Research Article

Effect of Chloride and Sulphate Dominated Salinity on Seed Germination and Early Seedling Growth of Senna (*Cassia angustifolia* Vahl.)

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Abstract

In the present investigation seed germination and early seedling growth of the medicinal plant Senna under the influence of salinity viz. chloride dominated and sulphate dominated salinity was assessed at varying EC levels viz. 0, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22 and 24 dSm^{-1} in petridish experiment. Results revealed that the progressive increase of EC levels not only inhibited the seed germination but also declined the speed of germination (Maguire index). Both salinity types proved deleterious to Senna seedlings as they decreased the seedling length, vigour index, fresh & dry weight and relative water content of seedling. Sulphate dominated salinity was found most detrimental to seedlings than chloride dominated salinity. Seed germinability and subsequent survival of seedlings up to 24 dSm^{-1} EC level of salinity indicated substantial salt tolerance in Senna.

Keywords: *Cassia angustifolia*, salinity, seedlings, seed germination and seedling vigour

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Introduction

Germination is the initial stage of a plant cycle and determines where and when a crop can be established. It is a complex metabolic process that oxidizes the lipids and carbohydrates within the seed and breaks down storage proteins in order to obtain energy and amino acids necessary for plant development [1]. Seed germination and early seedling growth under saline conditions are considered as major factors limiting the establishment of crops [2]. Interaction between seedbed environment and seed quality is also important [3]. Plant available water is restricted in soils containing excess sodium chloride, resulting in partial dehydration of cell cytoplasm. Such plassmolysis affects the metabolism of cells and functions of macromolecules and, ultimately, results in cessations of growth [4]. The effect of salinity on germination can be either by creating osmotic potential which prevents the uptake of water or by the toxic effects of ions on embryo viability [5]. Salts absorbs and retain crops with such strength thats not freely available in the soil, causing an increase of soil solution osmotic pressure. Salt stress may cause significant reductions in the rate and final germination percentage, which in turn may lead to an uneven stand establishment and a reduction in yield.

Cassia angustifolia Vahl. commonly known as Indian senna in English is an important medicinal plant species belonging to the family caesalpiniaceae. The leaves and pods of this species are cathartic, contains sennosides A, B, C, D, rhein and aloe-emodin in free and compound form of these sennosides. Sennosides A and B are present in large amount than others. The leaves and leaflets also contain koempferol, anthraquinone, essential oil, calcium salt and isorhamnetin. It is used as expectorant, wound dresser, carminative and laxative. It is also useful in loss of apetite, hepatomegaly, spleenomegaly, indigestion, malaria, skin diseases, jaundice and anaemia.

Medicinal and aromatic plants are gaining popularity globally as a source of raw material for pharmaceuticals and traditional health care system [6]. More than 85% of herbal medicines used in traditional health care systems are derived from medicinal plants [7] and ensure the livelihoods of millions of people. The areas becoming unsuitable for raising conventional crops due to one or the other reasons may be used for growing such plants depending upon their suitability to the prevailing environmental conditions. The present study was made to explore the feasibility of growing Senna in saline barren lands by assessing its seed germination and early seedling growth under different EC level of chloride and sulphate dominated salinity.

Materials and methods

Present investigation was conducted in laboratory conditions at CCS Haryana Agriculture University, Hisar Haryana.

Seeds of Senna var. sona for these experiments were obtained from the Institute of Herbal Heritage (A unit of Asian Medicinal plants and Health care trust) Sonamukhi Nagar, Sangaria Fanta, Salawas Road, Jodhpur-342005 (Rajasthan), India. Two types of salinity i.e. chloride (Cl^-: SO_4^{2-} (7:3); Na^+:Ca^{2+}+Mg^{2+} (1:1); Ca^{2+}:Mg^{2+} (1:3)) and sulphate (SO_4^{2-}:Cl^- (7:3); Na^+:Ca^{2+}+Mg^{2+} (1:1); Ca^{2+}:Mg^{2+} (1:3)) dominated salinity at various EC levels; 0 (control), 4, 6, 8, 10, 12, 14, 16, 18, 20, 22 and 24 dSm^{-1} given. Fifteen healthy seeds of uniform size were sown in each Petridish (9 cm. diameter) on filter paper beds soaked with 7 ml solution of respective stress level. Each stress treatment was replicated three times. Distilled water served as the control. The Petri dishes were kept at the room temperature (27±2ºC) and under natural photoperiod (10 h light and 14 h dark).

