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Morphophysiological and yield attributes of groundnut varieties under different salinity stress conditions

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ABSTRACT

The study sought to evaluate the response of three groundnut genotypes (Binachinabadam-3, Dacca-1 and Zhingabadam) to various salt concentrations (D_0 – Control, D_1 – 2.5 dS/m, D_2 – 5.0 dS/m, D_3 – 7.5 dS/m, D_4 – 10.0 dS/m, D_5 – 12.5 dS/m) through observation of morphological and physiological characters. Based on relative performance of yield contributing characters and nutrient contents of leaves and stem, Binachinabadam-3 emerged to be a tolerant variety and based on root shoot characters, Dacca-1 appeared as tolerant while Zhingabadam always performed as sensitive variety. Salinity treatments had most adverse effects at flowering stage and followed the trend of sensitivity as flowering stage > vegetative stage> pre sowing stage > pod filling stage. All varieties were found to be tolerant up to salinity level of 7.5 dS/m.

Key words: *Arachishypogaea*, Oil crops, Salinity stress, Salinity tolerance.

INTRODUCTION

Globally more than 800 million hectares of land are salt affected throughout the world. Soil salinity restricts normal crop production including groundnut.

In Bangladesh, 49 upazilas (Sub-district) of 19 districts of the country are affected by soil salinity and severity of salinity problem has increased o ver time which is about 26% in 1973 to 2009 (SRDI, 2010). The coastal zone of Bangladesh covers 20% of land area, inhabited by approximately 40 million peoples. About 64.7% of inhabitants directly depend on agriculture (BBS, 2010).

Groundnut requires only 350 mm water for completing life cycle (Azad*et al.,* 2014) and thus mostly grown under rain fed condition during November to April-May. Groundnut is moderately sensitive to soil salinity and can tolerate up to 3.4dS/m without affecting yield (Singh *et al.,* 2010). In this context, we need a variety of groundnut that will able to tolerate up to 4.0 to 8.0 dS/m salinity without much affecting yield.

The salinity tolerance of plants can be best evaluated in terms of growth or survival as it depicts many physiological mechanisms occurring within the plants (Gupta and Huang, 2014). Morpho-agronomic characters reflect the combined genetic and environmental impacts on plants, and parameters like survival under unfavorable conditions, plant height, and injury to salt stress, relative growth rate and relative growth reduction are considered as selection criteria for salt tolerance (Ashraf and Harris, 2004). So the ability of the plants to continue to grow would indicate a high level of salt tolerance (Shrivastava and Kumar, 2015). Salt tolerant groundnut genotypes are selected depending upon certain well defined morphological and physiological characteristics related to tolerance (Hoang *et al.,* 2016). Therefore, the objective of the present study was to develop standard protocol to screen groundnut germplasm under salinity stress condition at pre-sowing, vegetative, flowering and pod filling stages.

MATERIALS AND METHODS

The experiment was carried out in pot culture (27 × 22 cm) from November 2013 to March 2016 under controlled condition at BINA glass housewith three BARI improved groundnut varieties (Binachinabadam-3, Dacca-1 and Zhingabadam), subjected to six varied doses of salinity (D_0 – control, D_1 – 2.5 dS/m, D_2 – 5.0 dS/m, D_3 – 7.5 dS/m, D_4 – 10.0 dS/m and D_5 – 12.5 dS/m) at four growth stages (S1 - pre-sowing, S2 - vegetative, S3 - flowering and S4 - pod filling and laid out following three factorsat Complete Randomized Design (CRD) with three replications. Three pre-germinated seeds of each variety were sown in each pot.Recommended doses of urea, TSP, MoP, gypsum and zinc sulphate were applied. Cultural and intercultural practices were followed as and when required.

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Data recording: All the shoot-root characters, yield attributes and biochemical parameters were gathered from all the 3 plants grown in a pot and analyzed. Plant height (cm), number of branches, number of leaves, dry weight of leaves (g/plant), dry weight of shoots (g/plant), dry weight of roots (g/plant),total dry weight (g/plant), number of mature pods, number of immature pods, pod weight (g/plant) and kernel weight (g/plant) were recorded.

Relative performance =

(value of a trait under saline condition x 100) / value of a trait under control condition.

Data analysis: The recorded data were subjected to proper statistical analysis as per the design used. The treatment means were compared by using DMRT at 5% level of probability.

