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Effects of Saline Water on Seed Germination parameters of three Dryland Species (*Grewia tenax, Salvadora persica and Capparis deciduas*)

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Abstract**—***t—This study investigated the effects of saline water on seed germination percentage, germination index, water uptake, and mean salinity responses in three dryland species (Salvadora persica, Grewia tenax, and Capparis deciduas).The experiment was conducted under control conditions in the Genetic Engineering Laboratory at the National Center for Research, Ministry of Higher Education and Scientific Research, Khartoum.Seeds of Grewia tenax, Salvadora persica, and Capparis deciduas were collected from North Kordofan, Red Sea State, and Khartoum State, respectively. Seeds were soaked in water for 24 hours to clean them, remove the seed coat, and break dormancy, then germinated in sterilized Petri dishes lined with Whatman filter paper. Germinability was assessed using final cumulative germination percentage and germination index. The experiment followed a completely randomized design with four replicates for each salinity concentration and species, using 25 seeds per replicate. Four salinity concentrations (0%, 2%, 5%, and 10%) were used for irrigation, with 0% serving as the control. Initial dry weight was measured to three decimal places for four replicates of each species before soaking the seeds in the four salinity treatments for 48 hours. Fresh weight was then recorded to calculate water uptake for each treatment. Data were analyzed using analysis of variance (ANOVA) to test differences among species and salinity levels, and Duncan's multiple range test was used to separate means. Species differed highly significantly in water uptake (p = 0.0001), whereas salinity concentration had no significant effect. Salvadora persica had the highest water uptake, followed by Capparis deciduas, while Grewia tenax had the lowest. Species and salinity concentration also showed significant variation in seed germination (p = 0.003). Grewia tenax recorded the highest germination percentage (83.5%), followed by Salvadora persica (78%), while Capparis deciduas had the lowest (73.2%). Grewia tenax germinated more successfully under saline conditions than the other species. Selection criteria for these species at specific sites should therefore consider the relative importance of plantation objectives in dryland areas. The study concluded that salinity is a critical environmental stressor that can either prevent seed germination entirely or substantially reduce germination rates.*

Keywords**—** *Salinity stress, water uptake, seed germination %, germination index % and salt tolerance.*

I. Introduction

Salinity is one of the most important abiotic stresses that negatively affect plant growth and development around the world. It has been reported that approximately 19.5% of all irrigated land and 2.1% of dry land is affected by salt stress, and these percentages continue to increase [1]. Salinity in soil or water is one of the major stresses, especially in arid and semi-arid regions and can severely limit crop production [2]. Salinity and drought are the major environmental constraints to crop productivity throughout the arid and semi-arid regions of the world. Between 30 and 40% of the world irrigated agricultural lands are prone to salinity [3]. It was reported that approximately 19.5% of irrigated lands and 2.1% of dry lands were affected by salt stress. In addition, saline land is continuously increasing mainly due to improper irrigation management practices [4] and [5]. It is estimated that approximately 7% of world land is affected by salinity and approximately 20% of 230 million ha irrigated land is salt affected [6]. This number could be increased in the future due to increased land salinization because of contaminated artificial irrigation, climate change, and unsuitable land management [6]. Salt stress is an important a biotic stress factor that limits crop productivity through negative impacts on plant growth and development especially in arid and semi-arid regions **[7].** Germination is important stage in the life cycle of crop plants, particularly in saline soils as it determines the degree of crop establishment. Salinity has toxic effect on germination seeds and excessive salt hinders seeds from water uptake during [8]. Seed germination begins with imbibition, the uptake of water by the dry mature seed, and ends with visible protrusion of radical through testa [9] and [10].

Salinity may adversely influence seed germination by decreasing the amounts of seed germination stimulants such as GAs, enhancing ABA amounts, and altering membrane permeability and water behavior in the seed [11]. Salinity affects seed germination process through osmotic stress, ion-specific effects and oxidative stress, shown by decreasing germination rate and extended germination time [12]. Salinity increases external osmotic potential that reduces water uptake during imbibition's [13]. Salinity-induced osmotic and ion stress negatively influence plant growth and development, and such negative impacts largely depend on type of salt, level and duration of salt stress, genotype and developmental stage of the plant exposed to salt stress [14] and [15].

