekiti State University, Ado-Ekiti, Nigeria during the 2022 and 2023 late cropping seasons. The five soybean accessions used for the research were collected from diverse agroecological zones of Nigeria (Table 1). The climate in the experimental site is tropical humid with district wet (rainy) and dry seasons. The experiment was laid out in a completely randomized design with two factors (soybean accessions and salinity levels) and replicated three times.

The soil samples used for the pot experiment were collected from the Teaching and Research Station, Ekiti State University, Ado-Ekiti, Nigeria. The pots were perforated uniformly, well-labeled, and arranged based on the treatment. Each of the pots was filled with 7 kilograms of soil and water appropriately. An analytical reagent of Sodium chloride obtained from the Environmental Toxicology and Management Laboratory of Elizade University, Ilara-Mokin, Nigeria was used as the salt treatment. The initial salt in the soil sample is 0.64 dS/m which serves as the control. The sodium chloride was measured using an electronic scale to prepare the salt solution to electrical conductivity (EC) of 2.5, 5.0, 7.5, and 10.0 dS/m and distilled water without salt which serves as a control. After the salt preparation to varying concentrations, the procedure of was adopted with slight modification. These salt-varied solutions were prepared daily (Mshelmbula et al., 2015). Regular watering using the varied prepared salt solutions concentration and control was done every evening 10 days before planting to ensure salt mineralization in the soil before planting and throughout the experiment accordingly. The seeds were planted around 18 hours of the day and good agronomic practices were adopted to raise good crops.

Data were collected on seed emergence percentage, plant height (cm), the number of leaves per plant, number of pods per plant, pod weight (g), the weight of 100 seeds (cm), and grain yield/plant (g) at 12 percent moisture content. Data collected were subjected to analysis of variance using Statistical Tools for Agricultural Research software (STAR, version 2.0.1, 2014). Means were separated using the Duncan Multiple Range Test at P<0.05 level of significance.

**Table 1:** List of soybean accessions showing their source of collection

| S/N | Location | Agro-ecological zones |
|---|---|---|
| 1. | Zaria | Northern Guinea Savanna |
| 2. | Mokwa | Southern Guinea Savanna |
| 3. | Okitipupa | Forest |
| 4. | Ikole-Ekiti | Derived Savanna |
| 5. | Kujama | Northern Guinea Savanna |

## 3. Results and Discussion

The effect of different salinity levels on the seed emergence percentage of five soybean accessions is shown in Table II. Salt stress had a significant effect on the seed emergence of all accessions evaluated. The mean values of the seed emergence percentage continue to decrease as the salinity levels increase. The differences recorded in seed emergence percentage mean values between 7.5 dS/m and 10 dS/m were higher compared to 5.0 dS/m to 7.5 dS/m across the accessions. There was no significant difference in plots that received no salt solution (control), 2.5 dS/m, and 5.0 dS/m treatment in accessions from Zaria and Ayungba. The mean values recorded for seed emergence at 10.0 dS/m were significantly low compared to 2.5 dS/m for all the accessions. This result is in agreement with the findings of who reported that an increase in salinity level reduces the rate of seed germination in soybean (Essa and Al-Ani, 2001; Essa, 2002). A group researcher also reported a similar result in cowpea (Gulzer et al., 2003). The capability of a seed to germinate on saline soil is an indication that the seeds have some level of genetic potential for salt tolerance at this stage, though this does not guarantee that the emerged seedlings could continue to be optimally under salt stress (Essa, 2002). Table III presents the effects of different salinity levels on plant height of five soybean accessions. Salinity levels significantly ($P \leq 0.05$) affect plant height in all five accessions. Accession from Kujama had the highest mean value at 0.64, 2.5, 5.0, and 7.5 dS/m followed by accession from Ikole - Ekiti in 0, 2.5, and 5.0 dS/m respectively. The more saline the soil becomes, the shorter the plant height becomes. For all the accessions evaluated, the plant height at 10.0 dS/m is almost 50% shorter compared to the control (0.64). This is in agreement with the research findings of (Cordovilla *et al.,* 1995; Essa and Al-Ani, 2001; Dabuxilatu, 2005b; Essa, 2002). This reduction in plant height could be a result of distortion in metabolic processes like water and nutrient uptake that salinity has caused in the plant tissues.

