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Morphological performances of BINA soybean 6 (*Glycine max*) at several salinity stress concentrations in coastal region of Bangladesh

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ABSTRACT

A pot experiment was conducted from 2019 to 2020 at Noakhali Science and Technology University (NSTU), Noakhali, Bangladesh, to investigate the morphological performances of BINA Soybean-6 under various saline conditions. Salinity is a widespread problem responsible for limiting the productivity of oilseed crops and soybean cultivars differ in their sensitivity to soil salinity. The research material was BINA Soybean-6 collected from the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. There were five treatments of salinity viz., T_0 (distilled water), T_1 (50mMNaCl), T_2 (100mMNaCl), T_3 (150mMNaCl) and T_4 (200mMNaCl) were used in the experiment in which distilled water was used as control. Latin Square Design (LSD) with three replications was used in this experiment. In the present study, BINA Soybean 6 showed a significant variation in the contributing parameters. The experimental parameters used during the experiment were germination percentage and duration, height of plants (cm), number of branches/plant, number of leaves/plant, number of flowers/plant, number of pods/plant, length of pods (cm), seeds/pod, and length of root (cm). The highest germination percentage (83.33%) was observed in control (T_0) condition while germination percentage was suppressed under T_4 treatment i.e. 200mMNaCl concentration. Germination percentages were gradually decreased with the increase of salinity level. The highest plant height (34.22 cm), number of branch plant^{-1} (3.44), leaf number plant^{-1} (13.56), number of flower plant^{-1} (24.33), pod number plant^{-1} (21.22), seeds pod^{-1} (3.33), length of pod (5.44 cm) and root length (15.89 cm) were obtained at control (T_0) condition. It was observed that the parameters were diminished gradually with the rising of salinity levels compared to the treatment T_0 (Control).

Key Words*: BINA Soybean 6, Saline Concentration, Parameters, Growth and Development.*

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I. Introduction

Availability of excess soluble salt in soil is one of the key elements that decline the growth and development of cultivated crop plants in Bangladesh's coastal regions. Over 30% of net cultivable

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areas lie in the coastal area in Bangladesh, of which around 53% are contained varying degrees of salinity (Haque, 2006). It has 3 million hectares of land influenced by salinity, mainly in the coastal and south-east districts, with EC (Electrical Conductivity) values ranging from 4 dS/m to 16 dS/m (Zaman and Bakri, 2003). It is undeniable that salinization occupies a prominent place among the soil issues that threaten the sustainability of agriculture in Bangladesh. Observations in the recent research reported that because of ascending degree in salinity of certain areas and expansion of salt remain in those locations, normal crop production becomes more restricted. In an average year, 0.2 metric tons of crop production are descended in this region because of saline-water intrusion (Habiba et al., 2014).

Even salinity becomes one of the major environmental threats worldwide (Dasgupta et al., 2015). Though hard to estimate precisely, the area of saline soil is rising and it was accounted that 45 million ha (20%) of irrigated land, conducting one-third of the world's food, contains salt (Shrivastava and Kumar, 2015). Besides, as a consequence of growth arrest and metabolic damages, salinity imposes substantial adverse effects on the performance and physiology of crop plants, which eventually lead to plant death (Hasanuzzaman et al., 2012). It has been found that constraints in agricultural development increased following the soaring intensity of saline stress. The fertility status of most saline soil ranges from low to very low in respect to organic matter contents, nitrogen and micronutrients like copper and zinc concentration. In saline areas, soybean yield also reduces with an enhanced level of salinity (Han, 2005).

Soybean is a strategic crop plant which is known to be the "Golden bean" or "Miracle bean" or "Protein hope of Future" because of its high nutritive value. It is a plant of the leguminous family grown for its edible oil and forage (Vagadia et al., 2017). It has the highest level of protein in comparison with other leguminous plants that's why it is also considered a source of vegetable protein and oil (Moussa, 2004). In addition, 281.6 million tons of Soybeans are produced worldwide (FAO, 2013). Apart from this, out of the total cropped areas of 14.418 million ha, oil crops occupy about 0.366 million ha and the total production of the country stands at 0.786 million tones however, total oil cropped area, Soybean occupied 0.041 million ha and production is about 0.064 million tones (BBS, 2013). According to Department of Agricultural Extension sources in the research area, i.e., Noakhali that a total of 46,360 hectares was brought under soybean cultivation in 2019. In Ramgati Upazila, Soybean has been cultivated on 18,700 hectares while it is 15,500 hectares in Kamalnagor Upazila in Noakhali District. The rest is cultivated in Raipur, Sadar and Ramganj Upazila, respectively, in Noakhali (DAE, 2019). High sensitivity to soil and water salinity is one of the challenging hinders in Soybean crop production. Results have indicated that it affects the growth and development of plants through ionic stresses. Due to the accumulated salts in soil under saline conditions, plant wilts eventually while soil salts such as Na^+ and Cl^- disrupt natural establishment of plant (Khajeh-Hosseini et al., 2003; Farhoudi et al., 2007). There is a positive correlation between Na^+ and Cl^- contents of Soybean seedlings and susceptibility level to salinity. It is reported that Soybean is an important cash crop though its productivity is significantly hampered by salt stress. Similarly, high salt imposes negative impacts on growth, nodulation, agronomy traits, seed quality, and quantity and thus diminishes the soybean yield (Phang et al., 2008). It also reduces nodulation in soybean, thus affecting nitrogen fixation efficiency and ultimately yields (Dong et al., 2013). Inhibited soybean seedling growth induced by salinity occurs due to the limited water uptake caused by a reduction in hydrolysis and translocation of nutrient reserves, thereby reducing seedling vigour (Parveen et al., 2016). Besides, it alters the morphological, physiological and biochemical performance of soybean plants, reducing plant height and FW by 30-76% when NaCl was applied at 50-200mM concentrations (Amirjani, 2010). Moreover, the stress of salinity delayed the flowering stage and enhanced pod maturity in soybean, i.e., shortened the period of maturity and pod development, ultimately it is affecting development of grain that causing shrivel of grain (Ghassemi-Golezani et al., 2009; Mannan et al., 2013). Thus, the main objective of this experiment was to determine the impacts of several levels of salinity (NaCl) on the growth, development and other morphological attributes of BINA Soybean 6 in saline areas.