RESULTS AND DISCUSSION

Days to germination: In Table 1, at 5.0 dS/m salinity stress Binachinabadam-3 needed significantly more times to germinate than other two varieties. But at higher salinity levels (7.5 dS/m and 10.0 dS/m) Binachinabadam-3 needed significantly less times (20.33 and 21.33days) compared to Zhingabadam (24.33 and 29.00 days) and Dacca-1 (22.00 and 24.33 days). From the result of present study, it can be predicted that the Binachinabadam-3 might have some levels of salt tolerance as it required the less numbers of days to germinate at higher salinity levels compared to other varieties.

The results of our study showed that salinity stress delayed seed germination. But Binachinabadam-3 needed significantly less times compared to Zhingabadam and Dacca-1 at higher salinity level. The present result agrees with the reports of Francisco and Resurreccion (2008). So, it can be predicted that the Binachinabadam-3 might have some levels of salt tolerance as it required the less numbers of days to germinate at higher salinity levels compared to other varieties. Binachinabadam-3 also appeared to be most tolerant for its highest relative pod number, pod yield and kernel yields. This result of relative performance agrees with Haque (2006). Plant height number of leaves and pod yield were gradually decreased in groundnut with increasing salinity dose (Singh *et al.,* 2010; Azad *et al*., 2013; Azad *et al*., 2014.).

Table 1: Number of days required for germination.

Salinity levels (dS/m)	Binachina badam-3	Dacca-1	Zhinga badam
0.00	9.00 h	9.67 h	10.33 h
2.5	13.67 f	11.00 h	12.33 g
5.0	16.33 e	12.33 g	13.67 f
7.5	20.33 d	22.00 c	24.33 c
10.0	21.33 d	24.33 c	29.00 b
12.5	31.33 a	31.00 a	31.33 a

Note: Values with different lower case letters in a row are significantly different at $P < 0.05$ as per DMRT.

Root shoots characters

Plant height: The results in Table 2 showed that the relative plant height at growth stages is the highest (97.41%) at pod filling stage and the lowest at vegetative (64.50%) stage which followed by flowering (68.43%) and pre-sowing stage (74.25%), respectively.The interaction effects of variety × salinity dose x growth stage on plant height also presented in Table 2, Dacea-1 and Zhingabadam showed rapid decrease with the increase in salinity than Binachinabadam-3. Dacca-1 produced significantly tallest plant while Binachinabadam-3 had the shortest.

Leaf weight: In Table 2, the relative leaf weight was the highest (79.01%) at pod filling stage followed by vegetative (73.12%) and pre-sowing stage. The lowest percentage of relative leaf weight (59.64%) was recorded due to salinity at flowering stage. Among the interaction of variety, salinity doses and growth stages also presented in Table 2, at higher salinity levels Binachinabadam-3 produced highest leaf weight at pre sowing and vegetative stage and Zhingabadam always produced lowest.

Root biomass: The results presented in Table 2, relative % of root weight was significantly highest (78.73%) at pod filling stage followed by vegetative (77.01%) and pre-sowing stage (71.25%) and it was significantly lowest (63.28%) at flowering stage. The interaction effect of variety × salinity dosex growth stage on root weight also presented in Table 2, at all growth stages in highest salinity level, Dacca-1 produced the highest root weight followed by Binachinabadam-3 while Zhingabadam produced lowest root weight per plant.

Shoot biomass: It can be seen in Table 2, a significant variation also found in % relative shoot biomass. The maximum % relative shoot biomass (77.01%) was found in pod filling stage while lowest (64.32%) at flowering stage. Among the interaction effects Dacca-1 produced highest shoot biomass at all growth stages in all salinity levels in Table 2. For root and shoots biomass, Binachinabadam-3 and Dacca-1 were sensitive to 7.5 dS/m and Zhingabadam was sensitive to 5.0 dS/m.

Growth stages were classified based on sensitivity on relative performance in the order of flowering stage > vegetative stage > pre-sowing stage> pod filling stage. This result is in partial agreement with that of Aziz *et al.* (2006), they evaluated salt tolerance in mungbean plant in different growth stages. They concluded that flowering stage was being more sensitive than pod filling stage. Hoang *et al.* (2016) found that rice was very tolerant at germination and tillering stage of its growth but were very sensitive at 1-2 leaf and flowering stages. Negrão *et al.* (2017) reported that results of salinity would be different due to difference in crops and its sensitivity, methods of salinity imposition and salt used. Salinity adversely affects plant growth at all stages and at seedling and reproductive stages in particular,

dramatically reducing the crop yield (Azad *et al.*, 2013; Azad *et al.*, 2015; Hoang *et al.*, 2016).

