Comparative Levels of Salinity Tolerance of Different Vegetable Crops

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Abstract

Using a semi-hydroponic technique, experiments were carried out with the objective to evaluate the salinity tolerance in different hybrids of commercial vegetable crops (okra, onion, sponge gourd, carrot, bitter gourd, ridge gourd, bottle gourd, sweet corn, cucumber, water melon, tomato, and chilli) at seedling stage. In general, in all vegetable crops, highly significant differences were found among hybrids and NaCl concentration with respect to emergence (%), emergence index, shoot length and root length. Emergence was highly correlated with shoot length, and root length showing the contribution of shoot length to salinity tolerance in different vegetable crops. With increasing salinity, there was an increase in root length in salinity tolerant lines but there was a corresponding decrease in root length in susceptible ones. A comparative study on salinity levels revealed that two hybrids of okra genotypes can tolerate up to 0.15 M NaCl. Among these two hybrids, cv. Sleek is the best. Onion hybrids can tolerate up to 0.10 M NaCl and water melon can tolerate up to 0.15 M NaCl. Among the three water melon hybrids, cv. Slice is the best followed by cv. Candy. Bitter gourd can tolerate up to 0.15 M NaCl. Bottle gourd can tolerate up to 0.1 M NaCl. Cucumber hybrids showed an increase in root length under saline conditions which could be related to osmotic adjustment. Among the three cucumber hybrids, Salad is the best followed by cv. Harmony. Among all vegetable crops, gourds are tolerant to salinity, while onion, tomato and chilli are susceptible to this abiotic stress factor. The hybrids of these vegetable crop species which tolerate high levels of NaCl at the seedling stage, have a great potential under saline prone areas.

1. Introduction

Salinity is a serious environmental constraint to crop production in many parts of the world. It is especially prevalent in irrigated agriculture and in marginal lands associated with poor drainage or high water tables (Shannon, 1993). Vegetables are sources of minerals and vitamins for human diet. With increasing of population there is an increase demand of vegetables throughout the world urging a great necessity for increasing the production of vegetables. However, the productivity of vegetables is affected due to various abiotic stress factors such as drought, salinity and low nutrient conditions. Soil salinity is becoming a serious problem throughout the world. A large area of the cultivable land is being converted into saline soils due to indiscriminate use of chloride and sulphate containg fertilizers to build up of these ions in the soil profile (Maiti et al., 2004). Very little information is available on research on salinity in vegetables (Shannon and Grieve, 1999). Several studies have revealed that salinity affects germination and seedling growth in vegetable crops (Crucci et al., 2003). Maiti et al. (2004) reported significant variability to salinity tolerance among some vegetable crop species. Among them, celery showed higher level of tolerance followed by cabbage, beet leaves, green tomato. Salinity affects the quality and productivity of vegetables (Yo and Shaw, 1990; Singh and Mangal, 1991; Pascale and Barbieri, 1995; Sharma et al., 2001). It is reported that at certain concentrations, saline water might be utilized to irrigate vegetable crops (Kowaski and Palada, 1995). Maiti et al. (2007a) reported variability in salinity tolerance and osmotic stress among vegetable crop species. Brinjal showed higher level of tolerance to salinity. Okra-Bhendi showed the highest level tolerance to salinity. Genotypic variability in salinity tolerance at the seedling stage has been reported among tomato genotypes (Maiti et al., 2007b).

