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Evaluation of Performance and Variability of Six Sorghum Genotypes under Salinity Stress

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Abstract: *Sorghum (Sorghum bicolor (L) Moench) has been ranked the fifth in importance among the cereal crops. It is moderately salt tolerant and is a C4 grass that is well adapted to semi-arid and arid regions where salinity is the major problem. This study was conducted to evaluate the performance and variability of six sorghum genotypes under two salt concentrations (200 mM and 300 mM). The length, fresh and dry weight of shoot and root were measured during salt stress. The results revealed that the plant growth measurements of the six sorghum genotypes was significantly reduced at two salinity levels; however the genotypes showed tolerant to the salt concentration 200 mM more than the concentration 300 mM. On the basis of results obtained using above parameters, the genotype Milo was the most tolerant to salt stress followed by Red Mugud.*

Keywords: *Growth biomarkers, Salt Stress, Sorghum.*

1. INTRODUCTION

A biotic stresses such as salinity affect plant growth, development and productivity by imposing hyperosmotic and oxidative stresses, ion toxicity and nutrient deficiency. Saline soils are those soils with higher levels of soluble salts, such as sulphates (SO_4), carbonates (CO_3) , chlorides (Cl), calcium, magnesium, and potassium that among them sodium chloride has the highest negative effect on the plant growth and development. Soils contaminated with salts (EC > 4 dS m-1 or 40 mM NaCl or osmotic potential < 0.117MPa) are defined as saline land, which directly affects all stages of plant growth and development [1].

Salinity causes slow seed germination, sudden wilting, and reduce growth, marginal burn on leaves, leaf yellowing, leaf fall, restricted root development, and finally death of plants. Effects of salinity on crop productivity are more severe in arid and semiarid regions where limited rainfall, high evapotranspiration, high temperature, poor water quality, and poor soil management practices exacerbate salinity effect [2]. And it is one of the main problems for plant growth in agriculture, especially in countries where crops should be irrigated [3].Salinity has been considered a limiting factor to crop production in arid and semi arid regions of the world, where sorghum is cultivated in vast areas for food and feed uses [4].

Sorghum (*Sorghum bicolor* (L) Moench) has been ranked the fifth in importance among the cereal crops namely wheat, rice, maize and barley. Sorghum represents Africa's main contribution to the world food supply [5]. It is often grown in areas of relatively low rainfall, high temperatures and saline soils. Sorghum is moderately salt tolerant and is a C4 grass that is well adapted to semi-arid and arid regions where salinity is the major problem [6]. In this study, the performance of six sorghum genotypes under salinity stress was evaluated.

2. Materials and Methods

2.1. Plant Materials and Culture

The materials studied were consisted of six Sudanese grain sorghum genotypes namely, Wad Ahmed, Tabat, Tetron, Dwarf white Milo, Arfa Gadamak and Red Mugud. Seeds of these varieties were obtained from Agricultural Research Corporation (ARC) Wad Medani, Sudan.

To study the effect of salinity on six sorghum genotypes, a controlled experiment was conducted in growth chamber at 28˚C in the Department of biotechnology, University of Osaka, Japan (2014). Twenty seeds of each genotype were sown in sandy soil in pots to grow and establish under normal conditions with proper irrigation for seven days until emergence. Seven old seedlings were irrigated daily with half strength MS media [7] for 30 days before starting salt treatments. The treatments consisted of a control, plus two salinity levels that were obtained by adding 200 mM and 300 mM NaCl to ½ MS media. One month after growing, seedlings were irrigated daily with 50 ml half strength MS media containing 0 mM, 200 mM, 300 mM NaCl for ten days. The experiment was done as completely randomized design with three replicates. The experiment was repeated two times.

2.2. Plant Growth Measurements

To assess the effect of salinity on seedlings growth, ten samples from each genotype were collected randomly 10 days after salt treatments. At the end of the experiment, plant height was measured. The plants were then separated into shoots and roots, and the length of roots recorded. Fresh mass of shoots and roots were determined, and dry mass was obtained after oven drying the samples at 65^{o}C for 72 hr.

