International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(2): 2364-2367

Received: 13-01-2020
Accepted: 15-02-2020

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In vitro evaluation of tomato (*Lycopersicon esculentum* Mill.), chilli (*Capsicum annum* L.), cucumber (*Cucumis sativus* L.) and Bhendi (*Abelmoschus esculentus* L.) for salinity stress

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DOI: https://doi.org/10.22271/chemi.2020.v8.i2aj.9104

Abstract
Salinity is one of the most important abiotic stresses limiting yield potential. Salinity is even more harmful to seed germination and seedling development. The present study aimed to evaluate the effect of the salinity on germination and seedling growth in four different vegetable crops *viz.*, tomato, chilli, cucumber and bhendi. In this study, germination percentage (%), shoot length (cm), root length (cm), root to shoot ratio, fresh and dry weight (g) were recorded at four different salinity levels (50 mM, 100 mM, 150 mM and 200 mM NaCl) and one control (0 mM NaCl). Significant differences were observed in all the traits in all crops in this study. Based on the germination percentage, by comparing the four crops, cucumber had the highest tolerance to the salinity which was followed by bhendi. The crops of tomato and chilli were more sensitive to salinity.

Keywords: Salinity, seed germination, saline tolerance, tomato, chilli, cucumber, bhendi

Introduction

Salt affected areas worldwide are predicted to continue expanding at a rate of ~10 % per year due to low precipitation, high surface evaporation, erosion of rocks, irrigation with saline water and poor agricultural practices (Foolad, 2004) [1]. High salinity is one of the major abiotic stress to the crops. Salinity retards the ability of the plant to absorb water due to reduced water potential in the root zone. As a result, salt stress affects the growth and development of plants, thus reducing their yield (Arzani and Ashraf, 2016) [2]. Salinity disturbs crop establishment by decreasing the germination percentage and delaying seedling emergence (Begum *et al.*, 1996, Siddiky *et al.*, 2014) [3, 4]. Salinity affects plant growth by disturbing water balance, creating an imbalance in plant nutrition and affecting plant physiological and biochemical process (Yeo *et al.*, 1985, Karim *et al.*, 1993) [5, 6].

To increase productivity, there is a need to produce salt-tolerant crops which can grow successfully on salt affected lands. To develop salt tolerant crops, it is important to know the salinity tolerant mechanisms which help the breeder in the selection of parents for breeding programs.

Plant species differ greatly in their response to salinity (Dasgan *et al.*, 2002) [7]. To observe how crops are reacting to different salinity levels, four horticulturally important crops were taken to this study *viz.*, tomato, chilli, cucumber and bhendi. Vegetables are playing a major role in human nutrition. Keeping these points in view, the present investigation was undertaken to study the response of vegetable crops to increase salinity levels during the germination and seedling emergence.

Materials and Methods

The experiment was conducted at the Genetics and Plant Breeding Laboratory, Department of Crop Improvement, Dhanalakshmi Srinivasan Agriculture College, Perambalur during 2020. The crops *viz.*, tomato (*Lycopersicon esculentum* Mill.), chilli (*Capsicum annum* L.), cucumber (*Cucumis sativus* L.) and bhendi (*Abelmoschus esculentus* L.) were evaluated by employing germination test in an osmotic solution of NaCl (Sodium Chloride). The germination paper was moistened with distilled water (Control- T_0) and various NaCl concentrations (T_1-50mM, T_2-100mM, T_3-150mM and $T_4$200mm) and placed in the petri dish. Ten seeds of each crop were placed in a petri dish, ensuring that the seeds do not touch each other. At 14 DAS (Days After Sowing) data were recorded on germination percentage, shoot length (cm), root length (cm), root to shoot ratio, fresh and dry weight (g) at four different levels of treatment and control. This experiment was laid in a completely randomized design with two replications.

Results and Discussion

Effect of salinity in germination percentage (%)

Germination percentage was negatively influenced by the salinity treatments. When salinity increased, the germination percentage was decreased in all four crops. But the four crops showed different germination percentage in different levels of treatment. In tomato, control (T_0) was recorded with 100 % germination percentage and then it was reduced gradually to 95 % (T_1) and 80 % in T_2. After that, a sudden decline was observed in T_3 (40 %). However, there was no germination in T_4. The germination percentage of tomato was highly influenced by salt stress (Devi & Arumugam, 2019; Kumar *et al*., 2017) [8, 9]. When the salinity concentration increases, the NaCl makes water unavailable to seeds, affecting the imbibition process of the seed germination.

The chilli recorded 100 % germination in control (T_0) and 90 % in T_1. A sharp fall was recorded in T_2 (35 %). There was no germination in T_4 as like tomato. In cucumber, there was 100 % germination in T_0 and T_1. A slight decrease in germination percentage was observed in cucumber when salinity increase. At maximum decline was observed in T_4 (75 %). Increased salt concentration showed negative effects on germination percentage of cucumber (Marium *et al*., 2019) [10]. As like as cucumber, bhendi also recorded 100 % germination in T_0 and T_1. But in T_4 a sudden decline is observed which was 25 %. Increasing salt concentrations significantly affected the germination percentage in bhendi (Haq *et al*., 2012) [11].

