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Effect of salinity on some morpho-physiological characters and yield in three sesame cultivars

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Abstract

A pot experiment was conducted at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during February to May 2004 to assess the effect of different salinity levels on growth and yield attributes of three sesame cultivars namely BINA TIL-1, T6 and BARI Til-3. The salinity levels were control, 6 dS/m and 9 dS/m imposed by irrigation of NaCl salt solution at 45 days after sowing. The experiment was laid out following Randomized Complete Block Design with three replications. Plant height, leaf area, total dry matter, number of capsule per plant, number of seeds per capsule, seed weight per plant, 1000-seed weight and harvest index progressively decreased with the increasing salinity level. BINA Til-1 showed better performance on the above morpho-physiological parameters. BARI Til-3 had higher Na^+ in leaves and was found intermediate on the other parameters. T6 showed the lowest yield attributes, K^+ content and the highest Na^+ content in leaves. Salinity tolerance seemed to be better in BINA Til-1 followed by BARI Til-3 and T6.

Keywords: Salinity, Sesame and Yield

Introduction

Sesame (*Sesamum indicum*) is an important oilseed crop belonging to the family Pedaliaceae. It is grown in Asia, Africa and parts of Latin America. The major sesame producing countries are India, China, Thailand and Mexico. The yield per unit area in Bangladesh is lower than in other countries of the globe. Sesame yield in Bangladesh is 612 kg/ha, in India 322 kg/ha, in China 1089 kg/ha, in Mexico 556 kg/ha, in Thailand 615 kg/ha, in Egypt 1222 kg/ha (FAO, 2002). The oil seed crop occupies 5% of the total cropped area in Bangladesh. Among these area 73% is covered by rapeseed and mustard, 18% by sesame and 9% by groundnut (BBS, 2004). Despite of versatile use of sesame and quite adaptability to the agro-environment of Bangladesh, the crop is still neglected both in the research and farmers level. Due to lack of improved production technologies of the crop has not yet received proper attention to the farmers. Development of appropriate package technologies under production of the country could be solved by horizontal and vertical expansion of the crop.

Salinity is one of the major environmental stresses affecting plant growth and development and results in severe agricultural losses. It affects nutrient uptake (Varshney *et al.* 1998) and metabolic activities in the plants (Singh *et al.* 2001). There are studies that active osmotic adjustment causes positive effect on growth processes (Turner 1981). Osmotic adjustment helps in two ways under saline condition i) make capable plants to uptake water under saline condition and ii) to keep stomata open by maintaining turgor of the plant cell. The magnitude of the effect of salinity varied with the plant species, type and level of salinity (Bishnoi *et al.* 1987). So, plant species/varieties tolerant to high level of salt is essential for the utilization of the highly salt affected soils.

In Bangladesh, more than 30% of the total cultivable area is in the coastal belt. Out of 2.85 million hectares of the coastal and offshore landmass about 0.83 million hectares are affected by different degrees of salinity (Karim *et al.*, 1990). Moreover, the salt affected area is increasing day by day. The late planting sesame is cultivated in those areas. The application of additional salt affects the growth attributes like number of capsule per plant, plant height; stem diameter, yield and yield attributes like 1000-grain weight, seed yield of sesame. After harvesting aman rice a vast area of land remains either unused or covered by some minor crops. About 2.8 million hectares of land under saline area remain fallow for about 4-7 months (middle of November- June) in each year (Karim *et al.* 1982). In most of the areas farmers do not have any suitable crop to bring this land under cultivation in these months. There is a possibility of bringing this vast fallow saline land under sesame cultivation in rabi season (November-February) with reasonable economic benefit. Most of the released sesame cultivars in the country are susceptible to salinity. Sesame cultivation in those areas is limited mostly due to non-availability of suitable saline tolerant cultivars. The tolerant varieties may grow well in saline zone after cultivation aman rice for Bangladesh condition. For increasing oil production it is needed to extend cultivation of oil crops in the coastal areas where cropping intensity is still low. Cultivation of sesame is not easy because of lack of salinity tolerant cultivars of the crop. Keeping eyes on the above facts the objective of the study was to assess the effect of salinity on some morpho-physiological characters and yield of sesame cultivars.

