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EFFECT OF SODIUM CHLORIDE SALINITY ON SEED GERMINATION AND EARLY SEEDLING GROWTH OF *TRIGONELLA FOENUM-GRAECUM* L. VAR. PEB

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Abstract: *Triginella foenum-graecum*, is commonly known as methi or fenugreek. It is a cool season crop, cultivated for its leaves and seeds. Salinity exists naturally in arid and semiarid regions of the world. Under saline conditions, crop yield is reduced hampering agricultural productivity. The effect of different salinity levels on germination and early seedling growth of *Triginella foenum-graecum* were studied. Seeds were placed for germination and the seedlings were allowed to grow for seven days at different levels of NaCl salinity (0mM to 100mM). Though the lower concentrations of NaCl (upto 40mM) did not affect percentage germination, the germination was found to be delayed. At higher salinity levels, inhibitory effect on germination was recorded to an extent that seeds did not germinate at 80mM and above concentrations of NaCl. Gradual decrease in root length, shoot length, fresh weight and dry weight of the seedlings was observed with increasing concentrations of NaCl in the growth medium.

Keywords: Germination; NaCl; Salinity; *Triginella foenum-graecum*.

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INTRODUCTION

Addition of salts to water lowers its osmotic potential, resulting in decreased availability of water to root cells (Sairam *et al*., 2002). High salt concentration hampers vital processes such as seed germination, seedling growth and vigour, vegetative growth, flowering as well as fruit set. This ultimately reduces crop yield and quality of the produce (Sairam and Tyagi, 2004). Excessive salts are found in agricultural lands of arid and semiarid regions of the world (Madidi *et al*., 2004). The salts restrict the plant growth and hence salt stress has become an ever increasing threat to agriculture (Zhu, 2007; Pattanagul and Thitisaksakul, 2008). Salinity results in delayed germination, high rate of seedling mortality, stunted growth and reduced yield (Muhammad and Hussain, 2010). According to Omami (2005), the percentage germination and rate of germination of crop seeds are very important agronomically. In semiarid regions, where favourable conditions are brief, reduced rate of seed germination due to salinity can create critical conditions. According to her, one of the important agronomic aspects of crop establishment is the rate at which maximum seeds germinate and establish themselves during the limited period when environmental conditions are suitable.

According to Somani (2007), seed germination and seedling growth is a critical phase as the ability of a crop plant to germinate and establish seedlings frequently becomes a limiting factor in crop production. There are many reports which indicate that seeds of most plants attain their maximum germination in distilled water and are very sensitive to elevated levels of salinity at the germination and

seedling phases of development (Zehtab-Salmasi, 2008; Devkota and Zha, 2010; Al-Taisan, 2010). The effects of salinity on a plant may vary depending on the stage of its development. Soil salinity affects various physiological and biochemical processes which result in reduced biomass production. This adverse effect of salt stress appears on the entire plant at almost every stage of growth including germination, seedling development, vegetative and reproductive stages. However, tolerance to salt stress at every stage varies from species to species (Nawaz *et al*., 2010). Excessive salinity reduces productivity of many crops including most vegetables (Pena and Hughes, 2007). Vegetables are generally considered sensitive to soil salinity and alkalinity (Sharma *et al*., 2001). In the present investigation effect of varying concentrations of sodium chloride (NaCl) on preliminary parameters of *Trigonella foenum-graecum* L. var. PEB, a leafy vegetable has been studied.

EXPERIMENTAL

Seeds of *Trigonella foenum-graecum* L. var. PEB were obtained from the Indian Agricultural Research Institute, Pusa (New Delhi).

Percentage germination: Morphologically uniform, ten healthy seeds of *Trigonella foenum-graecum* were soaked and allowed to germinate in petriplates (110 mm diameter, 9 mm height) lined with filter paper. In one set of petriplates, filter papers were moistened with tap water (5 ml). This set served as control. Other sets were prepared where varying concentrations of sodium chloride (NaCl) ranging from 10 mM, 20 mM, till 100 mM (5 ml each) were used for moistening the filter papers. Five replicates were prepared for each treatment with ten seeds per petriplate. Moistening of filter paper was done every alternate day or as per the requirement depending on the surrounding environmental conditions. The seeds were considered germinated only with the emergence of the radicle. The germination percentage was calculated after seven days.

