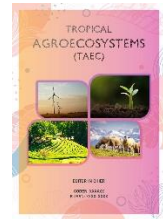


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RESEARCH ARTICLE

APPRAISEMENT OF SALINITY STRESS ON GERMINATION AND SEEDLING DEVELOPMENT OF OKRA (*Abelmoschus Esculentus* L.)Md. Morshedul Islam^a, Akhinur Shila^b, Pijush Kanti Jhan^a, Mehede Hassan Rubel^a, Kawsar Hossen^a, Md. Mostakim Billah Fahim^a, Rayhan Ahmed^{a*}^aDepartment of Agriculture, Noakhali Science and Technology University, Noakhali-3814, Bangladesh.^bDepartment of Agricultural Botany, Patuakhali Science and Technology University, Patuakhali-8602, Bangladesh.*Corresponding Author Email: rayhan.rimon@gmail.com

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ARTICLE DETAILS

ABSTRACT

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Salt stress is one of the most common abiotic factors which has a trouble impression on the seed germination and establishment of crops. A laboratory based incubation experiment was executed at the department of Agriculture, Noakhali Science and Technology University during the period from January to February 2019 to investigate the salt stress effects on germination and seedling development of okra. The experiment comprises on okra variety named 'Green Finger F1'. There were eight treatments viz. T₀ (0 mM NaCl), T₁ (20 mM NaCl), T₂ (50 mM NaCl), T₃ (100 mM NaCl), T₄ (150 mM NaCl), T₅ (200 mM NaCl), T₆ (250 mM NaCl) and T₇ (300 mM NaCl) and the experiment was designed at Completely Randomized Design (CRD) with three replications. Different parameters like germination percentage, speed of germination, seedling height, shoot elongation rate, shoot fresh and dry weight, root length, root fresh and dry weight and finally vigor index were compared among the all treatments. From the findings of this research trial, it can be extracted that the treatments T₀ to T₂ okra performed well as compare to the other treatments. So this study clearly indicated that the okra could be a promising crop for coastal areas and lead to improvements in agricultural production where mild saline condition present. However, it will not grow well under a high saline condition.

KEYWORDS

Okra, Salt stress, Germination percentage, Seedling growth, Vigor index.

1. INTRODUCTION

Crop plants are usually affected by different abiotic stresses which limits their vegetative and reproductive growth and development. Among these various stresses, salinity is the most severe one (Gao et al., 2013). It is a major environmental constraint to crop productivity in different regions, especially in arid and semi-arid regions of the world (Carpici et al., 2009). About 800 million hectares of land in the world are affected by salinity and sodicity (Khodarahmpour et al., 2012; Oyiga et al., 2018). The United Nations Environment Program (UNEP) identified that 20% of the agricultural land and 50% of the cropland in the world is seriously affected by salinity problems (Arvind, 2017). In Bangladesh, there are approximately 2.85 million hectares of coastal land of which about one million ha are salt-stressed (SRDI, 2010; Howlader et al., 2018; Ahmed et al., 2017). It has drastic effects on almost all development stages during the plant life-cycle, including seed germination, seedling establishment and development, vegetative and reproductive growth, and crop survival and yield (Shu et al., 2017). The major adverse effects of salt stress on plant growth and development has been imposed to osmotic inhibition of water availability as well as the toxic effect of salt ions responsible for salinization (Sardoei and Mohammadi, 2014). Such ions are responsible for nutritional imbalance which leads to reduction in photosynthetic efficiency and physiological disorders of crop plants (Hakim et al., 2010). Due to the salinity problem, approximately 30-50% of net cropped areas in the coastal region of Bangladesh remains fallow in Rabi season (Howlader et al., 2018). The salinity problem increases in March-April (dry months) and decreases in July-August (wet months) (Mahmud et al.,

2016).

