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Sunflower (*Helianthaus annuus* L.) Seeds Germination in Saline Hydroculture

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Abstract: Salinity affects seed germination, many plant growth and yield traits. This study assessed seed response, quality, ability and phenetic relationship in three sunflower (*Helianthaus annuus* L.) varieties (SSL-803, SSL-807 and SSL-809) in eleven concentrations of NaCl + $CaCl_2$ solutions (1:1 by weight). Electrical conductivity of the saline solutions ranged from 0.16 to 31.25 dS/m. The repeated factorial experiment (3x11) was laid out in a completely randomized design with three replications in the screenhouse. Germination of 20 seeds per treatment was evaluated within five to ten days after culturing in filter-paper lined petri-dishes. Salinity above 15.63 dS/m significantly ($p \leq 0.05$) inhibited seed germination; three seeds of twenty (16.7%) of variety SSL-809 and eight seeds (41.7%) of SSL-807 germinated in 18.75 dS/m solution, and high salinity (18.75 to 31.25 dS/m) caused seed discolouration and shrivelling in SSL-809 and SSL-803 varieties. Cluster analysis (Bray-Curtis' method) partitioned SSL-807 on a par with SSL-803 in terms of tolerance and adaptability to salinity, SSL-809 was at aversion with the two varieties in these traits. The variety SSL-807 is recommended for cultivation in soils with electrical conductivity below 21.88 dS/m and SSL-803 in saline environments below 18.75 dS/m. Future research on sunflower seed germination will be carried out on the field to verify and fully elucidate current studies.

Keywords: *Helianthaus anuus* L., Seed Germination, Sunflower, Tropical Ecology, Salinity Tolerance

1. Introduction

Salinity is the relative proportion of salt in a solution. Soil salinity influences crop production in several ways. High salinity is one of the major abiotic stress factors that cause substantial decrease in crop yield and has generated more concerns because saline conditions are increasing globally, aided by global warming; about 1.5 billion hectares of the world's rhizosphere are affected by salt, especially in arid and semi-arid regions [1]. Salinity tolerance varies within and between crop species [2, 3].

Katerji *et al*., [4] found a close association between reduction in plant growth and grain yield to salt stressed in sunflower and maize. Studies by Jampeetong and Brix [5] and Tang *et al*. [6] showed that the application of salt to root systems of plants inhibited growth and biomass accumulation by decreasing osmotic potential of the external solution. Salinity also impact on the photosynthetic process, water retentiveness and nutrient absorption capacity in plants. The biochemical composition of plants is also affected by salinity through changes in the concentration and type of proteins, amino acids, sugars and other carbohydrates produced by the plant [7]. Higher levels of salinity create an excessive accumulation of salts in plant tissues thereby causing toxicity. In summary, high concentrations and prolonged salinity in the soil reduce plant growth and yield.

Sunflower (*Helianthus annuus* L.) belongs to the family Asteraceae; this is a large family with composite inflorescence. It is grown worldwide as an important economic annual crop; it is edible and is the world's fourth largest oil-seed crop [8]. Sunflower is an ornamental and medicinal plant, food and feed and an industrial crop. As a medicinal crop, it is used to ameliorate alimentary tract discomfort and used as a feed stock or fodder crop; it is utilised in production of dyes for textile industry and employed in body painting and decorations, and in the manufacturing of paints and cosmetics [8]. Sunflower oil is used for cooking, salad dressings and for making margarine [9].

The basic chromosome number (x) for the genus *Helianthus* is 17; however, there are diploid, tetraploid and hexaploid varieties [8]. The growth and photosynthetic rate of sunflower are negatively affected by high salt levels in the soil [10]. Katerji *et al.* [4] noted that sunflower was more tolerant to salinity than many other species, such as grasses, Hasanuzzaman *et al.*, [11] opinion is that the use of salt tolerant crops does not remove the salt from the plant tissues and recommended halophytes that have capacity to accumulate and expel the salt as more effective remedy. However, in the absence of the halophytes, tolerant genotypes would suffice in crop production, which is the major focus of this study.