Growth of the seedlings: The effect of varying NaCl concentrations on the morphological characters such as root length, shoot length, root/shoot ratio and on fresh weight and dry weight was studied on seedlings grown for seven days. For this, small plastic cups of 6.7 cm diameter, 12 cm height were filled with sand: vermiculite mixtures in the ratio of 3:1. Morphologically uniform, ten healthy seeds of *Trigonella foenum-graecum* were allowed to germinate in plastic cups. Watering was done every day or sometimes twice a day as per the requirement. In the control set the seeds were watered with half strength Arnon and Hoagland's (1940) nutrient medium without NaCl. Similarly prepared experimental sets were treated with solutions of varying concentrations of NaCl ranging from 10 mM, 20 mM, till 100 mM prepared in half strength Arnon and Hoagland's (1940) nutrient medium. Root length and the shoot length were measured on the seventh day. For fresh and dry weight measurements, the seedlings were uprooted carefully from the seed medium. The sand particles sticking to the roots were removed carefully without disturbing the roots. Each seedling was weighed separately for fresh weight. For dry weight, these seedlings were dried at 80ºC till the constant weight was obtained. F test was used to test for the statistical significance and Student's *t*-test was use to compare the treatment means.

RESULTS AND DISCUSSION

Percentage germination: Germination represents a dynamic phase in the life cycle of plants as the seed makes the transition from a metabolically quiescent to an active and growing entity. Seed is one of the important organs of a plant which plays a crucial role in the continuation of the race. The sequence of germination follows simple events such as imbibition of water, enzyme activation, hydrolysis of stored material, initiation of growth, rupture of seed coat and emergence of the seedling. Gradual decrease in the seed germination percentage has been observed in *Trigonella foenum-graecum* with increase in salt concentrations in the surrounding medium. Although, there was no delay in the process of germination at lower concentrations of NaCl (up to 40 mM), higher concentrations of NaCl were found to delay the process of germination in *Trigonella foenum-graecum* (Table 1). According to Zekri (1993), salinity adversely affects germination by decreasing the osmotic potential of the soil solution to such a point that it retards or prevents the intake of water. Salinity may even produce toxic effects on the

embryo and the seedlings which results in delayed germination and or reduced percentage germination, which may be true even in the present study. In the present investigation, it was observed that the higher concentrations of NaCl (80 mM onwards) completely retarded the process of germination. According to Huang and Redman (1995), salt induced inhibition of seed germination could be attributed to osmotic stress or specific ion toxicity. Seed germination is an essential developmental event in plants (Kim and Park, 2008). It is an important growth stage often subjected to high mortality rates (Jamil *et al*., 2007; Asaadi, 2009). According to Begum *et al*. (2010), germination of seed depends on the utilization of reserved food material of the seed. Salinity interferes with the process of water absorption by the seeds. This subsequently inhibits the hydrolysis of seed reserves which ultimately delays and decreases seed germination. In the present investigation, varying NaCl concentrations have been observed to reduce the percentage germination in selected leafy vegetable. The process of germination was also observed to be delayed under NaCl salinity. This trend of decrease in percentage germination with increasing quantity of salt can be attributed to salinity. This may be due to the fact that the increased amounts of NaCl, disturbed the ionic balance of plant cells and also caused imbalances in plant nutrients, which must have affected the germination percentage.