In this research, we observed the impact of salinity on germination, growth and development of okra plant. Okra (*Abelmoschus esculentus* L.) is one of the most popular vegetable crop that grown throughout the tropics and subtropics of the world. It is a plant which belongs to the genus *Abelmoschus*, family Malvaceae. The vegetables of okra is mainly grown for its young immature fruits and consumed as a raw, cooked or fried (Molik et al., 2016; Bawa and Badrie, 2016). It is a very good source of dietary fiber, magnesium, manganese, potassium, vitamin K, vitamin C, folate, B1, and B6 (Bawa and Badrie, 2016). Okra production in the coastal areas of our country became low due to salt stress problem. In okra, salinity causes multifarious drastic effects in leaf growth, photosynthesis, mineral nutrition, stomatal conductance, transpiration, water and ion transport and increases sugars, amino acids and different ions along with severe effects on yield and quality (Abbas et al., 2014). So, okra can't survive under high ratio of toxic salts. Thus, salinity stress has been found one of the most adverse factors that limiting or inhibiting plant growth and development, delaying seed germination and finally germination percentage (Howlader et al., 2018) and productivity of okra crops. Hence, it is very important to know what extent of salinity level okra can tolerate at germination and early growth. Therefore, this research investigated to find out the impact of different level of NaCl treatments on germination and seedling development of okra and the results could lead to improvements in agricultural production worldwide, especially on saline land.

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2. MATERIALS AND METHODS

The experiment was carried out during the period from January to February, 2019 at the laboratory of the department of Agriculture, Noakhali Science and Technology University, Noakhali, Bangladesh. Only one okra genotype was used in this experiment. The name of this genotype is 'Green Finger F1'. This variety is famous for cultivation southern coastal regions of Bangladesh. Seven different salinity concentrations were used as treatment in this experiment. The treatments were 0 mM, 20 mM, 50 mM, 100 mM, 150 mM, 200 mM, 250 mM and 300 mM NaCl concentrations. The experiment was laid out in Completely Randomized Design (CRD) with three replications and conducted in plastic petri dishes of 12 cm diameter. Twenty seeds were placed on thin layer cotton bed in a spherical pattern. 10 ml of each treatment solutions was poured in each plastic petri dish. The plastic petri dishes were placed on a table in the laboratory and seeds were allowed to germinate at room temperature.

When the size of the radicles was 2 mm then it was considered that this seeds had germinated. Data was collected on germination percentage, speed of germination, seedling height, shoot elongation rate, root length, fresh and dry weight of shoot and root and finally vigor index. The number of seeds germinated was recorded starting from 2 days after sowing (DAS) to 10 DAS. The results obtained in each day were converted into percentage. Germination percentage was determined by the following formula:

$$\text{Germination Percentage (GP)} = \frac{\text{No. of germinated seeds}}{\text{Total no. of seed}} \times 100$$

Shoot length data was recorded at 9, 11, 13 and 15 DAS and root length data was recorded at 15 DAS. Shoot elongation rate was observed at 9, 11, 13, 15 DAS. Shoot elongation rate was calculated with the following formula:

$$\text{Shoot elongation rate (mm/day)} = \frac{\text{Shoot length at specific date}}{\text{Number of days at that specific date first}} \times 10$$

Vigor index (VI) was calculated by following formula as given by Abdul and Anderson (1970):

$$\text{Vigor index (VI)} = \frac{\text{Germination \%} \times (\text{Root length in cm} + \text{Shoot length in cm})}{100}$$

Speed of germination (SG %) was calculated by the following formula, as given by Ellis and Roberts (1981).

$$\% \text{ SG} = \frac{\text{Number of germinated seeds}}{\text{Days of first count}} + \frac{\text{Number of germinated seeds}}{\text{Days of final count}}$$

The recorded data were statistically analyzed following F-test and the mean comparisons were carried out at 0.05 probability level. Post-hoc analysis (Tukey HSD test) was used to determine which specific groups significantly differed from each other by maintaining alpha levels and statistical assumptions for normality.

3. RESULTS AND DISCUSSION

3.1 Germination percentage

Germination percentage was recorded at 2, 4, 6, 8 and 10 days after sowing (DAS). In 2 DAS some treatments had zero percent germination, that's why statistical analysis was not performed in that day. In other days germination percentage was significantly influenced by different levels of salinity. Table 1 shows that at 2 DAS 0 mM NaCl concentration had 15% germination, 20 mM NaCl concentration had 18.3% germination, 50 mM NaCl concentration had 21.6% and 100 mM NaCl concentration had 26.67 % germination. After 2 days (at 4 DAS) these four treatments had 75, 78.33, 80 and 85% germination. It indicates that most of the okra seed germinated within 4 DAS. At 4 DAS highest germination (85%) was recorded at 100 mM NaCl although it was not statistically different with that found at 0, 20 and 50 mM NaCl concentration. All these, four treatment had more than 85% germination at 10 DAS. Other concentrations had lower than 80% germination and were gradually decreased with the increase of concentration of salt. In 100 mM NaCl concentration maximum germination percentage (93.33%) was obtained at 10 DAS. Ratnakar and Rai (2013) showed that, upto 40 mM did not affect percentage germination, the germination was found to be delayed in *Triginella foenum-graecum*. Islam et al., (2019) suggested that, up to 80 mM NaCl concentration was tolerable for soybean but more than that the germination will be affected. Chowdhury et al., (2018) also found similar result in BARI Sunflower-2 (*Helianthus annuus* L.). They were found that, the highest salinity concentration (200 mM NaCl) remarkably decreased the germination percentage.

