



GROWTH, WATER RELATION, LEAF PIGMENTS AND YIELD OF SESAME AS INFLUENCED BY SIMULATED SALINE ENVIRONMENT

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Received: 30 November 2023, revised: 05 December 2023, accepted: 12 December 2023, DOI: <https://doi.org/10.59619/ej.5.2.13>

ABSTRACT

Salt stress is a significant environmental problem that restricts crop productivity. Despite being an important oilseed crop in Bangladesh, little is known about the phenotypic and physiological responses of sesame (*Sesamum indicum*) to salinity. In order to measure the plant height, number of leaf plant⁻¹, dry matter accumulation capability, leaf water uptake capacity, leaf chlorophyll content, and yield response six sesame genotypes viz., BD-6980, BD-7009, BD-7011, BD-6994, BD-6983, and BD-6999 were grown in pots and exposed to a 7.5 dS m⁻¹ simulated salty environment. These genotypes were chosen for this investigation from 86 genotypes according to the relative germination percentage at 10 dS m⁻¹ salinity. Results revealed that plant height, number of leaf plant⁻¹, dry matter accumulation capability, leaf chlorophylls a and b content, and yield were reduced in all the genotypes, but reduction rate was lower in genotype BD-7011. On the other hand, water uptake capacity in sesame leaf was increment in all the genotypes under salinity but increasing rate was lower in the same genotype BD-7011. These results suggest that the sesame genotype BD-7011 may be able to withstand salt stress with little detrimental effects on the growth, physiological traits, seed yield.

Keywords: Abiotic stress, oilseed crop, physiological traits

Introduction

One of the main abiotic stressors that have a major impact on plant growth and output is salinity (Gharsallah *et al.* 2016). Salinity reduces the amount of water available to plants. When salt concentrations are excessively high and plants are unable to absorb water, physiological drought takes place. No matter how much water may be in the soil, plant roots are unable to absorb it due to the negative osmotic pressure. By the middle of the twenty-first century, over half of all arable land would disappear due to the ongoing salinization of arable land caused by climate change (Islam *et al.* 2019). A multitude of factors contribute to the annual increase of saline areas, such as salts' capillary rise, rivers carrying seawater into freshwater during the dry season, tornado-induced inland floods, and more (Mannan *et al.* 2012). Different salinity levels have affected 26.7% of newly created land over the last 40 years in Bangladesh.

According to Zhang *et al.* (2013) and Rahnesan *et al.* (2018), a high concentration of salt causes ionic imbalance and osmotic stress in plants, which negatively

affects their morphology, biomass, physiology, and biochemical activity and eventually causes damage to the plants. In addition to chlorosis, leaf senescence, slowed development, decreased dry weight, decreased carbon fixation, increased stomatal closure and photosynthetic rate, decreased water content, and changed osmolytes, salinity has detrimental effects on plant morphology, physiology, and yield. Numerous plants have developed a variety of strategies to address these issues like less degradation of chlorophyll content and lower water uptake capacity in their leaves. Sesame is one of the world's greatest crops at withstanding droughts, although it cannot grow in too salinized soil (Langham *et al.* 2008). Since there might be variations across cultivars of the same species and between phenological stages of the same genotype, plants' responses to salt stress can vary greatly overall (Sánchez-Blanco *et al.* 2004). Abbasdokht *et al.* (2012) stated that sesame is a plant with a moderate salt resistance. This study focused on the agronomic responses of several sesame genotypes to salt stress and sought to identify genotypes that were sensitive to and tolerant of salt based on agronomic and physiological markers. The

objective of this research is to study the effects of salinity on sesame growth, leaf water and chlorophyll content, and yield under saline environment.