Plants tolerance towards salts is a complex phenomenon which affects several aspects of the plant. The germination rate and early growth under salty soils indicate clearly that the plants are tolerant to environmental stresses [16]. Species distribution and survival mainly depend on the seed ability to

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complete germination and the seedling ability to develop successfully under unfavorable conditions [17]. Seedling germination, seedlings emergence, and their survival are particularly sensitive to substrate salinity [18].

The salts interfere with seed germination and tree establishment and can affect seed Germination, and seedling characteristics are the most viable criteria used for selecting salt tolerance in plants [19] and [20]. Salinity tolerance of many perennial halophyte's dependent on a variety of abiotic [21]. Germination percentage, germination speed and seedling growth are the most criteria for selecting tolerance in plants [22].

II. Material and Methods

An experiment was carried out in Genetic Engineering lab in National Center for Research – Ministry of Higher Education and Scientific Research -Khartoum. The research experiment included three species of seed (*Grewia tenax, Salvadora persica* and *Capparis deciduas*). Three dry area species were used *Grewia tenax*, *Salvadora persica* and *Capparis deciduas* in the experiment. *Grewia tenax was collected* from North of Kordofan, *Salvadora persica* was collected from Red Sea State and *Capparis deciduas* was collected from Khartoum State, Soba area. The seeds were cleaned by water that by immersed them into water for 24 hours to extract seed coat and to break the seed dormancy, then the seeds were dry under shade.

A. Water uptake:

25 seeds were weighed by sensitive balance with three decimals for every replicate for the three species and four replicates were used for each. The dry weight was recorded for each replicate. Then every replicate was immersed into different salinity levels (0%, 2%, 5% and 10%) separately into labeled glass beaker for 48 hours, then the seeds were put in aluminum foil for two minutes under fan to avoid attached water out the seed coat. Then every replicate was weighted and the fresh weights were recorded, then the water up take was calculated for each replicate for each concentration for each species by the following equation[23].

$$\text{water uptake} = \frac{FreshWeight - dryweight}{Dryweight} \times 100$$

B. Seed germination:

The experiment was laid out as complete randomized design with four replicates for each salinity concentration for the three species with 25 seeds for each replicate. The experiment was carried out under Control laboratory conditions.

Four salinities concentrations (0%, 2%, 5% and 10%) were used to irrigate the seeds, 0% was used as control. The seeds were then germinated in sterilized Petri dishes Whatmann filter- paper with two layers were used as germination media moistened with 10mL of either distilled water (control) and NaCl concentration. Filter paper was altered every two days to avoid the accumulation of salt with everyday watering. The seeds were sterilized in 10% Clorox and washed three times with distilled water to remove the effect of Clorox. During the experiment, germinated seeds were counted on day. Seed germinability was assessed by the final cumulative percentage of germination at the end of the test. Germination was considered only when the radicals were longer than 2mm. Germination was calculated by this equation

$$\text{Germination\%} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds germinated}} \text{X } 100$$

Germination index (GI) was calculated according to the following equation:

$$\text{Germination index} = \frac{\text{\% Germinationineachtreatment}}{\text{\% Germination in control}}$$

**Mean (salinity): Mean salinity indicates the average value for the three salinity levels except control (0 % Nacl).

C. Data analysis:

Data was subjected to analysis of variance (ANOVA) to confirm the differences between the species and salinity level and Duncan Multiple Range Test to separate the means.

III. Results

A. Water uptake:

The species showed highly significant difference (.0001) but, the *concentration* did not show significant difference Table (1). *Grewia tenax* achieved high water uptake followed by *Salvadora persica* and the lowest water uptake was achieved by *Capparis deciduas* Table (2). *Grewia tenax*'s seed absorb more saline water than the other species. may be more tolerance to salinity than the other species.

TABLE 1. Anova: Seed water uptake percentage for the three species.

Source of variation	D.F	Meansquare	F value	Pr > F
Species	2	79600.99	16.51	. 0001
Concentration	3	358.78	0.07	0.97

TABLE 2. The means of the water uptake percentage for the three species

Species	Mean
Grewia tenax	89.2 [a]
Salvadora persica	80.8 [b]
Capparis deciduas	64.3 [c]

Mean with same letters in same column are not significantly different at 0.05

B. Germination percentage under Salinity concentration:

The species and salinity concentration showed high significant variation (0.003) in seed germination % and among concentration level (0.003), Table (3). *Grewia tenax* scored higher germination percentage than the other species and followed by *Salvadora persica* and lower one scored by *Capparis deciduas* Table (4) and figure (1). Highlighted the germination percentage of the three species. So that the *Grewia tenax* showed ability to germinate more seeds under saline water than the other species.

