Seedling Growth of *Cassia tora*, *Cassia occidentalis* and *Cassia sophera* in Relation to Salinity and pH

Sabiha Sultana and A.K.M. Nazrul Islam

Ecology and Environment Laboratory, Department of Botany, University of Dhaka, Dhaka 1000, Bangladesh

Abstract: The paper aimed to investigate the growth of seedlings of three species of *Cassia* (*C. tora*, *C. sophera* and *C. occidentalis*) at different concentrations of salinity (NaCl) and pH treatments. All the species showed the highest seedling length under control condition, and with the increase of salinity, *C. occidentalis* showed the highest sensitivity. The seedling length of *C. tora* at 0.05 M NaCl significantly ($P = 0.05$) decreased to 5.71 cm, and further increase of salinity to 0.1 M, the seedling length was decreased to less than the value of 0.05 M NaCl treatment and one-third (2.15 cm) of that of control (6.92 cm). Seeds of all the species failed to germinate at 0.5 M NaCl. Scarified seeds of *C. sophera* and *C. occidentalis* increased seedling length. The highest seedling length was in *C. sophera*, followed by *C. tora* and *C. occidentalis*. All the species showed significant decrease ($P < 0.05$) of fresh weight with the increase of salinity; scarification of seeds in *C. occidentalis* and *C. sophera* showed higher fresh weight than those of without scarification. Experiments at different pH levels did not show any significant ($P = 0.05$) change in seedling length, except *C. sophera*, while at acidic pH, both seedling length and dry weight were significantly ($P < 0.05$) decreased.

Key words: *Cassia* spp., seedling growth, salinity, pH.

1. Introduction

Salinisation of soil is common in arid and semiarid regions, where the amount of rainfall is insufficient for substantial leaching. High concentrations of salts have detrimental effects on plant growth [1-3]. Plant species differ in their sensitivity or tolerance to salts [4]. There is evidence that organs, tissues and cells at different developmental stages of plants exhibit varying degrees of tolerance to environmental conditions [5]. It is reported that soil salinity suppresses shoot growth more than the root growth [3, 6, 7]. An understanding of growth and survival of plants under saline conditions is needed for screening the plant species for the afforestation in saline deserts and realizing the mechanism that plants use in the avoidance and/or tolerance of salt stress.

In nature, the three species of *Cassia* (*C. tora*, *C. occidentalis* and *C. sophera*) appear differently to edaphic features, climatic factors and their seasonal

variation and availability of water. The influence of salinity on germination response was studied in halophytes and non-halophytes (glycophytes) by Rozema [8]. However, inhibition of germination by salt could play a decisive role in limiting geographical distribution of a species and determining their position in the vegetation [9]. Toxic effects of certain ions on seed germination and seedling development had been studied by a number of investigators at the beginning of the century. Stewart [10] and Harris and Pittman [11] found that chloride salts were the most toxic for germination, sulphate less so and carbonate the least. A similar concentration between the ability to germinate under saline conditions and zonation of plants in salt marsh was also reported by Ungar [12]. Seeds of *Limonium vulgare* Mill. and *Limonium humile* Mill. slowly germinated in sea water. Most of the seeds, which did not germinate in such a medium, rapidly germinated after being transferred to fresh water [13]. The same was true for *Puccinellia nuttalliana* [14]. Gale et al. [15] showed that the optimal concentration of sodium chloride in the

Corresponding author: A.K.M. Nazrul Islam, Ph.D., research fields: ecology and environment.

culture solution for growth of *Atriplex halimus* was a function of environmental conditions. The present investigation was an attempt to study the seedling growth of three *Cassia* spp. (*C. tora*, *C. occidentalis* and *C. sophera*) in relation to salinity and pH.

2. Materials and Methods

Seeds of three *Cassia* species (*C. tora*, *C. occidentalis* and *C. sophera*) were germinated with different concentrations of NaCl solution (0.05, 0.1, 0.2 and 0.5 M) and with various pH conditions to see the effect on seedling growth. Twenty-five healthy seeds of each species were placed on moistened filter papers in Petri dishes for each NaCl and pH treatments; four replications were done and the seeds in Petri dishes were moistened daily (approximately 2 mL) with the specific NaCl and pH solution. After, germination seedlings were allowed to grow in the Petri dishes for 7 d. A control with 25 healthy seeds was also done simultaneously.

After 7 d of growth, five seedlings of each species were harvested from each Petri dish. The length of root, shoot and fresh weight of each seedling were taken, then dried in the oven at 80 °C for 24 h and dry weight was then recorded.

3. Results

3.1 Seedling Growth

The growth of seedlings of all three species was the best at control, followed by 0.05 M and 0.1 M. This suggested that the growth of seedlings was prevented at high levels of NaCl salinity (Fig. 1 and Table 1).

The highest seedling length of *C. tora* was 6.92 cm in control, and with the increase of salinity to 0.05 M, the seedling length was decreased to 5.71 cm. Further increase of salinity to 0.1 M, the length of the seedling became less than half of 0.05 M treatment and one-third to that of control. At 0.2 M, the seedling length was the lowest (1.66 cm), and at 0.5 M, seeds did not germinate (Fig. 2).