Table 1: Effects of different levels of salinity on germination percentage of okra

Salt Concentration	2 DAS	4 DAS	6 DAS	8 DAS	10 DAS
T ₀ - 0 mM	15±0 ab	75±2.89 a	81.67±1.6 ab	86.67±1.67 a	88.33±1.67 a
T ₁ - 20 mM	18.33±1.6 bc	78.33±1.6 a	85±2.89 b	88.33±1.67 a	91.67±1.67 a
T ₂ - 50 mM	21.67±1.67 cd	80±2.89 a	88.33±1.67 b	90±0 a	91.67±1.67 a
T ₃ - 100 mM	26.67±1.67 d	85±2.89 a	91.67±2.89 b	93.33±1.67 a	93.33±1.67 a
T ₄ - 150 mM	11.67±1.67 a	53.33±3.3 b	70 ± 2.89 c	75±2.89 b	78.33±1.67 b
T ₅ - 200 mM	0	8.33±1.6 c	35±2.89 d	58.33±1.67 c	61.67±1.67 c
T ₆ - 250 mM	0	6.67±1.6 c	20±2.89 d	38.33±1.67 d	41.67±1.67 d
T ₇ - 300 mM	0	5±0 c	15±2.89 e	36.67±1.67 d	36.67±1.67 d

Common letters in a column are not significantly different at 5% level by Tukey HSD method.

3.2 Speed of germination

It is evident from figure 1 that, the different treatments exhibited a significant effect on speed of germination. Speed of germination ranged from 12% to 70.86%. The maximum (70.86%) speed of germination was found from T₃ and minimum (12%) speed of germination was found from T₇. This result indicates that lower NaCl concentration enhance the speed of seed germination than the high concentration. Islam et al., (2019) found the same result. Hakim et al., (2010) reported that, the speed of germination was decreased as the salinity levels increased. The reduction of speed of germination at high salt levels might be mainly due to osmotic stress (Heenan et al., 1988).

3.3 Seedling height

Considering the seedling height, significant variations were noticed among all treatments (Table 2). At 15 DAS highest seedling height (8.06 cm) was found in T₂ (50 mM) treatment and lowest seedling height (1.56 cm) was found in T₇ (300 mM). With the increase of the concentration of NaCl solution seedling height was gradually increased and after certain level of NaCl concentration seedling height was gradually decreased. The result clearly indicates that, higher NaCl concentration is harmful for okra seedling height. Hajer et al., (2006) showed that, other crops such as tomato, the seedling growth rate negatively affects in high salinity conditions. The growth rate of *Oryza sativa* L. was also low in high salinity (Lee et al., 2003). Khodarahmpour et al., (2012) reported that, reduction of seedling height is a common phenomenon of many crop plants grown under saline conditions.