A comparison of the response in the accessions studied showed that the number of leaves per plant was reduced at an increasing rate as the salinity level increased (Table 4). Accession from Zaria had the highest numbers of leaves per plant at all the salinity levels imposed while accession from Kujama had the least number of leaves per plant. All the accessions and salinity levels were significantly different from each other. The number of leaves per plant reduces as the salinity level increases. Sodium accumulation affects obstructions in various metabolic processes in the plant system. These obstructions inhibit the growth and developmental phases of plants (Nasir et al., 2007). Accumulation of sodium causes an imbalance in nutrient uptake. Thus, potassium and calcium accumulation in plant tissues reduces, thereby causing a reduction in the number of leaves (Maas and Grieve, 1987). This finding is in agreement with Amador and Dieguez who reported in their findings that salinity causes a reduction in the number of leaves in plants (Amador and Dieguez, 2007).

The accessions and salinity levels were significantly different from each other at P>0.05 for the number of pods per plant (Table V). Increasing salinity from 0.64 (Control) to 10.0 dS/m reduces the number of pods per plant from 32.147 to 11.447, 30.037 to 10.508, 27.508 to 8.640, 29.653 to 10.584 and 35.833 to 11.843 in accession from Zaria, Mokwa, Okitipupa, Ikole-Ekiti and Ayungba respectively. The number of pods per plant in each of the accessions keeps reducing as salinity keeps increasing. Accession from Kujama had the highest number of pods per plant in the control, 2.5, and 5.0 dS/m respectively while accession from Okitipupa had the lowest mean values at these salinity levels. The reduction in the number of pods per plant and pod weight could be a result of a reduction in the number of leaves that would have been used for the assimilation of carbohydrates through photosynthesis and the nutrient imbalance caused an accumulation of sodium in the soil. A similar result was reported (Abdul Mannan et al., 2013).

**Table 2:** Effect of salinity levels on seed emergence percentage of five landrace soybean accessions over two years.

| | Accessions | | | | |
|---|---|---|---|---|---|
| EC (dS/m) | Zaria | Mokwa | Okitipupa | Ikole-Ekiti | Kujama |
| 0.64 (Control) | 85.398$^{a}$ | 77.180$^{b}$ | 82.167$^{a}$ | 73.417$^{b}$ | 84.905$^{a}$ |
| 2.5 | 75.833$^{a}$ | 63.667$^{b}$ | 71.835$^{a}$ | 64.603$^{b}$ | 76.167$^{a}$ |
| 5.0 | 64.826$^{a}$ | 61.520$^{ab}$ | 56.201$^{c}$ | 58.040$^{bc}$ | 65.107$^{a}$ |
| 7.5 | 54.045$^{ab}$ | 53.187$^{b}$ | 48.127$^{c}$ | 52.400$^{bc}$ | 58.133$^{b}$ |
| 10.0 | 41.107$^{b}$ | 42.860$^{b}$ | 40.594$^{b}$ | 46.853$^{a}$ | 47.553$^{c}$ |

Means carrying the same letters across the columns and rows are not significantly different from each other (P<0.05).