Thus, the study was carried out with the aim to quantify and compare the seedling growth responses of twelve vegetable crops to different levels of NaCl as an approach to findout genetic variability material and seedling criteria traits to salt stress tolerance

2. Materials and Methods

The present study was conducted at the Seed Physiology Laboratory, Vibha Agrotech Ltd., (VAL), Hyderabad, India, using different vegetable crop hybrids developed by VAL for tolerance to NaCl-salinity at the seedling stage. Different experiments were conducted with different vegetable crop species for salinity tolerance using a novel hydroponic technique. For screening different vegetable crops, the following technique was adopted: the technique consists of sowing the seeds at a depth of 2 cm in a plastic pot (length 85 mm, diameter 80 mm) filled with coco peat (neutral delignified coir fibres) and then applying water or required saline concentration up to two thirds of the pot (about 70 mm). Twenty seeds were sown in each pot in the upper coco peat layer at 2 cm depth which receive water/solution by capillarity. We apply the solution only one time, say water, or saline solution up to the termination of the experiment (14 days after emergence). To protect seeds from fungal attack, seeds were treated with thiram solution (5%, p/v) for 5 minutes before sowing. Seeds were sown in each pot under control (distilled water) along with 0.10 M NaCl or 0.15 M NaCl as per specific experiment. Each of the treatments was replicated thrice for all the hybrids. This technique simulates a semi-hydroponic system where the upper layers of coco peat medium receive water/or saline solution only by capillary movement, while the roots are immersed in saturated lower coco peat medium. During capillary movement there is free flow of oxygen owing to constant evapo-transpiration. Observations were taken by taking 14 days old seedlings. Data were taken on average emergence percentage, shoot length (cm), root length (cm) on 14th day. The same procedure and the same variables were taken in all the experiments. The main objective of the present study is to determine the efficacy of this new technique on different sets of vegetable crops for tolerance to NaCl-salinity. In the following figures are represented the response of okra genotypes for salinity tolerance at different concentrations of salinity with respect to different seedling parameters showing large variability among genotypes. Vegetable crop hybrids were grown in room temperature and artificial light was provided to maintain light up to 14 days. Room temperature was about 27^{o}C.

2.1. Statistical analyses

Data of the seedling traits were analysed statistically from each experiment. Data were statistically analyzed using one-way analysis of variance with a factorial arrangement being hybrids and NaCl concentrations the factors. Where the F-test was significant (p<0.05), differences were validated using the Tukey´s honestly significant difference. Assumptions of normality of data were tested using the Kolmogorov-Smirnov test (Steel and Torrie, 1980). All applied statistical methods were computed according to the SPSS® (Statistical Package for the Social Sciences) software package (standard released version 13.0 for Windows, SPSS Inc., Chicago, IL).

3. Results and Discussion

Results of this study have revealed that there were differences between vegetable crop species, NaCl concentrations and hybrids within NaCl concentration for studied seedling traits (Table 1 and 2). Under control conditions, emergence percentage ranged from 100 (Okra, Sponge gourd, Bitter gourd, Bottle

Table 1: Emergence percentage and emergence index in commercial hybrids of different vegetable crops evaluated upto 0.15 M NaCl using a semi-hydroponic technique

Sl. No.	Crop-Hybrid	Emergence (%)			Emergence index		
		Control	0.1 M NaCl	0.15 M NaCl	Control	0.1 M NaCl	0.15M NaCl
1	Okra-Sleek	100.00	100.00	80.00	50.51	37.43	20.87
2	Okra-Slender	100.00	100.00	60.00	63.89	42.26	18.36
3	Onion-Rosy	60.00	60.00	0.00	16.59	15.00	0.00
4	Sponge gourd	100.00	80.00	60.00	40.63	20.53	14.95
5	Carrot-Newkurowda	50.00	10.00	0.00	27.19	7.14	0.00
6	Bitter gourd-Roma	100.00	100.00	80.00	29.41	18.23	13.15
7	Ridge gourd	80.00	100.00	30.00	25.40	39.39	24.29
8	Bottle gourd-Reena	80.00	40.00	30.00	40.40	70.00	18.33
9	Bottle gourd-Elina	100.00	50.00	30.00	28.13	21.54	16.03
10	Sweet corn-Delite	35.00	35.00	25.00	35.42	41.43	31.67
11	Cucumber-Salad	100.00	100.00	100.00	38.13	43.56	24.39
12	Cucumber-Racy	85.00	65.00	60.00	44.17	30.30	26.33
13	Cucumber-Harmony	100.00	95.00	90.00	55.73	40.22	25.09
14	Water melon-Ria	90.00	65.00	40.00	28.75	20.73	20.28
15	Water melon-Candy	95.00	70.00	50.00	35.24	26.43	22.48
16	Water melon-Slice	95.00	90.00	85.00	41.83	28.50	24.24
17	Tomato-Angel	95.00	10.00	0.00	28.34	9.09	0.00
18	Tomato-Jewel	85.00	20.00	0.00	28.59	20.00	0.00
19	Tomato-Gem	80.00	0.00	0.00	27.89	0.00	0.00
20	Tomato-Euro	95.00	0.00	0.00	30.14	0.00	0.00
21	Chilli-Supreme	85.00	30.00	0.00	20.22	14.55	0.00
22	Chilli-Blaze	40.00	20.00	0.00	16.67	0.00	0.00
23	Chilli-Capsi	80.00	15.00	0.00	18.42	0.00	0.00
24	Chilli-Spicy	55.00	0.00	0.00	17.16	0.00	0.00
SEm±		5.23			3.12		
CD (p=0.05)		10.33			6.16		