Table 1: Effect of varying concentrations of NaCl on seed germination percentage in *Trigonella foenum-graecum* L. var. PEB

S. No.	NaCl Conc.	Day1	Day2	Day3	Day4	Day5	Day6	Day7
01	0 mM (Control)	66 ± 4.89	98 ± 4.00	100 ± 0.00	100 ± 0.00	100 ± 0.00	100 ± 0.00	100 ± 0.00
02	10 mM	58 ± 4.00	90 ± 7.74	92 ± 6.00	100 ± 0.00	100 ± 0.00	100 ± 0.00	100 ± 0.00
03	20 mM	34 ± 4.89	60 ± 8.94	86 ± 4.89	98 ± 4.00	100 ± 0.00	100 ± 0.00	100 ± 0.00
04	30 mM	14 ± 4.89	44 ± 4.89	72 ± 7.48	96 ± 4.89	96 ± 4.89	100 ± 0.00	100 ± 0.00
05	40 mM	14 ± 4.89	38 ± 7.48	54 ± 4.89	70 ± 6.32	94 ± 5.29	98 ± 4.00	100 ± 0.00
06	50 mM	---	14 ± 4.89	24 ± 4.47	36 ± 4.89	48 ± 4.00	58 ± 4. 00	58 ± 9.79 #
07	60 mM	---	---	---	14 ± 4.89	26 ± 4.89	38 ± 4.00	40 ± 6.32 #
08	70 mM	---	---	---	---	06 ± 3.09	08 ± 1.78	12 ± 5.21 #
09	80 mM	---	---	---	---	---	---	---
10	90 mM	---	---	---	---	---	---	---
11	100 mM	---	---	---	---	---	---	---

Results are the mean of three determinants.

Two-way ANOVA was carried out and it was observed that F ratio for treatment as well as days was significant at 5% level of significance.

Significant at $p < 0.05$ (*t*-test was carried out to test whether there is significant difference between control and individual salt concentration).

Root length, shoot length and root/shoot ratio: Root length and the shoot length are the most important parameters for studying salt stress as roots are in direct contact with soil. They absorb water from soil which is translocated through shoots to the rest of the plant (Assadi, 2009). Root plays an important role in the growth of the shoot under saline conditions as it is the first organ exposed to salinity (Lopez and Satti, 1996). Table 2 depict that in *Trigonella foenum-graecum*, the root length as well as the shoot length decreased with increasing levels of salt. Similar findings are recorded by Assadi (2009) in *Trigonella foenum-graecum*. Jaleel *et al*. (2008) also reported a decrease in root length in *Catharanthus roseus* under salinity. Such a decrease in root length and stem length may be due to NaCl toxicity and disproportion in nutrient absorption by the seedlings, as suggested by Bybordi and Tabatabaei (2009). Similarly, Nyagah and Musyimi (2009) observed a reduction in growth in passion fruit seedlings with increasing concentrations of salt in the medium. In the present study, almost 50% reduction as compared to control in shoot length was observed at 10 mM NaCl concentration, which gradually decreased further with increasing NaCl in the medium. Bijeh keshavarzi *et al*. (2011) suggested that, salinity leads to reduced water uptake which interferes with cell division and differentiation, thereby affecting the root length and shoot length. In *Trigonella foenum-graecum* the root/shoot ratio was found to be higher than control upto 60 mM NaCl concentration (Table 2) thereafter

it decreased but remained close to the value of control. The root lengths as well as shoot lengths were adversely affected with salinity, however, the shoots were found to be more affected as compared to roots leading to increased root/shoot ratio. Similarly, Turan *et al*. (2010) reported that in maize, shoot growth was much more affected than root growth under saline conditions. According to Jamil *et al*. (2006), shoots are more sensitive and get hampered with salinity in the environment.

Table 2: Effect of varying concentrations of NaCl on root length, shoot length, root/shoot ratio, total length, fresh weight and dry weight of *Trigonella foenum-graecum* L. var. PEB seedlings