Seed germination (%)

Germination counts were made after fifteen days and germination percent was calculated for each treatment on fifteenth days. The criterion for seed germination was the emergence of radical (more than 1 mm in length).

Maguire index

Speed of germination in both salinity types was determined in terms of Maguire index (MI) and that was calculated by the following formula:

$$MI = \frac{X_1}{Y_1} + \left(\frac{X_2 - X_1}{Y_2} \right) + \ldots\ldots\ldots + \frac{X_n - X_{n-1}}{Y_n}$$

Where X_n = number of seeds germinated on the n^{th} counting date, Y_n = number of days after sowing to n^{th} counting

Seedling length (cm)

The length of five seedlings were measured with the help of a scale and averaged.

Vigour index

Vigour index (VI) was determined to evaluate the seedling vigour by the formula given as under:

VI= Per cent germination x seedling length (cm).

Fresh weight of seedling (mg)

The five seedlings from each treatment were removed from the Petri dishes and their fresh weights were measured with the help of an electronic balance. The data were presented on seedling basis.

Dry weight of seedling (mg)

The seedlings were wrapped in a paper and allowed to dry at 60ºC in an oven for 24 h. Their dry weights were measured with the help of an electronic balance after bringing them to room temperature. The data were expressed on seedling basis.

Relative water content (%)

Relative water content (RWC) was also calculated by the following formula [8].

$$RWC\ (\%) = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \times 100$$

Completely randomized design (CRD) was used in the experiment. Statistical analysis was done for this two factor assymetrical factorial experiment.

Results and Discussion

Seed germination (%)

The seeds of Senna showed 91.1 percent germination (**Table 1**) at 0 EC level (control). Seed germination was found to progressive and significant decline with the rise of EC levels of salinity resulting from lowering of osmotic potential in germination medium. Significant reductions in seed germination with the progressive increase of EC levels were quite evident beyond 10 dSm^{-1} EC level. The overall differential effect of chloride and sulphate dominated salinity on seed germination was not significant. The interaction effect of ST×EC on per cent seed germination, however, was significant. These results are in agreement with the findings of other workers who observed the inhibition of seed germination under increasing salinity gradient [9]. Taffou *et. al*. [10], [11] and [12] also reported reduced germination under saline conditions in some other plants that strengthens our findings. Significant decline and delay in seed germination was found in five isabgol genotypes [13] and in chandrashura [14] with the increase of EC levels under NaCl and $NaSO_4$ salt stress.

Table 1 Seed germination percent (GP) and Maguire index (MI) of Senna under varying salinity

EC level (dSm^{-1})	Seed germination percent (GP)			Maguire index (MI)		
	Salinity type (ST)			Salinity type (ST)		
	Chloride dominated	Sulphate dominated	Mean	Chloride dominated	Sulphate dominated	Mean
O(Control)	91.1 (75.0)	91.1 (75.0)	91.1 (75.0)	3.83	3.83	3.83
4	77.8 (61.9)	82.2 (65.6)	80.0 (63.8)	3.09	2.15	2.62
6	75.5 (60.4)	80.0 (63.4)	77.8 (61.9)	2.43	2.05	2.24
8	75.5 (60.4)	80.0 (63.4)	77.6 (61.9)	1.96	1.79	1.88
10	60.0 (50.8	71.7 (57.5)	65.9 (54.1)	1.22	1.53	1.38
12	55.5 (48.2)	66.7 (54.7)	61.1 (51.5)	1.13	1.47	1.30
14	53.5 (46.9)	60.0 (50.8)	56.7 (48.8)	1.05	1.14	1.10
16	48.9 (44.4)	51.1 (45.6)	50.0 (45.0)	0.96	0.99	0.98
18	42.2 (40.4)	37.8 (38.0)	40.0 (39.2)	0.90	0.74	0.82
20	33.3 (35.2)	28.9 (32.5)	31.1 (33.8)	0.61	0.47	0.54
22	26.7 (31.1)	22.2 (28.1)	24.5 (29.5)	0.46	0.33	0.40
24	26.7 (23.1)	6.7 (15.0)	16.7 (19.7)	0.25	0.09	0.17
Mean	55.6 (48.1)	56.5 (49.1)		1.49	1.38	
CD at 5%	ST = N.S., EC = 3.5, ST×EC = 5.0			ST = N.S., EC = 0.27,ST×EC = 0.38		