Materials and Methods

The pot experiment was carried out in a vinyl house in the Agronomy Department's research field at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh in the Kharif 1 season (February to June, 2023). Each pot was 30 cm in diameter and 24 cm in height. It was filled with 14 kg of air-dried soil and a 4:1 mixture of soil and cow dung. 0.64g, 0.62g, 0.52g, and 0.20g of urea, TSP, MoP, and gypsum @ 50.0-20.0-40.0-14.0 kgN-P-K-S ha⁻¹ were applied to the pot soil, respectively (FRG 2018). All fertilizers, with the exception of half of urea, were applied as basal and the remaining half at 15 DAE (days after emergence). The study employed a completely randomized design with three replications. In this experiment, six sesame genotypes like BD-6980, BD-7009, BD-7011, BD-6994, BD-6983, and BD-6999 were employed. In our earlier work, these genotypes were eliminated from 86 genotypes under 10 dS/m salinity during the germination stage. On February 5, 2023, ten healthy seeds were sown in a pot and covered with soil. To guarantee consistent germination, mild irrigation was administered following seed sowing. Three plants were kept 14 days after they emerged, and they received salt treatment (irrigation with 7.5 dS m⁻¹ saline water) for the duration of the growing season. Conversely, tap water was used to irrigate the control pots. Plant parameters such as height, leaf count, dry weight of the entire plant, water uptake capacity (WUC), and leaf chlorophyll content were measured at flowering stage, and yield parameter was measured at the maturity stage. Water uptake capacity (WUC): Water uptake capacity quantifies the capacity of plants to absorb a greater quantity of water per unit of dry weight in relation to turgid weight. It was measured by using the following formula:

$$WUC = \frac{TW - FW}{DW}$$

Where, TW = Turgid weight of the leaf, FW = Fresh weight of the leaf, DW = Dry weight of the leaf

Chlorophyll content:

Chlorophyll content was estimated from the fully expanded uppermost leaf samples at 15, 30, 45 and 60 days after saline treatment imposed using the method described by Witham *et al.* (1986). The fresh leaf sample of 20 mg were taken in small vials containing 20 ml of 80 % acetone and covered with aluminium foil, and preserved in the dark for 72 hours. Then reading was taken at 663 nm and 645 nm wave lengths by a double beam spectrophotometer (Model 200-20) and the result was expressed as mg g⁻¹ fresh weight. The formula for computing chlorophyll a, b and total chlorophyll were-

$$\text{mg Chlorophyll a g}^{-1} \text{ fresh weight} = [12.7 (D_{663}) - 2.69 (D_{645})] \times [V/1000 \times W]$$

$$\text{mg Chlorophyll b g}^{-1} \text{ fresh weight} = [22.9 (D_{645}) - 4.68 (D_{663})] \times [V/1000 \times W]$$

Where, D (663, 645) = Optical density of the chlorophyll extract at wave length of 663 and 645 nm, V = Final volume (ml) of the 80 % acetone with chlorophyll extract, W = Weight of fresh leaf sample in g.

Statistical analysis: The statistical tool MSTAT-C was used to analyze the data. The least significant difference (LSD) test was used to compare the means of the different treatments (Gomez and Gomez 1984). An Excel program was used to create the table and graph.

Results and Discussion

In sesame, salinity reduced plant height, with genotype-specific variations in the rate of decline (Table 1). BD-7009 had the highest plant height at control, whereas BD-6980 had the lowest. The genotypes' differences in plant height reduction at 7.5 dS m⁻¹ salinity varied from 11.73% to 25.56%. Salinity-induced reduction in plant height was less pronounced in the BD-7011 genotype (11.73%). With the largest percentage loss (25.56%) in plant height, genotype BD-6999 had the most detrimental effects of salinity. Salinity-induced reduction in plant height was found to be mild in genotypes BD-6980 and BD-7009. The BD-7011 genotype's apparent resistance to salt in relation to plant height has been ascribed to their capacity for rapid growth and for reducing the concentration of salt in plant tissue. Wahome *et al.* (2001) reported that high salinity

Table 1. Growth attributes of sesame genotypes influenced by salinity at flowering stage

Genotypes	Plant height (cm)		Number of leaf plant ⁻¹		Dry weight (g) plant ⁻¹	
	Control	Saline	Control	Saline	Control	Saline
BD-6980	61.43	52.67 (14.27)	29.00	23.67 (18.39)	4.13	3.39 (17.92)
BD-7009	69.00	55.07 (20.19)	28.00	19.33 (30.95)	4.63	2.89 (37.70)
BD-7011	64.80	57.20 (11.73)	22.67	18.00 (20.59)	3.25	2.90 (10.67)
BD-6994	68.97	57.60 (16.48)	27.33	18.67 (31.71)	3.66	2.67 (27.02)
BD-6983	66.83	54.93 (17.81)	28.00	20.00 (28.57)	4.43	2.74 (38.18)
BD-6999	68.60	51.07 (25.56)	24.33	18.33 (24.66)	362	2.51 (30.76)
Level of significance	*		*		*	
LSD (0.05)	7.18		6.34		1.15	