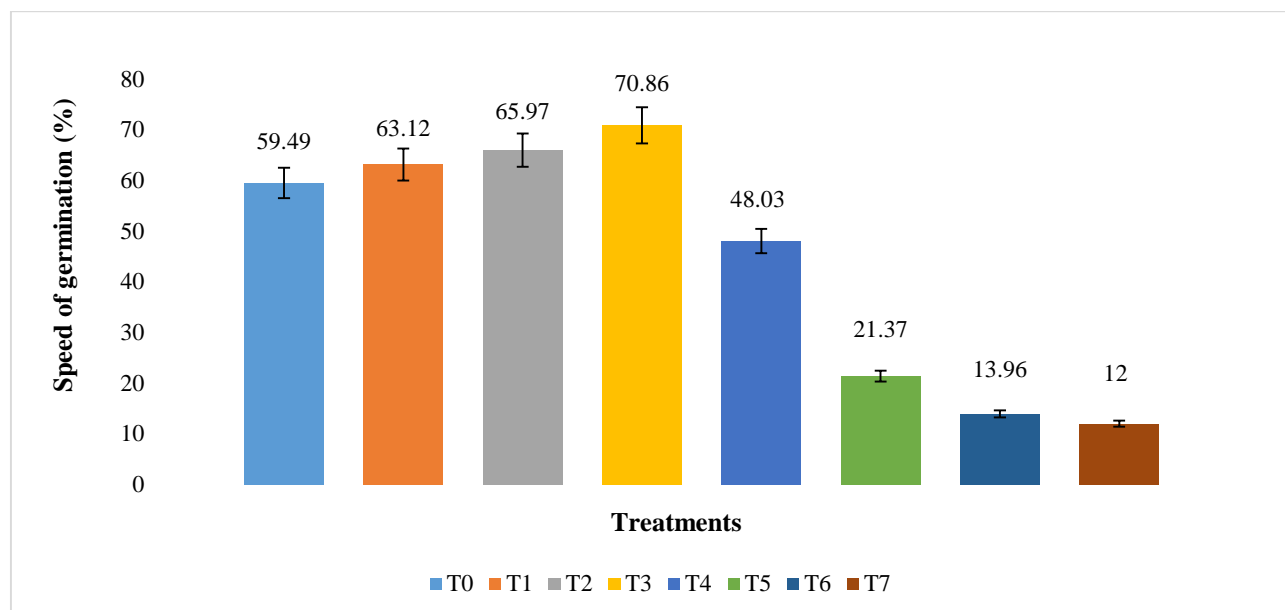


Figure 1: Effects of salt stress on speed of germination (%) of okra plant. Values represent the mean from three replications at 5% level of significance.

3.3 Seedling height

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Table 2: Effects of different levels of salinity on seedling height (cm) of okra

Salt Concentration	9 DAS	11 DAS	13 DAS	15 DAS
T ₀ - 0 mM	1.30±0.15 a	1.96±0.08 a	3.33±0.08 a	5.43±0.23 a
T ₁ - 20 mM	1.33±0.08 a	2.16±0.08 a	3.93±0.06 a	6.30±0.26 a
T ₂ - 50 mM	2±0.28 a	4.10±0.21 b	6±0.28 b	8.06±0.29 b
T ₃ - 100 mM	1.23±0.15 b	1.40±0.11 c	2.10±0.20 c	3.56±0.16 c
T ₄ - 150 mM	0.83±0.033 ac	1.03±.33 cd	1.87±0.08 c	2.63±0.08 d
T ₅ - 200 mM	0.76±0.03 ac	0.83±0.03 d	1.53±0.12 cd	2.03±0.08 d
T ₆ - 250 mM	0.73±0.03 ac	0.76±0.03 d	1.36±0.18 cd	1.63±0.08 d
T ₇ - 300 mM	0.46±0.09 c	0.56±0.03- d	0.86±0.06 d	1.56±0.08 de

Common letters in a column are not significantly different at 5% level by Tukey HSD method

3.4 Shoot elongation rate

Shoot elongation rate was calculated at 9, 11, 13 and 15 DAS, and significantly influenced by salinity. At 9 DAS highest (2.22 mm/day) elongation rate was found at T₂ (50 mM NaCl) treatment. In this date second (1.48 mm/day) and third position (1.44 mm/day) was ranked by T₁ (20 mM NaCl) and T₀ (0 mM NaCl) treatment. At 11 DAS highest (3.72 mm/day) position was also ranked by T₂ treatment, second (1.96 mm/day) and third position (1.78 mm/day) was recorded T₁ (20 mM NaCl) and T₀ (0 mM NaCl) treatment. At both 11 DAS and 13 DAS the highest position was ranked by T₂ treatment, the T₁ and T₀ had the second and third position, respectively. At 15 DAS highest (5.37 mm/day) elongation rate was found at T₂ (50 mM NaCl) treatment and the second and third position were found in T₁ and T₀ treatment. Results of this study showed that elongation rate in different salt concentrations also varied in different sampling dates. Howlader et al., (2018) reported that, increasing salt concentration reduced the shoot elongation rate at every sampling date and in lower salt concentration higher elongation rate was found.