Values in parentheses represent arc-sine transformation data

Maguire index

Maguire index, that indicates the speed of seed germination, also declined significantly from 3.83 to 0.17 with the decrease in osmotic potential of the culture solutions (Table 1). There was no differential effect of salinity types on maguire index. Maguire index was reduced significantly right from the EC level of 4 dSm^{-1} under chloride (from 3.83 to 0.25) as well as sulphate dominated salinities (from 3.83 to 0.09). These results are in conformity with the findings of [15] in *Albizzia lebbek* and *Leucaena leucocephala* and of Surajkala in guar [16]. Similar response was also noticed in some medicinal plants such as isabgol [17] and chandrashura [14].

Seedling length

No significant effect of salinity on seedling length was observed up to 8 dSm^{-1} EC level but beyond this level a gradual decline in the length of seedling from 7.51 cm to 1.80 cm was observed with the progressive increase of EC level (**Table 2**). Differential effect of the two salinity types on seedling length was observed. Sulphate dominated salinity was found more inhibitory to seedling length (from 7.57 cm to 1.00 cm) as compared to chloride dominated salinity (from 7.57 cm to 2.60 cm). The ionic effects prevailed over osmotic effects in reducing seedling length.

Seedling vigour

Seedling vigour measured in terms of vigour index declined with increasing stress levels right from 4 dSm^{-1} EC level due to reduced seed germination and arrested seedling length. It decreased from 601.4 (4 dSm^{-1} EC level) to 23.3 (24 dSm^{-1} EC level) when considered on mean basis irrespective of salinity types. The response to chloride and sulphate dominated salinity was, however, indifferent in this regard (Table 2). The decline in vigour index, however was more pronounced at higher EC levels. Similar results were also reported by [13] in isabgol genotypes but sulphate was found more inimincal in that case. Decline in vigour index of seedlings of *Albizia lebbek* and *Leucaena leucocephala* with the rise of salinity was also reported by [18] and in those of guar by [16].

Table 2 Seedling length (cm) and Vigour index of Senna under varying salinity

EC level (dSm^{-1})	Seedling length (cm)			Vigour index		
	Salinity type(ST)			Salinity type (ST)		
	Chloride dominated	Sulphate dominated	Mean	Chloride dominated	Sulphate dominated	Mean
O(Control)	7.57	7.57	7.57	690.0	690.0	690.0
4	7.61	7.46	7.54	592.2	610.6	601.4
6	7.71	7.48	7.60	582.0	598.4	590.2
8	7.52	7.49	7.51	567.7	599.2	583.5
10	6.47	6.08	6.27	386.9	432.3	409.6
12	5.75	5.61	5.68	318.7	374.0	346.3
14	5.66	5.53	5.60	301.9	332.0	316.9
16	4.62	4.77	4.70	225.6	242.7	234.2
18	4.15	4.21	4.18	180.4	160.1	170.2
20	3.37	3.25	3.31	113.9	94.8	104.3
22	3.05	2.63	2.84	83.1	58.7	70.90
24	2.60	1.00	1.80	39.9	6.7	23.3
Mean	5.51	5.26		340.2	350.0	
CD at 5%	ST = 0.20, EC = 0.50, ST×EC =N.S.			ST = N.S., EC = 37.4, ST×EC = N.S.		