Materials and Methods

A pot experiment was conducted at the Bangladesh Institute of Nuclear Agriculture (BINA) during 25 February to 20 May of 2004, to evaluate salinity tolerance levels of the sesame cultivars *viz.* BINA Til-1, T6 and BARI Til-3. Seven kg soils were taken in each pot. The experiment was laid out in Randomized Complete Block Design (RCBD) with 3 replications. Three hundred mg urea, 350 mg TSP and 120 mg MP were incorporated to each pot soils to apply 125 kg urea, 150 kg TSP and 50 kg MP per hectare, respectively. All TSP, MP and half of urea were applied as basal dose. The remaining urea was applied at 30 days after sowing (DAS). The salinity treatments were S_0 (Control, only water was added), S_1 and S_2. Adding 11.15 g and 16.73 g of NaCl in pot made salinity levels of 6 dSm^{-1} and 9 dSm^{-1}, respectively. At 45 DAS, the following treatments were started and maintained until harvest:

S_0 = Control, no salt were added (Average EC value was found to be 0.23 dSm^{-1})

S_1 = 0.5% NaCl of required water for 100% FC in the soils (Approximate soil salinity obtained, EC= 6 dSm^{-1})

S_2 = 1.0% NaCl of required water for 100% FC in the soils (Approximate soil salinity obtained, EC= 9 dSm^{-1}). At 50 DAS, data on leaf area per plant, Atomic Absorption Spectro-photometer recorded Na+ and K+ contents in leaves. At maturity, data on yield and yield components were also recorded. Data were analyzed using the MSTAT-C statistical program developed by Russell (1986).

Results and Discussion

Effect of salinity on plant height, leaf area, total dry matter per plant, Na^+ and K^+ contents in leaves of the sesame cultivars is presented in Table 1. Plant height was decreased with increase of salinity. The highest plant height was found in BINA Til-1 followed by T6. In contrast, the lowest plant height was observed in BARI Til-3. The result indicates that different genotypes had different levels of salinity tolerance for plant height character. BINA Til-1 showed the highest plant height at control and the lowest in T6 and BARI Til-3 at 9 dSm^{-1}. Under the two salinity levels plant height was higher in BINA Til-1 and it showed tolerance to salinity. The results are in conformity with Babu and Thirumurugan (2001) who reported decreased plant height in sesame under salinity. Salinity stress might inhibit cell division and/ cell enlargement, as a result plant height was reduced.

The highest leaf area per plant was produced under control and the lowest at 9 dSm^{-1}. Among the cultivars, BINA Til-1 produced the highest leaf area while T6 produced the least. Medium leaf area was obtained from BARI Til-3. The highest leaf area was observed in BINA Til-1 under control treatment and the lowest in T6 at 6 dSm^{-1} and 9 dSm^{-1}. Under the two salinity levels TDM was lower in T6 and it showed sensitivity to salinity. The results are in agreement with El-Midaaui *et al.* (1999) who observed decreased leaf area (-72%) and plant height (-67%) in sunflower under salinity levels of 50, 75 and 100 mM NaCl.

The highest TDM was produced under control and the lowest at 9 dSm^{-1}. Among the cultivars, BINA Til-1 produced the highest TDM while T6 produced the least. Medium TDM was obtained from BARI Til-3. The highest TDM was observed in BINA Til-1 under control treatment and the lowest in T6 at 9 dSm^{-1}. Under the highest salinity level TDM was the lowest in T6 and it showed sensitivity to salinity. The results are in agreement with Babu and Thirumurugan (2001) who observed decreased TDM with the increase of salinity in sesame cultivars.