**Table 3:** Effect of salinity levels on plant height of five landrace soybean accessions over two years.

| | EC (dS/m) | | | | |
|---|---|---|---|---|---|
| Accessions | 0.64 (Control) | 2.5 | 5.0 | 7.5 | 10.0 |
| Zaria | 34.803$^{b}$ | 31.618$^{c}$ | 24.067$^{b}$ | 20.506$^{b}$ | 15.080$^{cd}$ |
| Mokwa | 36.507$^{b}$ | 33.835$^{bc}$ | 30.187$^{a}$ | 24.508$^{a}$ | 18.505$^{ab}$ |
| Okitipipa | 29.243$^{c}$ | 26.065$^{d}$ | 22.853$^{b}$ | 18.500$^{b}$ | 13.250$^{d}$ |
| Ikole Ekiti | 37.509$^{ab}$ | 34.667$^{b}$ | 29.167$^{a}$ | 23.667$^{a}$ | 20.667$^{a}$ |
| Kujama | 39.876$^{a}$ | 37.540$^{a}$ | 30.360$^{a}$ | 25.075$^{bc}$ | 16.533$^{c}$ |

Means carrying the same letters across the columns and rows are not significantly different from each other (P<0.05).

Salt stress significantly reduced the pod weight of the five soybean accessions (Table 6). The reduction in pod weight was more pronounced in accession from Okitipupa. Accession from Kujama had the highest pod weight across all the soil salinity levels. The percentage decrease in the pod weight across the accessions as the salinity levels increased was relatively low. The effects of salinity levels on grain yield at 12 per moisture content are shown in Table 7. There were significant differences at P<0.05 across the accessions and salinity levels. Accession from Kujama had the highest grain yield per hectare across all the salinity levels imposed followed by accession from Zaria.

**Table 4:** Effect of salinity levels on number of leaves per plant of five soybean accessions over two years.

| | EC (dS/m) | | | | |
|---|---|---|---|---|---|
| **Accession** | **0.64 (Control)** | **2.5** | **5** | **7.5** | **10.0** |
| Zaria | 90.262$^{c}$ | 87.716$^{c}$ | 74.156$^{d}$ | 64.364$^{c}$ | 48.154$^{c}$ |
| Mokwa | 76.920$^{b}$ | 73.064$^{b}$ | 60.656$^{c}$ | 49.376$^{b}$ | 40.353$^{bc}$ |
| Okitipupa | 70.274$^{bc}$ | 67.670$^{ab}$ | 57.716$^{b}$ | 46.605$^{a}$ | 36.746$^{a}$ |
| Ikole | 79.343$^{b}$ | 73.166$^{b}$ | 61.746$^{c}$ | 49.630$^{b}$ | 39.156$^{c}$ |
| Kujama | 67.606$^{a}$ | 63.686$^{a}$ | 52.646$^{a}$ | 45.143$^{a}$ | 35.850$^{a}$ |

Means carrying the same letters across the columns and rows are not significantly different from each other (P< 0.05).

**Table 5:** Effect of salinity levels on number of pod per plant of five soybean accessions over two years.

| | Accessions | | | | |
|---|---|---|---|---|---|
| **EC (dS/m)** | **Zaria** | **Mokwa** | **Okitipupa** | **Ikole-Ekiti** | **Kujama** |
| 0.64 (control) | 32.147$^{b}$ | 30.037$^{bc}$ | 27.508$^{d}$ | 29.653$^{cd}$ | 35.833$^{a}$ |
| 2.5 | 28.157$^{b}$ | 26.497$^{b}$ | 23.820$^{c}$ | 27.657$^{b}$ | 31.737$^{a}$ |
| 5 | 23.700$^{ab}$ | 21.023$^{b}$ | 18.830$^{c}$ | 23.867$^{a}$ | 25.600$^{a}$ |
| 7.5 | 17.580$^{a}$ | 14.803$^{b}$ | 11.147$^{c}$ | 17.383$^{a}$ | 16.553$^{ab}$ |
| 10.0 | 11.447$^{a}$ | 10.508$^{a}$ | 8.640$^{b}$ | 10.584$^{a}$ | 11.843$^{a}$ |

Means carrying the same letters across the columns and rows are not significantly different from each other (P< 0.05).