TABLE 3. Anova: The effect of salinity concentrations of the seed germination of the three species.

Source of variation	D.F	Mean square	F value	Pr > F
Species	2	421.0	6.5	0.003
Concentrations	3	353.2	5.4	0.003

TABLE 4. The means of germination percentage for the three species

Species	Germination
Grewia tenax	83.5 [a]
Salvadora persica	78.0 [a b]
Capparis deciduas	73.2 [b]

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Mean with same letters in same column are not significantly different at 0.05

C. Salinity inhibition of seed germination across trees species:

Based on the results presented in Table 5, no significant differences are observed in the control treatment (0 concentration) among the plant species; however, it outperformed the other treatments in mean germination percentage. It showed high germination percentage (90%), followed by 2% concentration (89%) and the lowest one scored by 10% concentration (75%). When the salinity concentration increased the germination level decreased, so that salinity has harm effect on seed germination for the three species *Grewia tenax* showed high germination % under 0% concentration (90%) then followed by *Salvadora persica* (83%) and the lowest one showed by a *Capparis deciduas* (82%). There is no variation between the three species under 5% and 10% concentration, but *Grewia tenax* achieved better germinability than other species. Accordingly, the salinity leads to a reduction in seed germination percentage of the three species. The three species showed that it can respond similarly when the salinity levels increased. A comparison of the response of the three species indicated significant decrease in germination percentage with increasing salinity level. Increase in salinity from 2 to 10 % reduce the germination percentage from 89 to 75 for *Grewia tenax*, from 80 to 73 for *Salvadora persica* but, *Capparis deciduas* showed similar results under the three levels of salinity. The mean values of germination percentages were progressivity and significantly decreased as the level of salinity increased. Increasing the level of salinity from 0.2 to 10%, significantly reduced the average.

TABLE 5. The means of the germination percentage of the three species under the effect of salinitylevels.

Species	Germination %in different salinity concentrations			
	Control (0%)	2 %	5 %	10 %
Grewia tenax	90.0 ^{a}	89.0 ^{a}	80.0 ^{a}	75.0 ^{a}
Salvadora persica	83.0 ^{a}	80.0 ^{ab}	76.0 ^{a}	73.0 ^{a}
Capparis deciduas	82.0 ^{a}	71.0 ^{b}	70.0 ^{a}	70.0 ^{a}

Mean with same letters in same column are not significantly different at 0.05

D. Effect of salinity levels on overall germination percentage and germination index:

The mean values of germination percentages were progressivity and significantly decreased as the level of salinity increased. Increasing the level of salinity from 0.2 to 10%, significantly reduced the average. The data presented in Figure (1) displays the overall germination percentage for seeds of three different species the seeds from the three species were able to germinate at a Nacl, but, the germination index did not effect by salinity concentrations Figure (2) which displays the germination index percentage for the three species and figure 3 displayed, the mean (salinity) percentage for the three species.

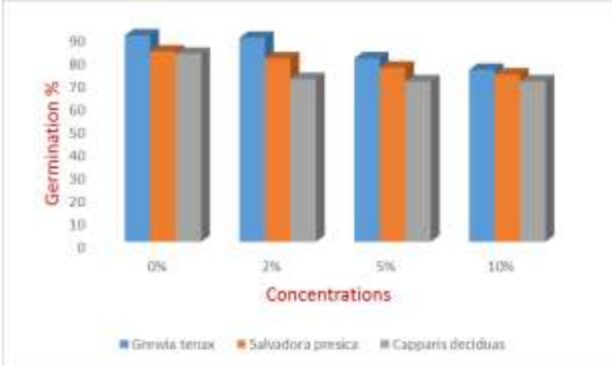

Fig. 1. Means of germination % of the three species affected by salinity concentrations

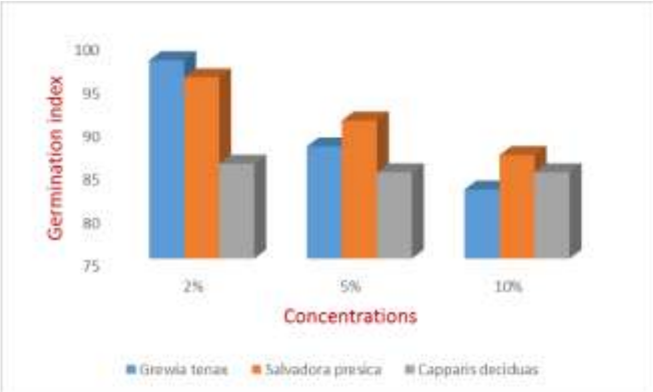

Fig. 2. Means of germination index for the three species affect by salinity concentrations.