Effect of salinity in shoot length (cm)

Shoot lengths were reduced with increasing NaCl concentration in all crops in this experiment except chilli. Maximum shoot length was observed 7.7 cm (T_0) and the minimum was 2.85 cm (T_3) in tomato. Similar results reported by (Devi & Arumugam, 2019) [8]. In chilli, highest shoot length was recorded in T_2 (4.03 cm) and the lowest was in T_3 (1.12 cm). In T_0, the shoot length was 3.49 cm and there was a gradual increase in shoot length up to 4.03 cm in T_2. After that, a sudden decline was observed in T_3 (1.12 cm).

In cucumber, the maximum shoot length was observed in T_0 (13.15 cm) and the minimum was in T_4 (3.76 cm). In bhendi also similar pattern was observed. The maximum shoot length was in T_0 (11.88 cm) and the minimum was in T_4 (1.13 cm). Similar results were reported in cucumber (Marium *et al*., 2019) [10] and bhendi (Abbas *et al*., 2014; Haq *et al*., 2012) [12, 11].

Effect of salinity in root length (cm)

In root length, a slight increase was observed in tomato, chilli and cucumber when the salinity level was increased. In tomato, the root length in T_0 was 8.44 cm and it was increased to 9.12 cm in T_2. In chilli also, the root length was recorded 3.36 cm in T_0 and 3.69 cm in T_1. Likewise, in cucumber recorded root length was 9.56 cm in T_0 and 12.18 cm in T_2. When there is non-availability of enough water to plants, the plant tends to develop better root structure for more water uptake to survive. May this be the reason behind the root length increase when the salinity level was increased.

However, bhendi showed a decrease in root length to increase in salinity treatment. It was recorded 9.07 cm in T_0 and 1.01 cm in T_4. Abbas *et al*. (2014) [12] reported a significant reduction in the seedling root length under salt stress.

Effect of salinity in root to shoot ratio

In this experiment, all the crops except chilli increase in root to shoot ratio were observed with increase in salinity level. Similar results reported in tomato (Seth, 2018; Seth & Kendurkar, 2015) [13, 14]. The shoot growth was reduced due to salinity induced water deficit so a greater proportion of plants assimilates can be allocated to the root system which supports its growth hence the ratio of root to shoot growth increases (Taiz and Zeiger, 2010, Maggio *et al*., 2007 and Parida and Das, 2005).

Effect of salinity in fresh and dry weight (g)

A gradual reduction in fresh and dry weight (g) was recorded irrespective of crops. Similar results reported in tomato (Kumar *et al*., 2017; Seth, 2018) [9, 13], in chilli (Kabir Howlader *et al*., 2018) [18] and in bhendi (Abbas *et al*., 2014) [12].

Table 1: Effect of different concentration of NaCl (control, 50mM, 100mM, 150mM and 200mM) on tomato (*Lycopesicon esculentum* Mill.).

S. No.	Treatment	Germination Percentage (%)	Shoot Length (cm)	Root Length (cm)	Root:Shoot ratio	Fresh weight (g)	Dry Weight (g)
1	T_0	100.00	7.70	8.44	1.10	0.0788	0.007164
2	T_1	95.00	7.42	8.97	1.21	0.0766	0.006964
3	T_2	80.00	6.05	9.11	1.51	0.0589	0.005355
4	T_3	40.00	2.85	4.80	1.68	0.0195	0.001773
5	T_4	0.00	0.00	0.00	0.00	0.0000	0.000000

Table 2: Effect of different concentration of NaCl (control, 50mM, 100mM, 150mM and 200mM) on chilli (*Capsicum annum* L.).

S. No.	Treatment	Germination Percentage (%)	Shoot Length (cm)	Root Length (cm)	Root:Shoot ratio	Fresh weight (g)	Dry Weight (g)
1	T_0	100.00	3.49	3.37	0.96	0.0610	0.005545
2	T_1	90.00	4.02	3.69	0.92	0.0472	0.004286
3	T_2	35.00	4.03	3.35	0.83	0.0502	0.004568
4	T_3	30.00	1.12	0.83	0.74	0.0100	0.000909
5	T_4	0.00	0.00	0.00	0	0.0000	0.000000

Table 3: Effect of different concentration of NaCl (control, 50mM, 100mM, 150mM and 200mM) on cucumber (*Cucumis sativus* L.).

S. No.	Treatment	Germination Percentage (%)	Shoot Length (cm)	Root Length (cm)	Root:Shoot ratio	Fresh weight (g)	Dry Weight (g)
1	T_0	100.00	13.15	9.56	0.73	0.7584	0.068945
2	T_1	100.00	13.01	10.77	0.83	0.6136	0.055782
3	T_2	95.00	12.06	12.18	1.01	0.4708	0.042800
4	T_3	95.00	8.07	7.93	0.98	0.3849	0.034991
5	T_4	75.00	3.76	3.92	1.04	0.1445	0.013136

Table 4: Effect of different concentration of NaCl (control, 50mM, 100mM, 150mM and 200mM) on bhendi (*Abelmoschus esculentus* L.).