Accession from Okitipupa performed woefully among the five accessions evaluated. An increase in salinity levels reduces the quantity of grain yield in all five accessions. The grain yield obtained at 10.0 dS/m was 50% lower compared to what is obtained at 2.5 dS/m for all the accessions studied. The grain yield, the most economically valuable part of soybeans to most farmers was also decreasing significantly by the salinity levels. This is an indication that soybean is sensitive to soil salinity but the degree of salinity varies among the accessions grown. This is in agreement with the result of who reported a decrease in grain yield in soybean as salinity levels increased (Abdul Mannan et al., 2013). The grain yield reduction by salinity level could be attributed to the aggregate reduction in all the vegetative and grain yield-related traits.

**Table 6:** Effect of salinity levels on pod weight of five landrace soybean accessions over two years.

| | Accessions | | | | |
|---|---|---|---|---|---|
| **EC (dS/m)** | **Zaria** | **Mokwa** | **Okitipupa** | **Ikole-Ekiti** | **Kujama** |
| 0.64 (Control) | 15.583$^{d}$ | 13.983$^{bc}$ | 13.504$^{d}$ | 14.807$^{abc}$ | 16.034$^{d}$ |
| 2.5 | 13.830$^{c}$ | 12.400$^{bc}$ | 11.967$^{c}$ | 13.406$^{ab}$ | 13.950$^{c}$ |
| 5.0 | 10.616$^{b}$ | 8.7521$^{b}$ | 8.3161$^{b}$ | 11.6540$^{a}$ | 10.621$^{b}$ |
| 7.5 | 8.266$^{ab}$ | 7.453$^{ab}$ | 6.034$^{b}$ | 8.416$^{a}$ | 8.766$^{ab}$ |
| 10.0 | 5.450$^{a}$ | 5.640$^{a}$ | 3.757$^{a}$ | 5.965$^{a}$ | 6.133$^{a}$ |

Means carrying the same letters across the columns and rows are not significantly different from each other (P< 0.05).

**Table 7:** Effect of salinity levels on the grain yield of five landrace soybean accessions over two years.

| | Accessions | | | | |
|---|---|---|---|---|---|
| **EC (dS/m)** | **Zaria** | **Mokwa** | **Okitipupa** | **Ikole-Ekiti** | **Kujama** |
| 0.64 (Control) | 1.383$^{c}$ | 1.360$^{cd}$ | 1.376$^{c}$ | 1.213$^{e}$ | 1.493$^{b}$ |
| 2.5 | 1.276$^{c}$ | 1.245$^{e}$ | 1.270$^{cd}$ | 1.136$^{e}$ | 1.301$^{b}$ |
| 5 | 1.043$^{cd}$ | 0.803$^{ef}$ | 1.342$^{cd}$ | 0.931$^{ef}$ | 1.054$^{bc}$ |
| 7.5 | 0.794$^{e}$ | 0.751$^{ef}$ | 0.753$^{e}$ | 0.683$^{ef}$ | 0.754$^{b}$ |
| 10.0 | 0.536$^{ef}$ | 0.456$^{f}$ | 0.486$^{ef}$ | 0.466$^{f\ cd}$ | 0.535a |

Means carrying the same letters across the columns and rows are not significantly different from each other (P< 0.05).

## 4. Conclusion

Soil salinity significantly reduces the mean performances of all the studied traits in the five landrace soybean accession predominately grown in the southern Guinea savanna of Nigeria. The reduction observed in the studied traits was induced by increasing salinity. The findings from the research work showed that soybean accessions were very sensitive to salinity but the level of salinity among the accessions varies. Considering the yield and yield-related traits studied, it was observed that accession 5 exhibits the highest level of salt tolerance among the five landrace accessions under study followed by accession from Zaria, Okitipupa, Mokwa, and IKole Ekiti respectively. It is therefore recommended that accession from Kujama, Zaria and Okitipupa should be planted by the farmers especially in the area where soil salinity is suspected or confirmed and these three accessions can further be improved by plant breeders using a good plant breeding strategy for salt tolerance.

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