Values in parenthesis indicates percent reduction in saline stress compare to control. *A significant difference at $p < 0.05$.

in the growing media negatively affects plant growth and development, which is consistent with our finding that salinity limits the growth of sesame plants. Hasanuzzaman *et al.* (2012) stated that these impacts could result in changed levels of growth regulators, membrane damage, nutritional imbalance, inhibition of certain enzymes, and metabolic inefficiencies, including photosynthesis. While soil salts such as Na and Cl disrupt normal plant growth and development, accumulating soil salts seem to shorten plant height under conditions of salt stress (Tunçtürk *et al.* 2011). Gaballah *et al.* (2007) found that high salinity levels reduced sesame height, with significant cultivar-to-cultivar variability in this characteristic. Plant tissues and cell size can alter as a result of salinity stress, which is caused by salt in water.

Salinity dramatically lowered the number of leaves produced per plant for sesame genotypes. In saline conditions, fewer leaves per plant were discovered (Table 1). The genotype BD-6994 had the largest reduction (31.71%), followed by BD-7009 (30.95%), BD-6983 (28.57%), BD-6999 (24.66%), and BD-7011 (20.59%). The genotype BD-6980 (18.39%) had the lowest reduction. A mean value of 21.56 leaves per plant in a sesame plant study by Janivan *et al.* (2017) showed that the number of leaves was unaffected by saline levels. In our study, however, we found that the salinity caused less leaves per plant than the control. Similar results were seen in tomatoes under salt stress by Romeroaranda *et al.* (2001). The number of leaves per plant is negatively impacted by salinity stress. This could be as a result of the decreased cell elongation and division, which inhibits

the physiological and biochemical activities of the plants (Kumari and Parida 2018).

Table 1 shows the reduction in total dry matter (DM) output as well as the variation in DM production among genotypes as a result of salt. In every sesame genotype under investigation, salinity had a considerable impact on the overall dry matter production. The variations in the reduction of root, leaf, stem, and pod dry matter over their control were the reason for the salinity-induced disparities in total dry matter production across the genotypes. BD-7011 had the lowest percentage reduction in total dry matter (10.67%), whereas BD-6983 had the highest percentage reduction (38.18%). Because BD-7011 produces leaf and stemdry matter more efficiently than other genotypes, its total dry matter was less influenced by salinity stress. Koca *et al.* (2007) found that as salt levels rose, the shoots and roots of some sesame cultivars shrunk, however there were significant differences amongst the cultivars. They concluded that salt-tolerant cultivars produced higher dry matter than salt-sensitive cultivars. Reduced plant biomass, leaf area, and growth have been seen in a variety of vegetable crops that have been subjected to salt stress (Giuffrida *et al.* 2013).

A higher water uptake capacity (WUC) indicates that a plant is under more moisture stress, as the plant must absorb more water to reach turgid weight (Sangakkara *et al.* 1996). The water uptake capacity of plants quantifies their ability to absorb water per unit dry weight in comparison to turgid weight. In all the sesame genotypes examined, salinity had a notable impact on WUC. Figure

1 show that all genotypes showed an increase in WUC when exposed to salinity, but the increase was greater in genotype BD-6983 (0.91) and lower in genotype BD-7011 (0.68). This suggests that genotype BD-7011 was less affected by water stress when exposed to salinity. Increased soluble salts slow down the uptake of nutrients and water, leading to osmotic effects and toxicity, which has a negative impact on plant-water relations (Yang *et al.* 2009, Jiang *et al.* 2014).