2.3. Statistical Analysis

All data were subjected to analysis of variance (ANOVA) and the differences contrasted using Tukey's multiple range test. Statistical analysis was performed at the level of P value less than 0.05 using SPSS 22.0 (SPSS Inc. USA).

3. Results and Discussion

3.1. Effect of Salinity on the Length of Shoot and Root

Salinity stress had significant effects on all the growth parameters, and differences among genotypes for all characteristics were significant (Table 1). Our results showed that the growth of the six sorghum genotypes was reduced with increasing NaCl concentration. Similar observations were made by [8] who reported significant reductions in sorghum growth when salinity was applied in range from 50 to 150 mM.

The obtained results showed that there were significant differences ($P \leq 0.05$) in root length among the six sorghum genotypes. All sorghum genotypes were sensitive to 300 mM NaCl since the average length of shoot and root was decreased as shown in Table (1). On the other hand the results indicated that the studied sorghum genotypes were varying in their responses to different salt concentrations. Reference [9] reported that salt stress tolerance in sorghum may vary among genotypes depending on their root system efficiency to absorb nutrients and K, Na uptake; also sodium mainly remained in roots as compared to shoots that might be due to the mechanism of retention more of Na+ in roots as compared to other plant parts. In this study the average of shoot length was ranged from 15.20 to

24.00 cm at the concentration 200 mM NaCl which presented by Tabat and Milo respectively. While the maximum shoot length was recorded in Milo at 300 mM NaCl. Moreover, the average of root length was ranged from 5.45 to 7.90 and from 2.85 to 7.90 in salt concentrations 200 mM and 300 mM respectively. Whereas the high values was recorded in the genotype Wad Ahmed as shown in Table (1).These results are in agreement with those of [10] who observed the reductions in root and in particular shoot growth with NaCl treatments for sugar beet, rice and cotton seedlings at higher salt treatment (200 mM). Similar results have been reported by [11] and [12] who found a significant decrease in shoot elongation in barley genotypes with increasing NaCl treatment.

Table1. *Effect of NaCl concentrations on the length of shoot and root of six sorghum genotypes*

	Shoot length (cm)			**Root length (cm)**		
Genotypes	**Normal**	**200 mM Nacl**	**300 mM Nacl**	**Normal**	**200 mM Nacl**	**300 mM Nacl**
Tabat	18.75^{abcd}	15.20^{ab}	13.33^{a}	8.10^{bc}	5.70^{bc}	5.20^{ab}
Tetron	20.70^{bcd}	19.05^{abcd}	17.30^{abc}	7.00^{b}	5.55^{ab}	5.15^{ab}
Red Mugud	21.60^{cd}	17.75^{abc}	16.45^{abc}	5.65^{ab}	5.45^{ab}	5.45^{ab}
Wad Ahmed	21.05^{bcd}	19.75^{bcd}	19.75^{bcd}	11.00^{c}	7.90^{bc}	7.90^{bc}
Arfa Gadamak	17.75^{abc}	17.05^{abc}	13.70^{a}	7.95^{bc}	6.30^{ab}	2.85^{a}
Milo	24.10^{d}	24.00^{d}	21.25^{cd}	7.40^{ab}	6.10^{a}	4.95^{ab}

Means sharing the same letter are not significantly different (P = 0.05) using Tukey's multiple range test. Significant at P = 0.05

3.2. Effect of Salinity on Fresh and Dry Mass of Shoot

Salinity significantly reduced the shoot fresh and dry mass in the six sorghum genotypes at the two salt treatments(Table 2).In 200 mM NaCl, the minimum reduction was recorded in Tetron, Red Mugud and Milo, while the maximum reduction was observed in Wad Ahmed followed by Arfa-Gadamak. Similarly at salinity level of 300 mM, the minimum reduction in shoot fresh weight was recorded in Red Mugud followed by Milo. Shoot dry weight was inversely related to increasing salinity levels. On the other hand the average of shoot dry weight was range from 0.13 to 0.17 g and from 0.08 to 0.16 g in 200 mM and 300 mM treatment respectively (Table 2). The high shoot dry weight was recorded in genotypes Milo in the salt treatments. Several studies have shown that the seedling shoot dry weight was more salt affected than seedling root dry weight and the increasing of salinity level caused simultaneous reduction of seedling shoots fresh and dry weight such as in wheat [13], sugar beet, cabbage [14], sorghum [15] and phaseolus species [16].

