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Screening of selected accessions of Ethiopian sesame (*Sesame indicum L.*) for salt tolerance

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ABSTRACT

Salinity is one of the most severe abiotic stress that limits crop production and productivity especially in arid and semiarid areas of the world. It causes morphological, physiological, biochemical, and molecular changes and adversely affects plant growth and metabolism. However, crops respond and perform differently when exposed to salinity and some can be tolerant. Therefore, selection and characterization of germplasm is needed to obtain salt tolerant crops. In this study, the response of fifteen accessions of Ethiopian sesame were evaluated at two stage growth using different concentration of NaCl (0, 50, 100, 150 mM). Qualitative and quantitative parameters like plant height, shoot length, root length, leaf number, leaf area, fresh weight, dry weight, Na^+ and K^+ content were used to characterize and rank the accessions using salt tolerance index value. Though, the performance of all accession was different, significant reduction was found in plant height, shoot length, leaf area, leaf number, fresh weight, dry weight, and K^+ content, whilst Na^+ ion increased as salinity level increases. Based on overall performance, accessions were grouped as tolerant, moderately tolerant and sensitive. Among the studied accessions, 203104, 211921, 241332, 17712, 207955, and 202290 showed better performance with increasing salinity and classified as salt tolerant. Accessions 208671, 235404, 202355, and 228816 were moderately tolerant. The remaining accessions were ranked as salt sensitive. This study indicated the existence of substantial variability in terms of salt tolerance within all studied accessions of sesame. Therefore, the tolerant accessions can be utilized for diversification to salinity exposed environment and employed for stress related breeding.

1. Introduction

Drought, salinity, extreme temperature, and oxidative stress are interconnected abiotic stresses damaging plant cell through morphological, physiological, biochemical, and molecular changes adversely affecting growth and productivity (Jewell et al., 2010). Salinity is one of the most serious factors limiting crop production and productivity mainly in arid and semiarid regions (Kakhki et al., 2012). Soil is considered to be saline when its electrical conductivity is 4 ds/m (equivalent to 40 mM) or more (FAO, 1997). Plants use different mechanism to overcome effect of soil salinity. At cellular level, plants cope up with salinity by osmotic adjustment involving vacuolar sequestration of ions and synthesis of osmoprotectants in the cytoplasm (Garg et al., 2002). At molecular level, plants synthesize stress proteins that may have diverse functions in regulating the effect of salinity. These may contribute to detoxification pathway in many forms such as part of scavenging enzyme, or help in the synthesis of antioxidants (Mittova et al., 2002).

The three common cations associated with salinity include Na^+, Ca_2^+, Mg_2^+; whereas the common anions include Cl^-, SO_4^{-2}, and HCO_3^-. However, Na+ and Cl^- anions constitutes 50–80% of the total soluble salts (Rengasamy, 2010). Globally, approximately 19.5% of the irrigated soils in the world have elevated concentrations of salts (Jin et al., 2010), damaging both the economy and the environment (Rengasamy, 2010; Yang et al., 2010). In Ethiopia, salt-affected soils are mostly prevalent in the Rift Valley and the lowlands. The Awash Valley in general and the lower plains in particular are dominated by salt-affected soils (Gebresellassie, 1993). It is expected that the increase of salt in agricultural fields will reduce the land available for cultivation by 30% in the next 25 years and up to 50% by the year 2050 (Rozema and Flowers, 2008).

Sesame (*Sesamum indicum* L.), a queen of oil seed is one of the most ancient oilseed crop used by the human (Weiss, 2000). It is an important oil seed crop of the world possessing oil with high antioxidant property, low cholesterol and high polyunsaturated fats (Ashri, 1993). Though, Sesame is one of the most drought tolerant crops in the world, it does not tolerate high soil salinity (Langham, 2008). In Ethiopia, Sesame is the major oil seed in terms of exports, accounting

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for over 90% of the values of oil seeds exports following coffee. Ethiopia is fourth largest producer of sesame seed in the world behind India, China and Sudan (USA foreign agricultural service, 2016).

Though, Ethiopia has a lot of arable land in arid and semiarid regions that can be ideal place for sesame cultivation, however, the current commercial production of sesame is limited mainly to southwest and northwestern parts of the Ethiopia (Wijnands et al., 2009). However, expansion of production to Eastern parts of Ethiopia and areas in rift valley, which is usually constrained by soil salinity has to be stressed to increase production and productivity. Furthermore, selection and adaptation of existing sesame germplasm to saline stress is much important to increase productivity. Despite the need, screening and evaluation of existing sesame land races to saline soil is lacking behind. Hence, in present study, salinity tolerance of the selected accessions of Ethiopian sesame was evaluated in green houses and accessions were characterized as tolerant, moderately tolerant and sensitive.

2. Materials and methods

2.1. Study area

The study was conducted in Wolkite University, department of biotechnology green house. Physically red soil was collected from nearby University area, mixed with sand and compost in 1:1:1 combination. The three components were then mixed very well and added to 4 kg of pot prepared for the study. The air dried combination of equal ratio of sand, compost and red soil was analyzed at JIJE bioglass analytical laboratory (Addis Ababa). The nature of the soil was indicated in the following Table 1.