Globally, the area under sunflower cultivation has increased greatly due to the development of dwarf high yielding hybrid lines that encourages mechanization [8]. Ukraine is the world's highest producer of sunflower seeds; producing about 11 millions tonnes of sunflower seeds, followed by Russia and Argentina as second and third, which produce about 10.6 and 3.1 million tonnes of sunflower seeds respectively, but Russia is the world highest producer of sunflower oil with 1.86 million tonnes [12]. According to FAOSTAT [13], South Africa is the highest producer of sunflower seeds in Africa, with 0.9 million or 46% of total Africa's production, followed by Tanzania with 35% [14]. Nigeria is one of the sunflower producing countries in Africa [15].

In Nigeria, poor small holder farmers cultivate and utilize the sunflower plant; according to Abayomi *et al.* [15], the farmers use sunflower as animal feed and to produce manure and fertiliser, they extract the oil and eat sunflower seed-cake, some people use sunflower parts in traditional medicine and as ornamental plant. Generally, agricultural productivity in Nigeria is grievously stricken due to her over dependence on petroleum. In the hope that there will be reconsideration in economic policy of the country, sunflower is an easy crop to grow, even in saline conditions; it is a fast-growing annual crop with a quick return potential on investment. Its production will be of great benefit to the resource poor farmers who hope to eke out livelihood growing the crop. Its production will aid the bid to alleviate poverty and boost the attainment of food security.

Selection of suitable genotypes in terms of seed germination is essential for the growth and yield of crops. Calabar, Cross River State, Nigeria has one of its borders with the Bight of Bonny and has large limestone deposits. The ocean water and limestone create soils with high sodium and calcium salt concentration, these conditions necessitated this study. If a reasonable quantity of the sunflower seed germination can be achieved, then the crop can be cultivated. The objective of the study was to evaluate seed germination of three sunflower varieties in saline solutions.

2. Materials and Methods

The experiment was carried out in Faculty of Agriculture, Forestry and Wildlife Resources Management screen-house, University of Calabar, Calabar. The seeds of three sunflower varieties (SSL-803, SSL-807 and SSL-809) were obtained from Institute of Agricultural Research (IAR) Samaru, Zaria, Nigeria. Sodium Chloride (NaCl) and Calcium Chloride ($CaCl_2$) manufactured by Loba Chemie Ltd, India; each salt solution contained equal proportions of NaCl and $CaCl_2$ (w/w), electrical conductivity of the solutions were measured with a conductivity meter (model 1500-20, Cole Parma Instrument Company, USA). The composition of the saline solutions is shown in Table 1.

Table 1. *Composition and electrical conductivity of the saline solutions used in seed germination.*

SN	Weight of NaCl (g)	Weight of CaCl (g)	NaCl + CaCl (g/litre of H_2O)	Electrical conductivity (dS/m)
1.	0	0	0	0.16
2.	1	1	2	3.13
3.	2	2	4	6.25
4.	3	3	6	9.38
5.	4	4	8	12.50
6.	5	5	10	15.63
7.	6	6	12	18.75
8.	7	7	14	21.88
9.	8	8	16	25.00
10.	9	9	18	28.13
11.	10	10	20	31.25

Twenty (20) seeds of each variety for each treatment were placed in 9 mm glass petri dish lined with Whatman® filter paper before 6 mm salt solution was added. The experiment was an 11 x 3 factorial laid out in a completely randomized design with three replications resulting in 99 experimental units, then repeated 14 days after first experiment. The number of germinated seeds (indicated by the protrusion of a radicle and a plumule) between five and ten days were counted and transformed with $\text{sine}^{-1}\sqrt{x}$ before the computation of analysis of variance (ANOVA). Means that were significantly different ($p \leq 0.05$) were separated with Least Significant difference (LSD) computed with GENSTAT version 8.1 [16].