Table 2: Shoot and root length in commercial hybrids of different vegetable crops evaluated upto 0.15 M NaCl using a semi-hydroponic technique

Sl. No.	Crop-Hybrid	Shoot length (cm)			Root length (cm)		
		Control	0.1 M NaCl	0.15M NaCl	Control	0.10 M NaCl	0.15M NaCl
1	Okra - Sleek	16.70	9.00	7.87	7.40	6.30	8.37
2	Okra - Slender	16.10	10.15	7.33	8.45	8.10	7.08
3	Onion - Rosy	5.10	4.50	0.00	6.00	4.00	0.00
4	Sponge gourd	16.05	13.00	10.38	11.75	8.50	10.94
5	Carrot - Newkurowda	3.00	2.00	0.00	2.88	1.50	0.00
6	Bitter Gourd - Roma	23.30	12.00	11.75	10.65	10.40	9.63
7	Ridge gourd	15.30	13.90	12.25	10.30	10.10	9.25
8	Bottle gourd - Reena	14.38	12.00	9.75	6.50	7.50	8.25
9	Bottle gourd - Elina	16.30	9.42	8.50	8.65	7.75	8.75
10	Sweet corn - Delite	8.42	8.21	7.58	15.92	15.25	18.25
11	Cucumber - Salad	17.20	13.40	10.80	3.50	4.40	5.30
12	Cucumber - Racy	13.20	10.80	9.60	4.40	4.80	5.50
13	Cucumber - Harmony	16.80	11.90	11.70	4.45	5.00	5.40
14	Water melon - Ria	21.30	14.00	14.80	6.10	6.95	8.12
15	Water melon - Candy	16.00	12.70	11.78	5.00	6.20	7.75
16	Water melon - Slice	21.90	17.40	15.50	5.90	9.60	7.10
17	Tomato - Angel	7.10	3.25	0.00	2.80	1.25	0.00
18	Tomato - Jewel	7.60	6.00	0.00	3.30	1.25	0.00
19	Tomato - Gem	8.60	0.00	0.00	2.55	0.00	0.00
20	Tomato - Euro	7.70	0.00	0.00	3.20	0.00	0.00
21	Chilli - Supreme	6.50	5.00	0.00	4.90	3.88	0.00
22	Chilli - Blaze	5.80	6.00	0.00	3.77	3.00	0.00
23	Chilli - Capsi	6.40	2.50	0.00	3.90	1.17	0.00
24	Chilli - Spicy	5.45	0.00	0.00	4.50	0.00	0.00
	SEm±	0.57			0.42		
	CD (p=0.05)	1.12			0.83		

gourd, and Cucumber) to 35 % (Sweet corn); at 0.10 M NaCl from 100 (Okra, Bitter gourd, Ridge gourd, and Cucumber) to 0% (Chilli and Tomato); at 0.15 M NaCl from 100 (Cucumber, salad hybrid)) to 0% (Onion, Tomato and Chilli). With respect to emergence index, under control conditions it ranged from 63.90 (Okra) to 16 (Onion and Chilli-Blaze); at 0.10 M NaCl from 70.0 (Bottle gourd - Reena) to 0 (Tomato and Chilli); at 0.15 M NaCl from 31.67 (Sweet corn) to 0 (Onion, Toamto