2.2. Plant material, experimentation and growth condition

Out of sixty accessions received from Ethiopia biodiversity institute, fifteen accessions were selected for this study. The accessions were collected from different parts of Ethiopia to represent all potential sesame producing areas. The description of the accessions was given in the Table 2 below. Representative samples were selected systematically following the gene bank barcode information. location of original place and altitude were considered during sample selection. Healthy seeds of selected accessions were sown on April 23, 2016 in green house (28 ± 2 °C) of using 4 kg soil capacity pot (16 seeds per pot with equidistance) and the data were collected two times within a gap of two weeks after seventh days of germination. The seeds were watered tap water up to ten days within a gap of two days. Thinning was done tenth days after sown (03 May 2016). Salinization was induced on seventh days after sown by three level NaCl concentrations (50, 100, 150 mM).

Table 1
Physical and chemical characteristic of research soil.

SN	Content	Type	Amount	Unit
1	Micronutrients	Cu	0.78	mg/Kg
		Zn	3.36	mg/Kg
		Mn	6.99	mg/Kg
		Fe	28	mg/Kg
2	Soluble salts	$SO4^{2-}$	0.06	Meq/100 g Soil
		Na^+	4.92	Meq/100 g Soil
		K^+	3.77	Meq/100 g Soil
		Ca^{++}	0.58	Meq/100 g Soil
		Mg^{++}	0.3	Meq/100 g Soil
		Cl^-	4.21	Meq/100 g Soil
		HCO_3^-	0.11	Meq/100 g Soil
3	pH by H_2O		6.2	pH
4	pH by pest extract		7.55	dS/m
5	EC By H_2O		0.19	dS/m
6	EC by pest Extract		0.64	dS/m

Table 2
Pass port data of selected sesame accessions of current study.

Acc. number	Code	Region	Zone	Woreda	Altitude
17701	7	Oromia	East Wollega	Ibantu	2055
17712	8	Oromia	East Wollege	Jima argo	1522
202290	12	Amara	Oromia zone	Artuma fursina	1630
202323	13	Amara	Oromia zone	Bati	1585
202355	15	Amara	North wollo	Guba lafto	1860
203104	17	Oromia	Jimma	Sokoru	1400
207955	18	Gambella	Zone 1	Gambella	500
208671	19	Oromia	West Hararge	Habro	1900
211921	21	Amara	East Gojjam	Dejen	1600
216733	22	Gambella	Zone 2	Abobo	600
228816	23	Oromiya	East Hararge	Babille	1500
235404	24	Amara	North Gondar	Metema	1900
241314	25	Amara	North Gondar	Addi Arkay	1460
241327	26	Amara	North Gondar	Sanja	1050
241332	27	Amara	North Gondar	Metema	750

Tap water without NaCl was served as control. All treatment were watered with 500 mL of respective concentration of NaCl whilst the controls were watered with 500 mL tap water. In current study, datas collected at early, and mid developmental stages at 28 and 44 days after sown were used for the analyses as plants are the most sensitive to salinity during the vegetative and early reproductive stage and less sensitive during flowering and grain filling stage (Mass and Poss, 1989).

2.3. Data collected for analysis

A total of nine major parameters (leaf number, Plant height, shoot length, root length, shoot fresh weight, root fresh weight, total dry weight, leaf area, Potassium and sodium content) were used for analysis. Plant height, shoot length and seedling root length were measured twice at 28 days after sown (DAS) and 44 days after sown (DAS) and presented in centimeter (cm). Data from shoot fresh weight (SFW), and root fresh weight were presented in gram (g) for two growth stage. For total dry weight (TDW), the whole fresh plants were dried for three days in oven at 75 °C. Sodium ions (Na^+) and potassium ions (K^+) were estimated by flame photometer at Ethiopian Public Health Institute, food science and nutrition laboratory. Leaf area (LA) was measured and calculated according to Cornelissen (2005). The height and width of the middle leaflet were measured, and leaf area was calculated using formula:

$LA=0.74\times3\times N\ (L\times W\times\prod/4)$; Where, LA: leaf area; L: height of the middle leaflet (cm); W: width of the middle leaflet (cm); ∏: 3.1416; and N: total number of leaves.

2.4. Ranking of accessions for salt tolerance

All data were analyzed using salt tolerance indexes (STI). Salt tolerance index is the mean values under each salinity divided by the mean of the controls. All values under each parameters were converted to salt tolerance indices before cluster analysis to allow comparisons among genotypes for salt tolerance by using multiple agronomic parameters. Cluster group rankings were obtained based on Ward's minimum variance cluster analysis using means of the salt tolerance indexes (Chaparzadeh et al., 2014).

2.5. Data analysis

The results were presented as mean of three independent experiments. Data of all required parameter were analyzed by SPSS version 23 and Microsoft excel program. Significant means were separated using the Jukes test at 5% level, and correlation analysis was performed to determine the relationship between variables at 5% level.