Seeds of *C. occidentalis* also showed the highest

seedling length 7.57 cm in control (with scarification) and 4.2 cm (without scarification). The seedling length decreased to 5.07 cm and 3.90 cm at 0.05 M NaCl with and without scarification, respectively. At 0.1 M NaCl, the seedling length was 3.75 cm and 2.93 cm with and without scarification, respectively; the length was 1.95 cm at 0.2 M with scarification (Fig. 2).

C. sophera also showed the highest length of seedlings (7.74 cm and 7.28 cm with and without scarification, respectively) in control. At 0.1 M, the seedling length was 6.49 cm and 3.18 cm with and without scarification, respectively. These two species did not show any growth at 0.5 M NaCl without scarification (Fig. 2). The seedling length of *C. sophera* at different NaCl concentrations is higher than *C. occidentalis*. The results show that both *C. occidentalis* and *C. sophera* are sensitive to salinity and suggest the reason for absence of these two species from the coastal habitat. Seedling length of *C. tora* with various pH treatments did not show any significant difference; but seedling length of both *C. occidentalis* and *C. sophera* at pH 4 was significantly lower ($P < 0.05$) than those grown in pH 6 and pH 8 (Fig. 3 and Table 2).

3.2 Fresh Weight and Dry Weight of the Seedlings

All three species of *Cassia* were sensitive to salinity treatment, and showed decrease of fresh and dry weights as the salinity levels were increased. There was a significant decrease ($P < 0.05$) of all the measurements (Table 1) when concentration of NaCl was increased from 0.05 M to 0.1 M condition. Both *C. tora* and *C. occidentalis* exhibited the highest fresh and dry weight at control, i.e., 0.47 g (FW) and 0.037 g (DW), 0.48 g (FW) and 0.042 g (DW) with scarification and 0.437 g (FW) and 0.037 g (DW) without scarification, respectively.

Both species showed drastic reduction of fresh weight and dry weight at 0.2 M salinity treatment. The scarified seeds of *C. sophera* and *C. occidentalis* always

(a)

(b)

Control 0.05 M 0.1 M 0.2 M 0.5 M

(c)

Fig. 1 Seedlings of *Cassia* spp. in different salinity treatments.

a: *C. tora*; b: *C. sophera*; c: *C. occidentalis*. Seedlings in the upper row are *C. sophera* and *C. occidentalis* scarified, respectively.

showed high values from the seedlings of non-scarified seeds. Delay in germination in non-scarified seeds possibly decreased the growth. All

three species of *Cassia* (*C. tora*, *C. occidentalis* and *C. sophera*) exhibited highest fresh and dry weight at control.

Fig. 2 Mean length (cm) of *C. tora*, *C. occidentalis* and *C. sophera* at different NaCl treatments with and without scarification.

Fig. 3 Mean length (cm) of *C. tora*, *C. occidentalis* and *C. sophera* seedling at different pH treatments with and without scarification.

Total dry weight of *C. tora* was unaffected by pH treatments. However, significant decrease ($P < 0.05$) of dry weight was observed both in *C. occidentalis* and *C. sophera* at pH 6 and pH 8 (Table 2). Dry

weight/fresh weight in scarified seeds of *C. occidentalis* (except grown at pH 8) and *C. sophera* was higher than those grown without scarification (Table 2).

Table 1 Fresh and dry weight (g) of *C. tora*, *C. occidentalis* and *C. sophera* at different salinity (NaCl) treatments.

Plant species	Treatment NaCl (M)	Fresh weight (g)	Total dry weight (g)	Fresh weight/dry weight
<i>C. tora</i>	0	0.470 ± 0.024	0.037 ± 0.008	12.702
	0.05	0.410 ± 0.595	0.035 ± 0.089	11.714
	0.1	0.290 ± 0.205	0.032 ± 0.142	9.062
	0.2	0.250 ± 0.129	0.031 ± 0.1591	8.333
	0.5	-	-	-
<i>C. occidentalis</i> (with and without scarification)	0	0.437 ± 0.0826 (0.481 ± 0.0459)	0.037 ± 0.00817 (0.042 ± 0.0079)	11.81 (11.42)
	0.05	0.392 ± 0.0459 (0.411 ± 0.0458)	0.031 ± 0.0082 (0.042 ± 0.0009)	13.06 (10.25)
	0.1	0.305 ± 0.0716 (0.361 ± 0.0288)	0.025 ± 0.0226 (0.032 ± 0.0093)	12.20 (11.25)
	0.2	(0.212)	(0.012)	(17.66)
	0.5	-	-	-
<i>C. sophera</i> (with and without scarification)	0	0.317 ± 0.061 (0.357 ± 0.039)	0.025 ± 0.00091 (0.035 ± 0.00091)	12.68 (10.20)
	0.05	0.300 ± 0.038 (0.395 ± 0.020)	0.025 ± 0.00091 (0.033 ± 0.00079)	12.00 (12.15)
	0.1	0.105 ± 0.040 (0.352 ± 0.064)	0.015 ± 0.00091 (0.033 ± 0.00079)	7.00 (10.83)
	0.2	(0.167 ± 0.032)	(0.012 ± 0.00079)	(13.91)
	0.5	-	-	-

Each value is the mean of four replicates and each replicate is the mean of five seedlings. Values in parenthesis are the result with scarified seeds. 95% confidence limits are given. -: means no growth.