Different levels of salinity had a significant effects on the root length and root fresh and dry weight of okra plant (Table 4). The highest root length (3.11 cm) was found in T₂ (50 mM NaCl) treatment and highest root fresh weight (5.29 gm) and dry weight (0.49 gm) also found in T₂ treatment. The lowest root length (0.68 cm) was found in T₇ (300 mM NaCl) treatment and lowest root fresh weight (1.31 gm) and dry weight (0.13 gm) also found in T₇ treatment. That's why in this treatment roots were deformed and twisted. Ratnakar and Rai (2013) showed that root length of *Triginella foenum-graecum* seedlings decreased with the increasing of NaCl concentrations in the growth medium. Vibhuti et al., (2015) reported that, rice root length can be affected due to salinity. Robin et al., (2016) indicated that, salinity induced reduction of root surface area in wheat. Vasquez et al., (2006) said that, reduction in root length caused the decrease in biomass which is commonly observed under salt stress. Carpici et al. (2009) reported that, root dry weight of cultivars decreased significantly as the levels of salinity increased from 0 to 250 mM NaCl. Akram et al. (2007) explained that, root dry weight of all corn hybrids showed a decline towards increase in salinity level.

3.5 Root length and root fresh and dry weight

Table 3: Effects of different levels of salinity on shoot elongation rate (mm/day) of okra

Salt Concentration	9 DAS	11 DAS	13 DAS	15 DAS
T ₀ - 0 mM	1.44	1.78	2.56	3.62
T ₁ - 20 mM	1.48	1.96	3.02	4.21
T ₂ - 50 mM	2.22	3.72	4.61	5.37
T ₃ - 100 mM	1.37	1.27	1.61	2.37
T ₄ - 150 mM	0.92	0.93	1.43	1.75
T ₅ - 200 mM	0.85	0.75	1.17	1.35
T ₆ - 250 mM	0.81	0.69	1.05	1.08
T ₇ - 300 mM	0.51	0.51	0.66	1.04

Table 4: Effects of different levels of salinity on root length (cm) and root fresh and dry weight (gm) of okra

Salt Concentration	Root length (cm)	Root fresh weight (gm)	Root dry weight (gm)
T ₀ - 0 mM	1.90±0.14 bc	3.13±0.11 c	0.31±0.01 c
T ₁ - 20 mM	2.24±0.04 b	4.31±0.13 b	0.38±0.03 b
T ₂ - 50 mM	3.11±0.21 a	5.29±0.13 a	0.49±0.02 a
T ₃ - 100 mM	1.32±0.16 cd	2.95±0.09 c	0.26±0.02 cd
T ₄ - 150 mM	1.24±0.25 cd	2.83±0.06 c	0.21±0.01 de
T ₅ - 200 mM	1.00±0.06 d	2.01±0.05 d	0.19±0.01 def
T ₆ - 250 mM	0.79±0.04 d	1.60±0.03 de	0.16±0.02 ef
T ₇ - 300 mM	0.68±0.03 d	1.31±0.04 e	0.13±0.04 f

Common letters in a column are not significantly different at 5% level by Tukey HSD method

3.6 Shoot fresh and dry weight

There was a significant effect of salinity on shoot fresh and dry weight of okra. Shoot fresh weight and dry weight were ranged from 3.9 to 28.3 gm and 0.55 to 2.73 gm over different levels of salinity (Table 5). The highest shoot fresh and dry weight were found in 50 mM NaCl concentration and lowest were found in 300 mM NaCl concentration. So, it would be concluded that there was a significant effect of salinity on shoot fresh and

dry weight of okra. Carpici et al. (2009) reported that, shoot dry weights of cultivars were negatively affected. They also observed that, the values of shoot dry weight gradually decreased throughout the increasing salt concentrations by increasing salt treatments. Shila et al. (2016) reported that, increasing the concentration of the NaCl solution shoot fresh weight and dry weight were reduced gradually.

Table 5: Effects of different levels of salinity on shoot fresh and dry weight (gm) of okra

Salt Concentration	Shoot fresh weight (gm)	Shoot dry weight (gm)
T ₀ - 0 mM	12.70± 0.15 c	1.46±0.03 b
T ₁ - 20 mM	17.66±1.45 b	1.70±0.11 b
T ₂ - 50 mM	28.33±1.66 a	2.73±0.14 a
T ₃ - 100 mM	9.57±0.29 cd	1.06±0.03 c
T ₄ - 150 mM	8.43±0.17 de	0.96±0.02 cd
T ₅ - 200 mM	6.56±0.23 def	0.72±0.01 de
T ₆ - 250 mM	5.36±0.12 ef	0.67±0.01 de
T ₇ - 300 mM	3.97±0.24 f	0.55±0.02 e

Common letters in a column are not significantly different at 5% level by Tukey HSD method

3.7 Vigor index

Salinity had significant effect on vigor index of okra (Figure 2). The highest vigor index (10.23) was found in 50 mM NaCl concentration and lowest (0.83) was found in 300 mM NaCl concentration. When vigor index value were compared with control treatment it was found that the vigor index

were increased in 20 and 50 mM NaCl concentrations and decreased in other concentrations. Shila et al. (2016) reported that, increasing concentration of salt gradually decreased the vigor index and 97.9% decrease in vigor index was found at highest concentration of 320 mM NaCl. Hokmalipour, (2015) showed that, seed vigor index of Chicory (*Chichorium intyus* L.), Cumin (*Cuminum cyminum* L.) and Fennel (*Foeniculum vulgare*) showed higher in low saline dose.