3. Results

Seed germination of the sunflower varieties in the eleven saline solutions is presented in Table 2. There was above

80% germination in saline solutions with conductivity of 0.16 to 6.25 dS/m in the three varieties; that is, 16 or more seeds out of the 20 seeds cultured achieved germination. In saline solutions with the electrical conductivity 9.38 to15.63 dS/m, more than 10 seeds (50%) of the sunflower seeds germinated in all the varieties, whereas, in higher saline concentrations (18.75 to31.25 dS/m), the seed germination of the sunflower varieties was below 45%, the seed germination declined as the concentration of salt increased. In saline concentration 18.75 dS/m; 8.3 (41.67%) of the seeds of variety SSL-807 germinated, 6.7 (33.3%) of the seeds of SSL-803 and 3.3 (16.67%) of the seeds of SSL-809 germinated. In salinity 28.13 dS/m; 6.67% of seeds of SSL-807 germinated, 5% of SSL-803 and 1.67% of SSL-809 germinated. There was no significant ($p \geq 0.05$) difference in the interaction between sunflower varieties and salinity concentration.

There were variations in seed shape and colour in the experiment (Table 3), for example, in the saline solutions with electrical conductivity 18.75 to 31.25 dS/m, there were bleaching (discolouration) and shrivelling of the seeds in varieties SSL-803 and SSL-809. In saline solution with the conductivity 18.75dS/m, a mean of five and six of the twenty seeds in the experimental dishes containing varieties SSL-803 and SSL-809 respectively were discoloured and shrivelled. Seed discoloration and shrivelling in variety SSL-807 was not observed except in saline solutions with electrical conductivity of 28.13 to 31.25 dS/m; only three seeds in solution with electrical conductivity 28.13 dS/m and six seeds in 31.25 dS/m showed deformation.

Table 2. Sunflower seed germination in the different concentrations of salinesolution.

Salinity (dS/m)	Germination (%)*			Salinity mean
	SSL-807	SSL-803	SSL-809	
0.16	17.0 (14.5)	16.7 (14.3)	17.0 (14.5)	16.9 (14.5)
3.13	16.3 (14.1)	16.3 (14.1)	16.0 (13.9)	16.2 (14.0)
6.25	18.3 (15.4)	16.3 (14.1)	16.0 (13.9)	16.9 (14.5)
9.38	15.3 (13.4)	13.0 (11.8)	12.0 (11.0)	13.4 (12.1)
12.50	12.0 (11.0)	12.0 (11.0)	10.3 (9.7)	11.4 (10.6)
15.63	11.7 (10.8)	10.0 (9.5)	12.7 (11.5)	11.4 (10.6)
18.75	8.3 (8.1)	6.7 (6.7)	3.3 (3.5)	6.1 (6.2)
21.88	6.3 (6.4)	6.3 (6.4)	5.3 (5.5)	6.0 (6.1)
25.00	9.3 (9.0)	4.3 (4.5)	2.3 (2.4)	5.3 (5.5)
28.13	1.3 (1.3)	1.0 (0.9)	0.3 (0.2)	0.9 (0.8)
31.25	0.3 (0.2)	0.7 (0.5)	0.3 (0.2)	0.4 (0.3)
Variety mean	10.6 (9.9)	9.4 (9.0)	8.7 (8.4)	

Salinity $(S)_{F-LSD\,(0.05)}$ = 5.49; Variety $(V)_{F-LSD\,(0.05)}$ = 3.96; S x V interaction$_{F-LSD\,(0.05)}$ = NS;
*Figures in parentheses were $\sin^{-1}\sqrt{x}$ transformed data to which F-LSD apply.

Figure 1 shows the Bray-Curtis clustering based on the similarity and deviation among the three sunflower varieties in the study. These varieties were partitioned into two major clusters namely; varieties SSL-807 and SSL-803 in one cluster and SSL-809 in another cluster.