Table 2 Mean seedling length, fresh and dry weight (g) of *C. tora*, *C. occidentalis* and *C. sophera* at different pH treatments.

Plant species	Treatment pH	Length (cm)	Fresh weight (g)	Total dry weight (g)	Fresh weight/dry weight
<i>C. tora</i>	4	11.96 ± 0.48	0.425 ± 0.036	0.025 ± 0.00684	17.00
	6	12.00 ± 0.48	0.467 ± 0.059	0.028 ± 0.0059	16.98
	8	10.25 ± 1.84	0.420 ± 0.049	0.025 ± 0.0068	16.80
<i>C. occidentalis</i> (with and without scarification)	4	4.31 ± 0.66 (4.84 ± 1.44)	0.250 ± 0.059 (0.170 ± 0.009)	0.025 ± 0.0091 (0.015 ± 0.0092)	10.00 (11.33)
	6	6.24 ± 0.26 (5.24 ± 0.43)	0.232 ± 0.038 (0.220 ± 0.025)	0.0175 ± 0.0079 (0.010 ± 0.000)	13.25 (22.00)
	8	7.185 ± 1.79 (4.83 ± 1.65)	0.230 ± 0.060 (0.210 ± 0.065)	0.012 ± 0.0075 (0.018 ± 0.0079)	19.16 (12.00)
<i>C. sophera</i> (with and without scarification)	4	4.30 ± 0.39 (6.23 ± 0.31)	0.230 ± 0.950 (0.327 ± 0.030)	0.030 ± 0.0076 (0.027 ± 0.0079)	7.60 (12.11)
	6	7.42 ± 1.65 (5.81 ± 0.86)	0.210 ± 0.030 (0.275 ± 0.062)	0.022 ± 0.0079 (0.025 ± 0.0092)	9.54 (11.00)
	8	6.70 ± 1.64 (7.00 ± 0.48)	0.220 ± 0.008 (0.330 ± 0.190)	0.020 ± 0.000 (0.025 ± 0.0066)	11.00 (13.20)

Values in parenthesis are with scarification. 95% confidence limits are given.

4. Discussion

Salinity is a major form of land degradation worldwide [16]. Growth of plants on salt-affected soils may be restricted by salinity (high concentrations of soluble salts).

Greenway [17] in his experiments with *Hordium vulgare* exposed to salinity treatments showed the

results of leaf growth, shoot and roots separately. In general, NaCl treatment decreased the development of leaves. He has also shown that the uptake of sodium by the leaves was the main factor for the decrease of growth.

It was found that *C. occidentalis* and *C. sophera* are more sensitive to NaCl treatment than *C. tora*, and

growth of seedlings is retarded with the increase of NaCl concentration. Reduction of plant growth and dry matter accumulation in *Phaseolus vulgaris* under saline condition was also reported in Refs. [3, 18]. An eco-physiological investigation into the salt tolerance of *Glaux maritima* L. was carried out by Rozema [8] and found that high salt concentration significantly decreased fresh and dry weight production. Wheat cultivars (*Triticum aestivum* L. cv. Inia 66 and cv. Sonalika) were found to grow well at low salinity levels [19]. Nazrul Islam and Sabiha [20] in the earlier investigation have shown that increasing salinity has a decreasing effect on germination for all three *Cassia* spp..

Optimal shoot growth of *Aster tripholium* occurred when plants were in a salt solution, whereas, roots grew the best in fresh water [21]. Increase in root growth and decrease of shoot growth were obtained under high water stress induced by NaCl, whereas, total growth of the plants was reduced [22, 23]. Shoot growth of *Aster tripholium* was the best at 1% NaCl [24]. In *Atiplex polycarpa*, salinity inhibited shoot growth more than the root growth [25].

Length of *Cassia* seedling showed a significant ($P < 0.05$) reduction with the increase of salinity from 0.05 M onwards, suggesting that seedling growth of *Cassia* spp. is not detrimental at low salinity level. Death of fine roots of *Poncirus trifoliata* in response to increased NaCl was observed by Tozlu et al. [26], and they designated this mechanism as “fine root turnover” which was also noted in the present investigation with *Cassia* spp..

Response of the three *Cassia* spp. in relation to pH treatments did not show any significant difference. It suggested that the species can grow and establish in soils of wide range of pH conditions.

5. Conclusions

All the three *Cassia* spp. were sensitive to salinity. *C. tora* showed tolerance at the lowest salinity level and suggested that this species can survive, grow and

establish in the coastal areas of low saline condition. Low population of *C. sophera* and *C. occidentalis* in the natural environment is due to their poor germination. *C. tora* will grow both in acid and alkaline soils. *C. sophera* and *C. occidentalis* will face difficulty to grow and survive in alkaline soils.

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