Sr. No.	NaCl Conc.	Root Length (cm) *	Shoot Length (cm) *	Root/ Shoot Ratio	Total Length (cm)	Fresh Weight (g) •	Dry Weight (g) *
01	0 mM (Control)	2.39 ± 0.13 #	4.23 ± 0.22 #	0.566	6.68 ± 0.324 #	0.0660 ± 0.0012	0.0067 ± 0.0001
02	10 mM	1.45 ± 0.03 #	2.22 ± 0.18 #	0.650	3.94 ± 0.326 #	0.0615 ± 0.0021	0.0053 ± 0.0003
03	20 mM	1.64 ± 0.10 #	2.49 ± 0.19 #	0.703	3.86 ± 0.265 #	0.0546 ± 0.0026	0.0048 ± 0.0003
04	30 mM	1.20 ± 0.14 #	1.72 ± 0.10 #	0.616	3.12 ± 0.300 #	0.0585 ± 0.0035	0.0039 ± 0.0001 #
05	40 mM	1.21 ± 0.09 #	1.32 ± 0.17 #	0.943	2.53 ± 0.268 #	0.0419 ± 0.0024	0.0036 ± 0.0002 #
06	50 mM	1.11 ± 0.05 #	1.20 ± 0.14 #	0.945	2.31 ± 0.248 #	0.0250 ± 0.0005	0.0016 ± 0.0002 #
07	60 mM	0.96 ± 0.02 #	1.18 ± 0.13 #	0.844	2.34 ± 0.407 #	0.0134 ± 0.0014	0.0008 ± 0.0000 #
08	70 mM	0.40 ± 0.06 #	1.06 ± 0.24 #	0.532	1.46 ± 0.260 #	0.0076 ± 0.0016	0.0006 ± 0.0000 #
09	80 mM	---	---	---	---	---	---
10	90 mM	---	---	---	---	---	---
11	100 mM	---	---	---	---	---	---

Results are the mean of three determinants.

* One-way ANOVA was carried out and the F ratio was significant at 5% level of significance.

Significant at $p < 0.05$ (*t*-test was carried out to test whether there is significant difference between control and individual salt concentration).

Total length of seedlings: The length of the seedling is considered as a useful criterion to understand the effect of salinity at seedling establishment stage. Turkyilmaz *et al*. (2011) while working on barley suggested that seedling length is a very sensitive trait related to salinity. In *Trigonella foenum-graecum*, there is almost 60 percent reduction in the length of seedling at 10 mM NaCl concentration as compared to control (Table 2). As the root length and shoot length have reduced significantly with increasing salinity, length of the seedling was also observed to decrease. According to Nawaz *et al*. (2010), salt stress reduces the ability of plants to absorb water which leads to reduction in growth. However, Heidari *et al*. (2011), on the basis of their experiments on *Helianthus annuus* suggested that reduction in plant growth is due to decreasing turgor pressure in the cells under saline environment.

Fresh weight and dry weight of the seedlings: Table 2 depicts a decrease in the fresh as well as dry weight of seven day old seedlings of *Trigonella foenum-graecum*. According to Mahmood and Athar (2003), as salt concentration increases in the medium, plants absorb lesser water causing physiological desiccation. This type of restriction of water absorption may be responsible for decrease in fresh weight. Abass and Latif (2005) also recorded a decrease in fresh weight and dry weight of jute seedlings under NaCl stress. A decrease in the fresh weight of *Pisum sativum* under NaCl salinity has been observed by Okcu *et al*. (2005). They have attributed such a decrease, to the presence of NaCl which decreases water potential thereby reducing fresh weight remarkably. According to Atak *et al*. (2006), reduction in dry weight is relatively dependent on the decrease in shoot length and root length. Dadkhah and Grrifiths (2006) attributed such a decrease in dry weight to greater reduction in uptake and utilization of mineral nutrients by plants under salt stress. In general, there is a decrease in dry weight of plants under saline conditions which can be attributed to reduced rate of photosynthesis, as suggested by Jafari *et al*. (2009). Turan *et al*. (2009) recorded a decrease in dry weight in maize plants. They observed that the growth of plant is inhibited under saline conditions which lead to corresponding decrease in biomass production. Cha-Um and Kirdmanee (2009) observed a decrease in fresh weight as well as dry weight in maize seedlings under NaCl salinity. According to them, salinity leads to water

deficit in plants thereby causing a decrease in fresh weight and dry weight, which may be true even in the present study.

CONCLUSION

On the basis of present study it can be concluded that *Trigonella foenum-graecum* is sensitive to NaCl salinity. Increasing concentration of NaCl in the growth medium adversely affected the percentage germination, delayed the process of germination. Salinity also adversely affected growth as there was decrease in root length, shoot length, fresh weight and dry weight of the seedlings.

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CONFLICT OF INTEREST: Nothing