Root / shoot ratio: In Table 2, the root shoot ratio per plant of the groundnut variety under study differed due to the mean effect of different salinity levels. The lowest value 0.1098 was found in Dacca-1 and lowest value (0.1049) was found in Zhingabadam. The highest value (1.055) was found, when salinity was imposed at pre sowing stage, lowest value (0.7256) was found at flowering stage.

All root shoot characters and yield contributing characters started decreasing drastically after applying 7.5 dS/m salinity dose. The root-shoot and yield contributing characters gradually decreased with the increase in salinity, but at lower salinity level (0-2.5 dS/m) the performance of these characters decreased very little and sometimes it increased. This means that these characters also showed significant difference groundnut is less sensitive to lower salinity, more or less tolerate up to 7.5 dS/m and more sensitive to higher salinity levels.

Table 2: Means and relative performance (%) of different root shoot characters of three varieties affected by six salinity levels and four growth stages.

	PH (cm)	PH (%)	LN/P (No)	LN/P (%)	LW/P (g)	LW/P (%)	RB/P (g)	RB/P (%)	SB/P (g)	SB/P (%)	R/ S ratio
Salinity level (dS/m)											
Control	26.18 a	100.0 a	54.90 a	100.0 a	11.37 a	100.0 a	1.74 a	100 a	16.69 a	100.0 a	0.104 ab
2.5	24.14 b	92.61 b	52.61 b	97.10 b	9.84 b	85.92 b	1.62 b	93.79 b	15.31 b	91.79 b	0.106 ab
5.0	20.28 c	78.71 c	47.72 c	89.02 c	8.38c	74.66 c	1.36 c	78.98 c	13.85 c	83.38 c	0.097 b
7.5	17.11 d	66.82 d	42.53 d	78.64 d	7.31 d	64.50 d	1.12 d	65.10 d	10.58 d	63.99 d	0.106 ab
10.0	16.74 d	65.41 d	34.60 e	65.47 e	5.23 e	46.67 e	0.92 e	53.46 e	8.37 e	50.71 e	0.111 ab
12.5	14.01 e	53.33 e	22.09 f	42.56 f	4.23 f	37.47 f	0.77 f	44.09 f	6.72 f	41.31 f	0.115 a
Varieties											
Binachinabadam-3	15.88 c	81.79 a	37.74 c	82.93 a	6.46 a	73.73 a	1.23 b	80.24 a	11.67 b	79.67 a	0.105 a
Dacca-1	22.98 a	75.69 b	49.62 a	75.87 c	9.07 b	66.14 b	1.45 a	75.28 b	13.57 a	72.41 b	0.110 a
Zhingabadam	20.36 b	70.97 c	39.86 b	77.60 b	7.65 c	64.73 c	1.08 c	62.18 c	10.52 c	63.51 c	0.105 a
Growth stage											
Pre sowing	16.38 d	74.25 b	38.67 d	68.44 d	6.07 b	61.04 b	1.19 c	71.25 a	11.88 c	71.12 c	0.104 a
Vegetative	17.83 c	64.50 d	46.08 a	81.37 b	8.42 c	73.12 c	1.29 b	77.01 b	12.34 b	75.01 b	0.105 a
Flowering	18.28 b	68.43 c	40.74 c	71.61 c	6.80 d	59.64 d	1.09 d	63.28 d	10.79 d	64.32 d	0.103 a
Pod filling	26.48 a	97.41 a	44.13 b	93.77 a	9.63 a	79.01 a	1.45 a	78.73 a	12.66 a	77.01 a	0.115 a

Note: Values with different lower case letters in a row are significantly different at $P < 0.05$ as per DMRT.
Here, PH-Plant Height, LN/P- Leaf number/plant, LW/P-Leaf weight /plant RB/P-Root biomass/plant,SB/P-Shoot biomass/ plant, R/S-Root shoot ratio.