Table 3. *Variation in sunflower seed morphology in response to salinity level.*

Salinity	SSL-807	SSL-803	SSL-809
0.16	None	None	None
3.13	None	None	None
6.25	None	None	None
9.38	None	None	None
12.50	None	None	None
15.63	None	None	None
18.75	None	Discolouration Shrivelling (25%)	Discolouration Shrivelling (30%)
21.88	None	Discolouration Shrivelling (25%)	Discolouration Shrivelling (25%)
25.00	None	Discolouration Shrivelling (30%)	Discolouration Shrivelling (30%)
28.13	Discolouration Shrivelling (15%)	Discolouration Shrivelling (30%)	Discolouration Shrivelling (40%)
31.25	Discolouration Shrivelling (25%)	Discolouration Shrivelling (40%)	Discolouration Shrivelling (50%)

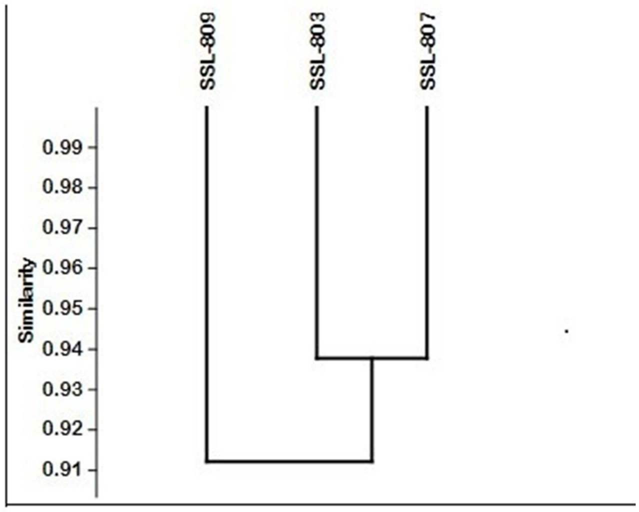

Figure 1. *Cluster (Bray-Curtis) similarity analysis of sunflower varieties response to saline solution.*

4. Discussion

From these results, there were various effects of salinity on response and quality of sunflower seed; for example, there was decline in sunflower seed germination in response to higher concentration (18.75 to 31.25 dS/m) of NaCl and $CaCl_2$. All the varieties showed relatively large reduction in seed germination; the reduction in germination ranged from 65 to 95 per cent in solutions with electrical conductivity above 15.6 dS/m. There was no significant difference in the variety by salinity interaction indicating that salt levels suppressed seed germination in these varieties in a uniform manner. The higher salinity also incited changes in seed shape and colouration. The changes in the seed germination and morphology as result of high salinity are consequences of osmotic stress and failure of cell expansion [7], which accordingly affected seed nutrient absorption and water retention.

In terms of relationship and adaptability to saline conditions, SSL-803 and SSL-807 were more tolerant to salinity than SSL-809. The varieties in the same cluster share closer association in their sensitivity to salinity than the variety in a different and separated cluster.

5. Conclusion

Soil salinity poses great challenges to crop production, high soil salinity reduces seed germination, inhibit photosynthesis, growth and yield of the plants and cause the deposition of toxic substances in the plant tissues. Sunflower (*Helianthaus anuus L.*) is an important economic crop whose production has potential to alleviate poverty and ensure food security for poor farmers.

The study environment, Calabar is bordered in the south by ocean and has limestone deposit, which influence the soil types. Three sunflower varieties were tested in eleven solutions contaning sodium chloride and calcium chloride, the composition of the saline solutions had electrical conductivities of 0.16 to 31.25 dS/m. In this study salinity levels greater than 15.63 dS/m electrical conductivity reduced seed germination in the three sumflower varieties by 55 to 85%, caused discolouration and shrivelling of the seeds. However, varieties SSL-807 and SSL-803 were more tolerant and better adaptable to the saline conditions than SSL-809. Consequently, the varieties SSL-807 and SSL-803 are recommended for cultivation in saline environment.

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