Na^+ content in leaves increased but K^+ decreased with the increase of soil salinity (Table 1). BINA Til-1 had lower Na^+ but higher K^+ in leaves. T6 showed lower Na^+ and the lowest K^+ content. BARI Til-3 contained the highest Na^+ and medium K^+. Na^+ in leaves was the highest in T6 and BARI Til-1 at the highest salinity level (9 dSm^{-1}). BINA Til-1 contained the highest K^+ content. All the cultivars showed the highest Na^+ and the lowest K^+ contents in leaves at 9 dSm^{-1}. The highest salinity level decreased K^+ contents in all the cultivars similarly but Na^+ content increased more in T6 and BARI TIL-1. This indicates some tolerance of BINA Til-1 compared to other two cultivars. The results are in conformity with Yahya (1998) who reported that plants treated with 10 or 20 mM NaCl contained relatively low Na^+ concentration and there were no consistent effects on growth and presence of Na^+ decreased the uptake of K and Ca^{++} at all applied levels of salinity.

Effect of salinity on yield and yield contributing characters of the sesame cultivars is presented in the Table 2. Number of capsule per plant was decreased with the increase of soil salinity. The highest number of capsule per plant was found in BINA Til-1 followed by BARI Til-3 and the lowest number of capsule was found in T6. The highest number of capsule per plant (32.70) was produced in BINA Til-1 at control condition while the lowest

(16.00) in T6 at 9 dSm^{-1}. The highest salinity level decreased the number of capsule/plant more in T6 and BARI Til-1 compared to BINA Til-1. Babu and Thirumurugan (2001) reported that number of capsule per plant was decreased with increasing salinity.

Table 1. Effect of salinity on plant height, leaf area, total dry matter per plant, Na^+ and K^+ content in leaves of three sesame cultivars

Treatment	Plant height (cm)	Leaf area/plant (cm^2)	Total dry matter/plant (g)	Na^+ % in leaves	K^+ % leaves
Salinity (dS/m)					
0.23 (T_0)	59.35 a	483 a	19.50 a	0.173 c	1.170 a
6 (T_1)	53.92 b	456 b	16.58 b	0.290 b	0.842 b
9 (T_2)	47.75 c	421 c	13.44c	0.602 a	0.651 c
Cultivars					
BINA Til-1 (V_1)	57.12 a	483 a	20.56 a	0.344 b	1.060 a
T6 (V_2)	50.91 c	407 c	12.75 c	0.352 b	0.791 c
BARI Til-3 (V_3)	53.03 b	470 b	16.21 b	0.370 a	0.857 b
Salinity x cultivar					
V_1T_0	62.46 a	530 a	26.20 a	0.168 e	1.533 a
V_1T_1	58.20 c	488 b	18.92 b	0.281 d	0.820 c
V_1T_2	50.70 c	431 c	16.58 bc	0.582 b	0.693 d
V_2T_0	55.33 d	429 c	15.00 c	0.174 e	0.917 c
V_2T_1	51.43 e	405 d	14.27 c	0.271 d	0.835 c
V_2T_2	45.96 f	388 d	9.00 d	0.611 a	0.620 d
V_3T_0	60.27 b	491 b	17.32 bc	0.177 e	1.060 b
V_3T_1	52.13 e	475 b	16.57 bc	0.317 c	0.870 c
V_3T_2	46.60 f	445 c	14.75 c	0.615 a	0.640 d

Values having common letter(s) within a column of similar treatments do not differ significantly at 5% level as per DMRT

Table 2. Effect of salinity on yield and yield components of three sesame cultivars

Treatment	Capsule/plant (no.)	Seeds/capsule (no.)	1000-seed weight (g)	Seed yield/plant (g)	Harvest Index (%)
Salinity (dS/m)					
0.23 (T_0)	29.27 a	59.05 a	3.17 a	5.71 a	28.69 a
6 (T_1)	24.16 b	59.03 a	2.75 b	4.06 b	24.01 b
9 (T_2)	18.33 c	47.69 b	2.35 c	2.12 c	15.61 c
Cultivars					27.26 a
BINA Til-1 (V_1)	26.40 a	69.42 a	3.01 a	5.78 a	20.98 b
T6 (V_2)	22.00 c	45.24 c	2.65 b	2.79 c	20.07 b
BARI Til-3 (V_3)	23.36 b	51.81 b	2.61 c	3.31 b	
Salinity x Cultivar					
V_1T_0	32.70 a	75.33 a	3.50	8.61 a	33.22
V_1T_1	25.50 cd	72.90 a	3.00	5.57 b	29.39
V_1T_2	21.00 f	60.04 b	2.53	3.18 ef	19.17
V_2T_0	27.01 bc	50.20 cd	3.00	4.04 cd	26.92
V_2T_1	23.00 e	47.80 cd	2.63	2.95 f	20.55
V_2T_2	16.00 h	37.73 e	2.31	1.39 g	15.48
V_3T_0	28.10 b	51.63 c	3.01	4.49 c	25.93
V_3T_1	24.00 de	58.50 b	2.61	3.66 de	22.10
V_3T_2	18.00 g	45.30 d	2.21	1.80 g	12.19