Seedling fresh and dry weight (mg)

Data presented in **Table 3** indicated that there was a significant decline in fresh and dry weight of seedling i.e. from 103.7 mg, 14.4 mg to 57.1 mg, 8.1 mg respectively with the progressive increase of EC levels (0-24 dSm^{-1}). It may be due to inhibition of hydrolysis of reserve/synthesizing food or its translocation to the growing axis (shoots) [19]. This reduction in seedling growth under salt stress is ascribed to be the effect of osmotic stress that caused reduction in water uptake. According to Bernstein and Haywood [20], suppression of plant growth under salt treatment is the resultant of reduced water absorption. Delayed germination at higher salinity level caused reduction in seedling length. Significant differential effect of salinity types on fresh weight of seedling was also observed. Sulphate dominated salinity was found more reducing than chloride dominated salinity as far as fresh weight of seedling is concerned. Length, fresh weight and dry weight of seedlings were found to more adversely influenced by sulphate dominated salinity as compared to chloride dominated salinity indicating higher toxicity of sulphate ions on seedling growth. These findings corroborate the results of [21] on isabgol seedlings and [14] on chandrashura. These findings are in agreement with other workers who observed reduction under salt stress in guar [16], faba bean [22] wheat [23].

Relative water content (%)

Relative water content of seedlings of Senna decreased with increasing the levels of salinity from 4 (88.51%) to 24 dSm^{-1} EC level (66.13%) when considered on mean basis irrespective of salinity types. Similar results were observed in isabgol [17], chandrashura [14] and in guar [16], who have observed decline in water uptake by plants under saline conditions. Sulphate dominated salinity more adversely affected the relative water content than chloride dominated salinity. In sulphate dominated salinity, it decreased from 88.45% (4dSm^{-1}) to 62.57% (24dSm^{-1}) whereas in chloride dominated salinity decreased from 88.58% (4dSm^{-1}) to 69.68% (24dSm^{-1}). Relative water content directly reflects the water status of plants and its decrease suggest that salinity caused water deficit in plants. The negative effect on plant water relations was induced by an increase in soluble salts, which slowed down the uptake of water and nutrients, causing osmotic effects and toxicity.

Table 3 Seedling fresh and dry weight (mg) of Senna under varying salinity

EC level (dSm^{-1})	Seedling fresh weight (mg)			Seedling dry weight (mg)		
	Salinity Type (ST)			Salinity Type (ST)		
	Chloride dominated	Sulphate dominated	Mean	Chloride dominated	Sulphate dominated	Mean
O(Control)	103.7	103.7	103.7	14.4	14.4	14.4
4	101.6	97.5	99.6	13.3	13.3	13.3
6	97.4	95.4	96.4	13.2	13.0	13.1
8	95.5	94.1	94.8	12.9	12.5	12.7
10	87.3	86.6	86.9	12.7	12.3	12.5
12	86.2	84.9	85.5	12.4	11.6	12.0
14	80.9	79.3	80.1	11.8	11.4	11.6
16	73.1	71.8	72.4	11.6	11.0	11.3
18	69.1	67.7	68.4	11.2	10.7	10.9
20	66.7	65.1	65.9	10.9	10.0	10.5
22	61.8	59.0	60.4	10.6	10.4	10.5
24	59.4	54.8	57.1	9.9	6.3	8.1
Mean	81.9	78.4		12.1	11.4	
CD at 5%	ST = 0.7, EC = 1.7, ST×EC = N.S.			ST = 0.2, EC = 0.6, ST×EC = 0.8		

Table 4 Relative water content (%) of seedling of Senna under varying salinity

EC level (dSm^{-1})	Relative water content (%)		Mean
	Salinity type (ST)		
	Chloride dominated	Sulphate dominated	
O(Control)	92.73	92.73	92.73
4	88.58	88.45	88.51
6	88.09	87.87	87.98
8	87.79	85.85	86.82
10	86.46	83.62	85.04
12	84.55	82.24	83.34
14	83.34	77.92	80.63
16	83.20	73.42	78.31
18	80.57	72.18	76.38
20	78.45	67.92	73.19
22	74.86	63.54	69.20
24	69.68	62.57	66.13
Mean	83.19	78.19	
CD at 5%,	ST = 0.36, EC = 0.87, ST×EC = 1.24		

Conclusion

The above results revealed that salinity stress reduced percent germination and seedling growth. Germination of seeds of Senna occurred upto 24 dSm^{-1} EC level of salinity irrespective of the salinity type. Sulphate dominated salinity, in general, was found more deleterious to seed germination and early seedling growth. Survival of seedlings up to 24 dSm^{-1} EC level of salinity despite reduction in growth indicates a substantial salt tolerance in Senna and supports the possibility of its cultivation in saline barren lands.

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