Six genotypes of sesame plants showed different levels of chlorophyll in their leaves depending on salinity. All genotypes showed a significant drop in chlorophyll a and b content at 7.5 dS m⁻¹ salinity level (Table 2). The genotype with the lowest chlorophyll a and chlorophyll b decrease was 17.03% and 17.86%, respectively in BD-7011, while the genotype with the highest predicted reduction was in genotype BD-6983. In salinity conditions, genotype BD-7011 showed a greater quantity of chlorophyll a and chlorophyll b than the other genotypes, suggesting that this genotype is comparatively salt tolerant. In the current study, salinity treatments considerably decreased the pigments involved in photosynthesis, such as chlorophyll a and chlorophyll b, in sesame genotypes. Chlorophyll content has been proposed in a number of studies as a biochemical indicator of plant salt tolerance. It is well known that while salt-sensitive plants exhibit a high decrease in chlorophyll contents, salt-tolerant plants

exhibit less decreased or unchanged levels of chlorophyll under salinity conditions (Stepien and Johnson 2009, Ashraf and Harris 2013).

The relative (% of control) seed yield of six genotypes varied under salinity environment, ranging from 21% to 53.147% (Figure 2). BD-7009 had the largest loss in seed output per plant (79%) whereas BD-7011 had the lowest (53%). The highest relative seed yield of genotype BD-7011 was mostly caused by the highest relative pod number/plant and individual seed weight of this genotype. Plants undergo morphological, physiological, and biological changes under salt stress. This reduces plant yield and negatively affects reproductive characteristics (Hasanuzzaman *et al.* 2021). Rapid water loss from plant cells caused by salt stress have a significant impact on the reproductive stages of sesame plants, which require water for flower and capsule growth. Plant growth characteristics negatively affected by salinity include fresh weight, dry weight, leaf size, leaf area, and leaf number. Furthermore, osmotic stress caused by salinity in plants changes the overall nutritional status of plants and negatively affects hydraulic conductivity (Babu and Thirumurugan 2001). Therefore, growth retardation, ion and nutrient imbalance, changes in water conditions, and inhibition of photosynthesis affect the yield characteristics of sesame plants.

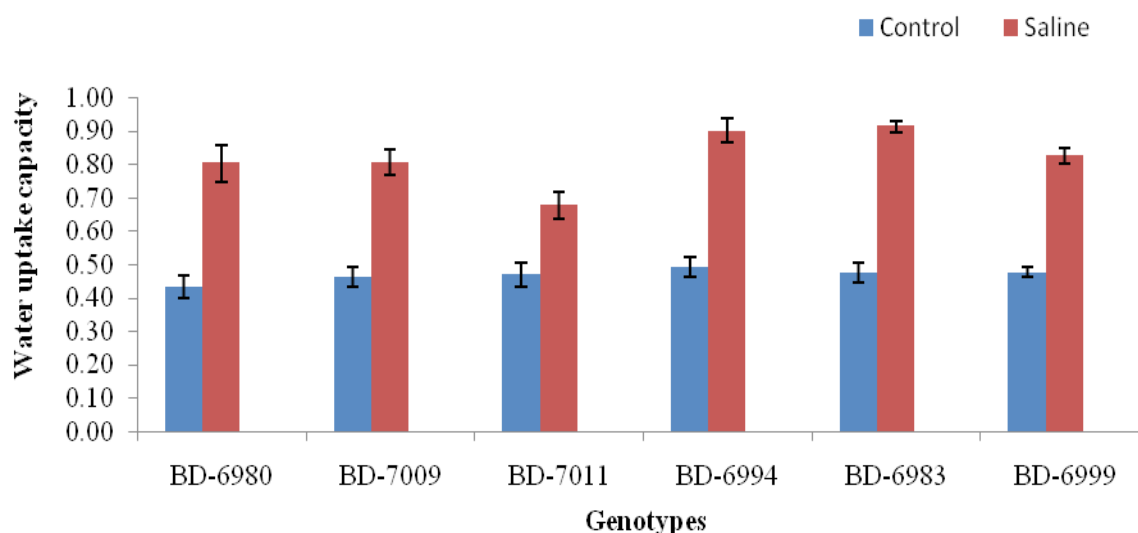
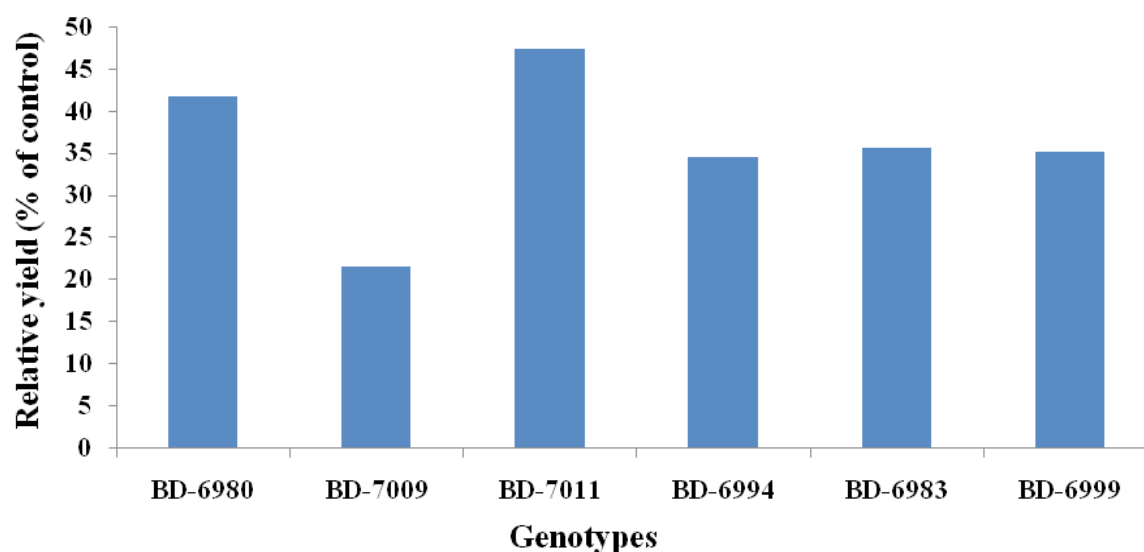