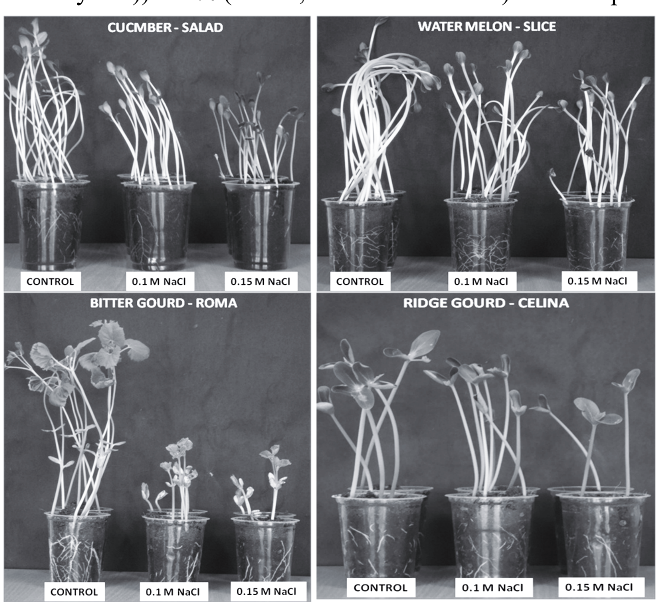

Plate 1: Seedling growth responses of Cucumber, Water melon, Bitter gourd and Ridge gourd to different NaCl concentrations

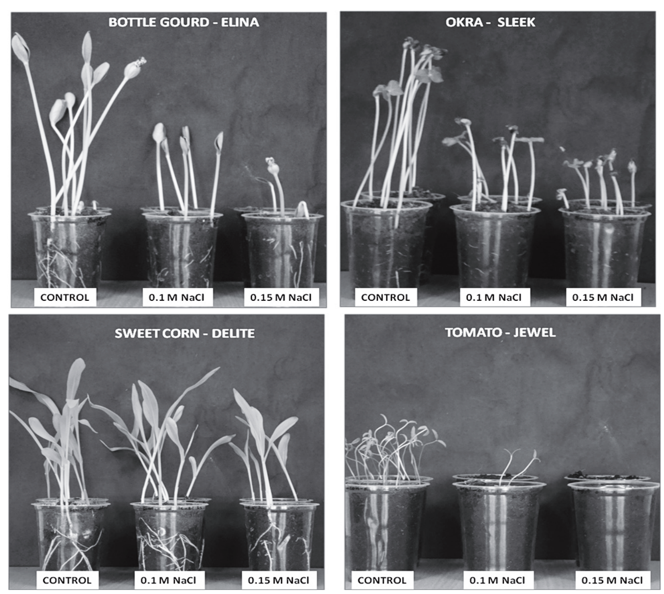

Plate 2: Seedling growth responses of Bottle Gourd, Okra, Sweet corn and Tomato to different NaCl concentrations