Fig. 3. Mean salinity indicates the average value for the three salinity levels except control (0 % Nacl).

IV. Discussion

A. Water uptake:

The *Grewia tenax*s seed is a most permeability to saline water that means has a seed coat are low thick, followed *Salvadora persica* and *Capparis deciduas* scored the lowest one. The physical process of water uptake leads to activation of metabolic processes as the dormancy of the seed is broken following hydration. The first phase of water uptake by the seeds involves movement of water into the free space and does not depend on the osmotic potential of the surrounding solution [10]; [24]. Seed germination begins with the water uptake of dry seed (imbibition) and ends with radicle protrusion. Seed germination is affected by adverse environmental conditions including salinity, high temperature, and drought [6].

Germination percentage:

The mechanism of inhibition of generation and growth by Nacl, may be related to radical emerge due to insufficient water absorption, or may be described to toxic effects on the embryo [25]. Salinity primarily affects plant production by interfering in the absorption of water and nutrients, as well as toxicity in plant cells ([26].

The results reported in this study suggest that the three species showed good germination percentage under the three levels of salinity levels but, when the salinity levels increased the germination decreased. Reduction in germination of plants by increasing salinity levels has been described by numerous authors [27]; [28]. Salinity increases external osmotic potential that reduces water uptake during imbibition's [13]. Salinity may affect the germination of seeds by the toxic effects of excess sodium and chloride ions on embryo viability [29] and [30].

In germination, the species investigated showed different responses to saline water stress under concentration levels. It seems that decrease in percent germination may be due to decrease of water movement into the seeds which can be called water deficit effects of salinity. The three species reveal their varying ability of seed germination towards salinity. The group of plants that are well adapted to saline habitats are called halophytes. Germination of many halophytes occurs when the combination, soil water and soil salinity is optimal for plant growth [31], [32], and [33].

The results reported in this study suggest that the three species are salt tolerance and *Grewia tenax* is one of the more salt tolerance species and are more suitable species for planting in high salt soil. These results agreed with [7] who found that high levels of salinity can significantly inhibit seed germination. Our findings indicate that saline stress leads to decrease in germination percentage across the three species. According to [34] metabolic imbalances within the seeds were responsible for the reduced germination under stress conditions.

The extent of germination percentage reduction varied for each species *Grewia tanax* displayed a higher germination percentage than *Salvadora persica* and *Capparis deciduas* at 2% and 5% concentration, but the three species seem to display similar germination percentage at 10%. Genetic and environmental factors both effects seed germination, and different species have developed adverse mechanisms to adapt to sodium- chloride- induced adverse conditions, [35] and [36]. The sensitivity of the species to salinity was manifested by reduction in germination percentage, shoot height, root length and increased mortality. In conclusion, the results of this study suggest that salinity reduces seed germination, but that the three species appeared kind of tolerance of salinity level to some extent [37]. Therefore, we suggest that the use of *Grewia tenax*, *Salvadora persica* and for reclamation in arid and semi-arid areas, where salinity affects vegetation development, could lead to suitable results.

Salinity stress inhibits seed germination through a complex interplay of physiological and biochemical processes that fundamentally disrupt the delicate balance required for successful seedling emergence [38]; [39].

These mechanisms primarily involve osmotic stress, ion toxicity, and hormonal imbalances, all contributing to reduced germination rates and delayed seedling establishment [40] and [41] and [42].

V. Conclusion

Our findings indicate that saline stress led to a decrease in germination percentage. Salinity is a major stress responsible for the inhibition of seed germination or reduction in germination percentage the results of this study suggest that salinity reduces seed germination, but that the three species appeared kind of tolerance of salinity level to some extent. *Grewia tanax* displayed a higher germination percentage than *Salvadora persica* and *Capparis deciduas* at 2% and 5% concentration, but the three species seem to display similar germination percentage at 10%.

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