Table2. *Effect of NaCl concentrations on the fresh and dry mass of shoot of six sorghum genotypes*

	Shoot fresh weight (g)			**Shoot dry weight (g)**		
Genotypes	**Normal**	**200 mM Nacl**	**300 mM Nacl**	**Normal**	**200 mM Nacl**	**300 mM Nacl**
Tabat	1.20^{h}	0.90^{f}	0.001^{a}	0.17^{h}	0.16^{g}	0.08^{a}
Tetron	1.30^{i}	1.30^{i}	0.90^{f}	0.14^{d}	0.13^{d}	0.12^{c}
Red Mugud	1.80^{l}	1.30^{i}	1.30^{i}	0.20j	0.17^{h}	0.16^{g}
Wad Ahmed	1.30^{i}	0.50^{d}	0.20^{b}	0.19^{i}	0.14^{d}	0.14^{d}
Arfa Gadamak	1.80^{l}	0.80^{e}	0.40^{c}	0.15f	0.13^{d}	0.10^{b}
Milo	2.40^{m}	1.30^{i}	1.10^{g}	0.24^{k}	0.17^{h}	0.12^{c}

Means sharing the same letter are not significantly different (P = 0.05) using Tukey's multiple range test. Significant at P = 0.05

3.3. Effect of Salinity on Fresh and Dry mass of Root

The main effects (genotype and treatments) were significant for root fresh mass and root dry mass (Table 3).Root dry weight was observed with the highest value at 200 mM in genotype Red Mugud (0.08 g), while it was noted minimum in Milo (0.04). Similarly, at 300 mM level of NaCl, the genotype Red Mugud showed maximum root dry weight (0.07) while the genotypes Tabat and Wad Ahmed showed lower root dry weight (Table 3). On the basis of root fresh and dry weight stress tolerance, the genotype Red Mugud exhibited better results at 200 mM and 300 mM salt treatments. That gave it the priority to be the best salt tolerant genotype among the six genotypes. Similar reductions in dry matter production have been shown in for hybrids of maize [17]; sugarcane [18] and wheat [19].

Table3. *Effect of NaCl concentrations on the fresh and dry mass of root of six sorghum genotypes*

	Root fresh weight (g)			Root dry weight (g)		
Genotypes	**Normal**	**200 mM Nacl**	**300 mM Nacl**	**Normal**	**200 mM Nacl**	**300 mM Nacl**
Tabat	0.70^{e}	0.50^{d}	0.30^{b}	0.06^{d}	0.05^{c}	0.03^{a}
Tetron	0.40^{b}	0.40^{b}	0.30^{b}	0.30^{h}	0.05^{c}	0.04^{b}
Red Mugud	0.70^{e}	0.70^{e}	0.50^{d}	0.09^{g}	0.08^{f}	0.07^{e}
Wad Ahmed	0.30^{b}	0.30^{b}	0.20^{a}	0.07^{e}	0.05^{c}	0.03^{a}
Arfa Gadamak	0.40^{c}	0.40^{c}	0.40^{c}	0.05^{c}	0.05^{c}	0.04^{b}
Milo	0.70^{e}	0.70^{e}	0.30^{b}	0.06^{d}	0.04^{b}	0.04^{b}

Means sharing the same letter are not significantly different (P = 0.05) using Tukey's multiple range test. Significant at P = 0.05

4. CONCLUSION

In general, the results of this study demonstrate that salinity stress affects most of morphological traits in sorghum. Sorghum genotypes showed tolerant to the salt concentration 200 mM more than the concentration 300 mM. Responses of sorghum to salinity differed among genotypes. Tolerant genotypes had longer mesocotyls with faster growth rates than the susceptible genotypes. The mechanism involved in salinity tolerance appears to be that of avoidance by fast growth. Based on growth and visual salt damage in two salt concentrations the genotype Milo was the most tolerant to salt stress followed by Red Mugud among the six sorghum genotypes.

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