Table 3: The mean effect and relative performance (% of control) of yield contributing characters of three varieties affected by six salinity levels at four growth stages.

	PN/P	PN/P (%)	PY/P(g)	PY/P (%)	KY/P(g)	KY/P (%)	Shelling (%)
Salinity level (dSm^{-1})							
0 (Cont)	7.39 a	100 a	6.42 a	100 a	3.64 a	100 a	57.20 a
2.5	5.96 b	80.34 b	5.33 b	82.58 b	2.64 b	72.56 b	49.38 b
5.0	3.64 c	50.88 c	2.53 c	38.61 c	1.20 c	32.48 c	49.22 b
7.5	1.95 d	28.26 d	1.47 d	28.05 d	0.758 d	20.07 d	33.20 c
10.0	1.17 e	17.52 e	0.57 e	13.82 e	0.297 e	7.54 e	19.74 d
12.5	0.48 f	6.81 f	0.18 f	9.46 f	0.076 f	1.96 f	15.75 e
Variety							
Binachinabadam-3	3.76 a	59.38 a	3.34 a	50.20 a	1.80 a	44.11 a	45.66 a
Dacca-1	3.62 b	41.30 b	2.56 b	44.48 b	1.24 c	37.98 b	32.21 c
Zhingabadam	2.92 c	41.48 b	2.35 c	41.58 c	1.27 b	35.20 c	34.38 b
Growth stage							
Pre sowing	3.72 b	50.02 b	2.75 b	40.37 b	1.35 b	36.52 b	33.88 c
Vegetative	2.82 c	41.32 c	2.13 c	36.58 c	1.01 d	34.00 c	27.42 d
Flowering	2.47 d	32.73 d	1.94 d	34.05 d	1.23 c	29.47 d	39.00 b
Pod filling	4.72 a	65.47 a	4.18 a	70.68 a	2.16 a	56.39 a	49.36 a

Note: Values with different lower case letters in a row are significantly different at $P < 0.05$ as per DMRT.Here, PN/P- Pod number/ plant, PY/P- Pod yield/plant, KY/P- yield/plant.

Yield Attributes

Pod number/plant: Results presented in Table 3, highest number of pods (4.72) was found when salinity imposed at pod filling stages followed by pre-sowing (3.72). Lowest number of pods (2.47) was recorded in flowering stage followed by vegetative stage (2.82). The same phenomenon was found in respect to relative % of pod number. The Variety × salinity dose × growth stage interactions are demonstrated in Table 3 that with the increase in salinity Binachinabadam-3 did not significantly decreased up to 5.0dS/m at all growth stages except flowering stage.

Pod yield: In Table 3, the highest pod yield was found, when the plants were salinized at pod filling stage followed by salinization at pre-sowing (2.75g) and vegetative stage (2.13g), while the lowest pod yield was recorded in crops salinized at flowering stage. In the Table 3, at salinity of 7.5 dS/m or above Dacca-1 and that at 10 dS/m or above Zhingabadam failed to produce any pod whereas, Bianchinabadam-3 could produce significantly higher pod yield up to higher salinity level, this might be due to good adaptability of this variety at high salinity. With salinization at flowering stage, Binachinabadam-3 and Dacca-1 could not produce any yield above 7.5 dS/m.

Kernel yield: In Table 3, the highest value (56.39%) of relative kernel yield was also found in pod filling stage and the lowest value (29.47%) was recorded at flowering stage followed by vegetative (34.00%) and pre-sowing (36.52%) stage. The interaction effect of variety × salinity dose x salinity stage on pod yield in Table 3, Binachinabadam-3 showed the highest yield after salinization at vegetative and pod filling stage.

The most interesting findings of the present study indicated that flowering was the most sensitive stage for most of parameters and salinity levels 7.5-8.0 dS/m could be appropriate for screening program.

CONCLUSION

Among the growth stages, flowering stage is the most sensitive stage, followed the trend of sensitivity-flowering stage > vegetative stage> pre sowing stage > pod fillingstage. Based on relative performance of different root shoot characters and yields contributing characters, Binachinabadam-3 appeared as a tolerant genotype, Dacca-1 moderately tolerant while Zhingabadam as sensitivegenotype. Finally, for screening Groundnut genotypes should be screened at vegetative to flowering stage and the suitable salinity dose ranged from 7.5- 8.0dS/m.

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