Values having common letter(s) within a column of similar treatments do not differ significantly at 5% level as per DMRT

The highest (59.73) number of seeds per capsule was obtained from 6 dSm^{-1} which was similar to control treatment but significantly different from 9 dSm^{-1} salinity level. Application of 6 dSm^{-1} proved to be better than 9 dSm^{-1} for the character. The fewer number of seeds per capsule (47.69) was recorded under 9 dSm^{-1} that was significantly different from other two treatments. The cultivar BINA Til-1 produced the maximum (69.42) seed per capsule but this was significantly different from other two cultivars. The cultivars T6 gave the minimum (45.24) number of seeds per capsule. Among the three cultivars BINA Til-1 found superior under salinity treatments for the character. The maximum of seeds per capsule was obtained from control in BINA Til-1 and the minimum of seeds per capsule was found in T6 at 9 dSm^{-1} salinity. Under the two salinity levels number of seeds/plant was higher in BINA Til-1 and it showed tolerance to salinity. Reduced number of seeds under salinity might due to less translocation of assimilates towards reproductive organ. Babu and Thirumurugan (2001) reported that number of seeds per plant was decreased with increasing salinity.

Thousand seed weight represents seed size. The highest 1000-seed weight (3.17 g) was found at control and the lowest was 2.35g at 9 dSm^{-1}. From the result it is found that1000-seed weight decreased significantly with increasing salinity levels. A significant variation was found among the cultivars. The highest 1000-seed weight was found 3.01g in BINA Til-1 and the lowest was 2.61g in BARI Til-3. Here it is to be noted that the seed size of BINA Til-1 was genetically bigger. Thus seed weight variation in the cultivar was their inherent genotypic expression. The highest 1000-seed weight (3.50 g) was found in the BINA Til-1 at control condition and lowest (2.21 g) in the BARI Til-3 at 9 dSm^{-1} level of soil salinity. Lyra *et al.* (1992) reported that 1000-seed weight was decreased with the increase of salinity levels.

The highest seed yield per plant (5.71g) was found in control and the lowest was (2.12 g) at 9 dSm^{-1} level of soil salinity. Among the cultivars the highest grain yield (5.78g) was recorded in BINA Til –1 and the lowest (2.79 g) in T_6. The moderate grain yield (3.31 g) was recorded in BARI Til-3. The cultivars BINA Til-1 produced the highest grain yield (8.619g) at control condition and the lowest (1.39 g) in T_6 at 9 dSm^{-1} level of soil salinity. T_6 was found sensitive to salinity.

Harvest index (HI) indicates translocation ability of cultivar. The highest harvest index (28.69%) was obtained from control and the lowest (15.61%) from 9 dSm^{-1} level of soil salinity. Higher harvest index (27.26%) was found in BINA Til-1 and lower harvest index was found in BARI Til-3 and T_6. The results showed that different cultivars had different harvest index under saline stress. This means genotypic difference exists in salinity tolerance. The interaction effect of salinity levels and cultivars in relation to harvest index was found insignificant. Higher harvest indicates higher translocation ability to sink organ. Ludlow and Muchow (1990) thought that a lower harvest index in drying soil environment could result from the higher partitioning of dry matter to roots at the expenses of shoot.

From the above results, it may be stated that increasing salinity levels decreased yield and yield attributes of sesame and BINA Til-1seemed to be tolerant to salinity up to 9 dSm^{-1}. It may be tested in the saline areas for final recommendation.

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