S. No.	Treatment	Germination Percentage (%)	Shoot Length (cm)	Root Length (cm)	Root:Shoot ratio	Fresh weight (g)	Dry Weight (g)
1	T_0	100.00	11.88	9.07	0.76	0.5596	0.050873
2	T_1	100.00	10.10	7.63	0.76	0.4222	0.038382
3	T_2	90.00	5.55	6.70	1.21	0.2615	0.023773
4	T_3	80.00	2.24	1.73	0.77	0.2081	0.018918
5	T_4	25.00	1.13	1.02	0.90	0.1245	0.011318

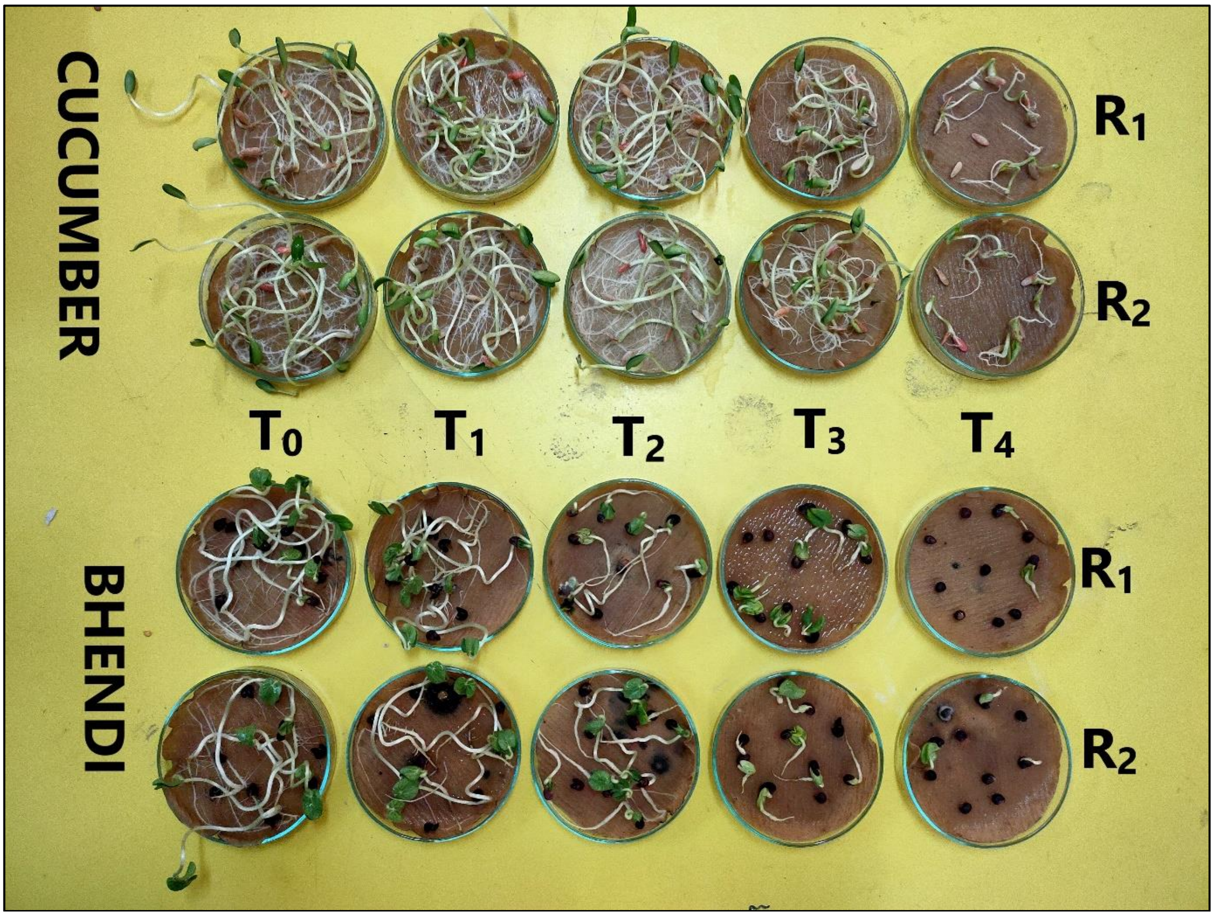

Plate 1: Effect of different concentration of NaCl (control, 50mM, 100mM, 150mM and 200mM) on cucumber (*Cucumis sativus* L.) and bhendi (*Abelmoschus esculentus* L.).

Conclusion

On the whole, by comparing the four crops, cucumber had the highest tolerance to the salinity based on the germination percentage in T_4 (75 %) which is followed by bhendi 25 % in T_4. There is no germination in tomato and chilli in T_4. These crops were more sensitive to salinity when compared to cucumber and bhendi.

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