and Chilli). In regard to shoot length (Table 2), under control conditions it varied from 23.3 (Bitter gourd) to 3 cm (Carrot); at 0.10 M NaCl from 17.4 (Water melon - Slice) to 0 cm (Tomato and Chilli); at 0.15 M NaCl from 15.50 cm (Water melon - Slice) to 0 (Onion, Carrot, Tomato, and Chilli). Root length (cm) under control conditions ranged from 15.9 (Sweet corn) to 2.55 cm (Tomato - gem); at 0.10 NaCl from 15.2 cm (Sweet corn) to 0 (Tomato and Chilli); at 0.15 M NaCl from 18.25 cm (Sweet corn) to 0 (Onion, Carrot, Tomato, and Chilli). As a general trend, emergence percentage, emergence index shoot and root length among vegetable crop hybrids decreased by about 621, 67, 62 and 32%, respectively, between control and 0.15 M NaCl. Studied seedlings traits in Onion, Carrot, Tomato, and Chilli are more susceptible to high NaCl than the other vegetable crop species, which seem more tolerant to salinity, particularly, Okra, Gourd vegetable crop species and Cucumber. High NaCl concentration enhanced root length in Bottle gourd, Sweet corn, Cucumber and Water melon. Plate 1 and Plate 2 show the seedling growth responses of Cucumber, Water melon, Bitter gourd, Ridge gourd, Bottle gourd, Okra, Sweet corn and Tomato to different NaCl concentrations.

Results of these experiments have revealed that there is genetic variability among vegetable crop hybrids to be selected for crop improvement for salt tolerance during the early stages of crop growth and development. Results have also suggested that among studied seedling traits, emergence percentage, shoot and root length could be selected as salt stress criteria for concentration upto 0.15 M NaCl. In addition, among studied vegetable crop hybrids, it seems that the most promising genotypes to tolerate concentrations upto 0.15 M NaCl are the ones corresponding to Okra, Gourd hybrids, and Cucumber - Salad since they showed the lesser decrease with respect to their control counterparts. In contrast, the most susceptible hybrids to high salinity for studied seedlings traits are Onion, Carrot, Tomato and Chilli. Thus, for massive genetic screening selection, materials could be evaluated upto 0.15 M NaCl in order to identify sources of germplasm tolerant to salt stress.

The present study showed high genetic variability in salinity tolerance with respect to different seedling traits (emergence percentage, emergence index, shoot and root length. The evidences of the present study are in agreement with the results achieved by Giaveno et al. (2007) in screening tropical maize for salt tolerance. Genotypic variability has been reported by some authors (Nordquist et al., 1992; Maiti et al., 1996). In this study, increasing salinity decreased emergence percentage, shoot length, root length and seedling dry weight. These observations coincide with those of several authors (Alberico and Cramer, 1993; Rodriguez et al., 1997). Traits associated with seedling vigor, such as seedling weight and growth rate, and photochemical efficiency under stress conditions can be used as selection criteria among vegetable crops species in breeding programs (Giaveno et al., 2007). It is observed that a large variability exists among studied vegetable crops to different levels of salinity with respect to emergence and seedling growth. Similar findings were observed by different studies (Cruci et al., 1994; Kowalski et al., 1995; Maiti et al., 2004; 2007a, b; Pascale and Barbieri, 1995; Shanon and Grieve, 1999; Sharma et al., 2001). Tomato and Chilli were found to be susceptible to salinity. Maiti et al. (2007b) reported variability in tomato hybrids in tolerance to salinity and selected some hybrids moderately tolerant to salinity.

4. Conclusion

On the basis of results the following vegetables crop species were selected showing tolerance to moderate level of NaCl-salinity. The two hybrids of okra genotypes can tolerate up to 0.15 M NaCl, among these two verities – Sleek is the best. Onion can tolerate up to 0.1 M NaCl. Water melon can tolerate up to 0.15 M NaCl. Among the three water melon varieties Slice is the best followed by Candy. Bitter gourd can tolerate up to 0.15 M NaCl. Bottle gourd can tolerate up to 0.1 M NaCl. Cucumber varieties showing increased root length under saline conditions for osmotic adjustment. Among three varieties of cucumber Salad is the best followed by Harmony. Among all the crops gourds are tolerant to salinity. These vegetable crops can grow under saline areas and brackish water regions

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