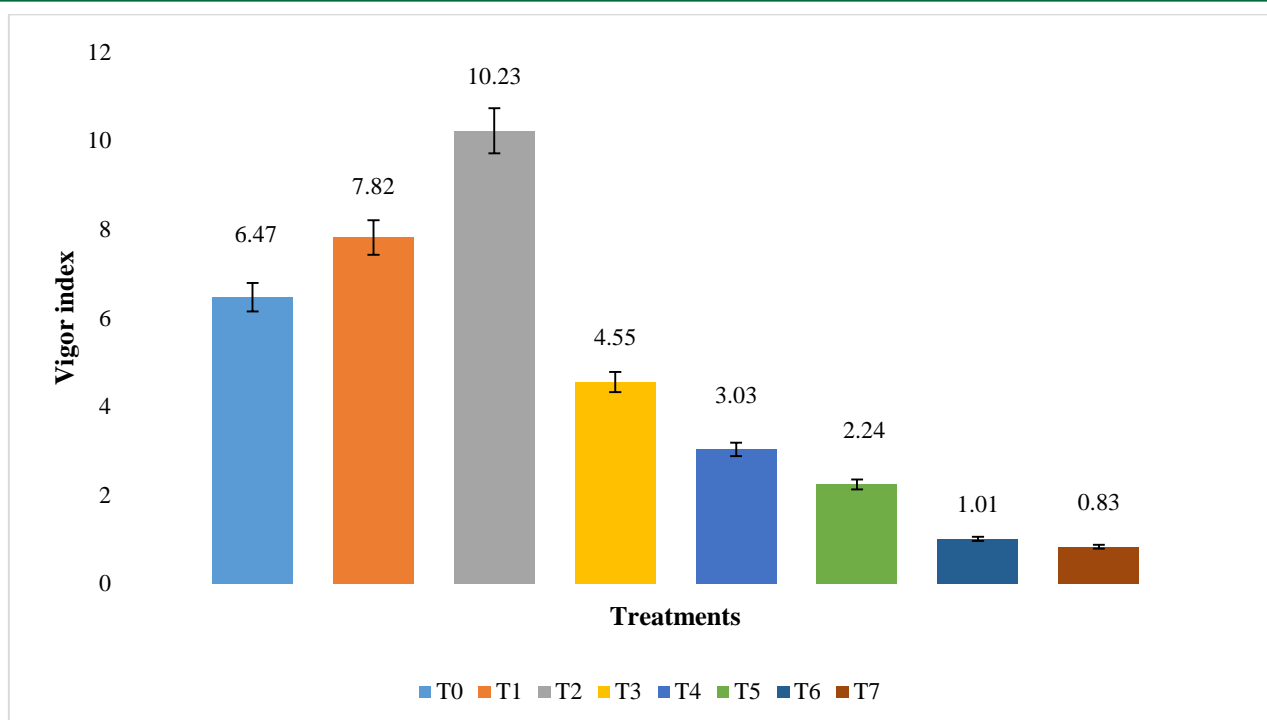


Figure 2: Effects of salt stress on vigor index of okra plant. Values represent the mean from three replications at 5% level of significance.

4. CONCLUSION

From the result it had been found that, salinity has multifarious drastic effects on growth and development of okra plants upto certain level of NaCl concentration in the growth medium. 0 mM, 20 mM and 50 mM NaCl solution was found as safe for okra seed germination, speed of germination, seedling height, shoot elongation rate, root length, fresh and dry weight of shoot and root and finally vigor index. Hence, the present study results showed that, 85 percent of seeds germination was occurred in upto 100 mM NaCl concentration. Upto 50 mM NaCl solution favors for plant growth which indicates the necessity of NaCl in lower concentration for plant growth and development. At higher concentration of NaCl like 300 mM, root was more affected than shoot. Further study should be needed to evaluate the performance of different okra genotypes at different concentration NaCl.

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