Figure 1. Water uptake capacity of sesame leaf as influenced by salinity. Bars indicate (±SE)

Table 2. Leaf chlorophylls of sesame genotypes as influenced by salinity at flowering stage

Genotypes	Chlorophyll a (mg g ⁻¹ FW)		Chlorophyll b (mg g ⁻¹ FW)	
	Control	Saline	Control	Saline
BD-6980	0.72	0.53 (73.61)	0.43	0.32 (74.41)
BD-7009	0.78	0.51 (65.38)	0.40	0.31 (77.50)
BD-7011	0.94	0.78 (82.97)	0.56	0.46 (82.14)
BD-6994	0.59	0.46 (77.96)	0.53	0.20 (37.73)
BD-6983	0.65	0.41 (63.06)	0.55	0.19 (34.54)
BD-6999	0.65	0.43 (66.15)	0.53	0.15 (28.30)
Level of significance	*		*	
LSD (0.05)	0.14		0.17	

Values in parenthesis indicates percent reduction in saline stress compare to control. *A significant difference at $p < 0.05$.

**Figure 2.** Effect of salinity on yield of sesame under salinity stress

Therefore, the reduction in height, yield, composition and seed yield of sesame when exposed to salt is due to cell division, hypertrophy, differentiation and growth, wilting and stomata caused by the removal of water from the cells by osmotic pressure. It can be explained by decreased closure and decreased water withdrawal from the cells. Similar results were obtained from Shani and Dudley (2001), who reported that the yield caused by impaired cellular function, increased consumption of energy and carbohydrates in osmoregulation, and decreased photosynthetic activity due to saline conditions. Ghadiri *et al.* (2006) expressed concern about decreased water intake due to salt. Salinity is caused by high osmotic

potential and high concentrations of certain ions in the soil, which can cause physiological problems in plant tissues and lead to reduced yields, are in agreement with these findings.

Conclusion

The plant height, dry matter accumulation, chlorophyll a and b content in sesame leaf, and yield parameters of sesame genotypes to salt stress showed wide variation. Genotype BD-7011 has high tolerance to salt stress due to high low water uptake capacity, higher chlorophylls, which significantly contribute to high seed yield of this genotype.

Acknowledgement

The authors are grateful to Ministry of Science and Technology, Government of Bangladesh for funding the research.

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