II. Materials and Methods

Experimental site

The experiment was conducted at Noakhali Science and Technology University (NSTU), Noakhali, situated in the South-Eastern part of Bangladesh, from 2019 to 2020. The experimental site fell under

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Young Meghna Estuarine Floodplain. The site was situated in the tropical climatic zone, with average annual temperature 25.6°C and about 2980mm precipitation falls annually.

Soil condition

The salt content in the experiment was measured by EC meter (SenslON+EC7) in the laboratory of the Department of Agriculture, Noakhali Science and Technology University. The soil contained EC 0.91 dSm^{-1} (deci Siemens per meter). So, the soil was considered non-saline soil. The results were obtained from Soil Resource and Development Institute (SRDI), Noakhali District (Table 01).

Table 01. Physical characteristics of soil used in the experiment.

Sl No.	Soil Characteristics	Analysis
1	PH	7.3-8.5
2	Nitrogen	0.04%
3	Phosphorus	27.79%
4	Potassium	0.18
5	Organic matter	0.68%
6	EC	>2dS/m

The soil temperature was recorded during the experimental period through a Digital thermometer (Model no. JR-1). The month wise average soil temperature for different treatments were shown in Figure 01.

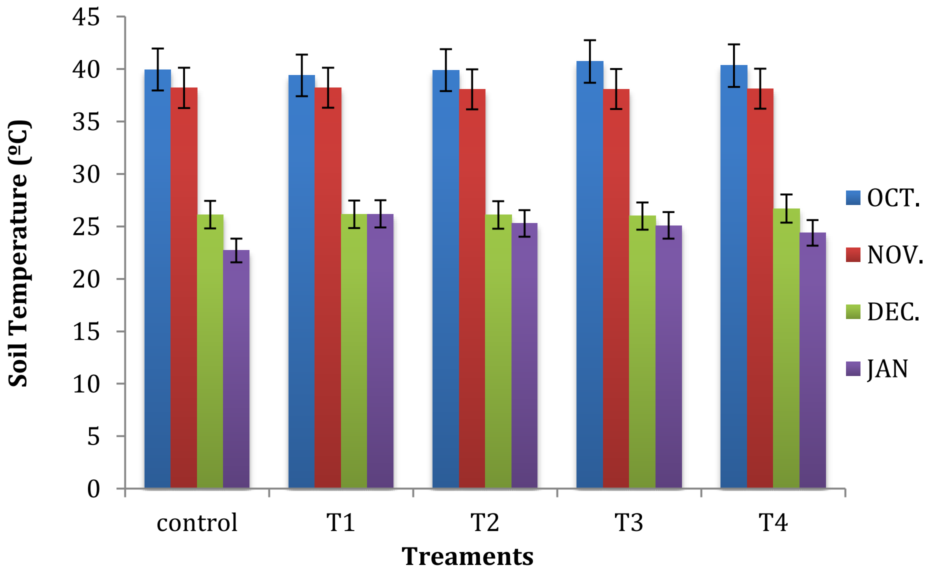

Figure 01. Average Soil Temperature during Pot Experiment

Research material

BINA Soybean 6 variety was used as a material in the experiment. Seeds of BINA Soybean 6 were collected from the Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh. Moreover, 15 new plastic pots with 20cm depth and 25cm diameter were used to prepare drainage holes in the bottom. Each pot was filled with 4.8 kg dried soil and 1.5kg cow dung.

Experimental treatments

Four different saline concentrations and distilled water were used in the experimental pots as treatments (Table 02). The 1st saline doses were done before seed sowing and then the 2nd, 3rd and 4th doses were done at ten days intervals.

Table 02. The treatments used in the experiment

Treatment	Salt Concentration(mMNaCl)
T_0	No salt was added. Distilled water (500ml)
T_1	50 mMNaCl (1.46g salt with 500 ml water)
T_2	100 mMNaCl (2.92g salt with 500 ml water)
T_3	150 mMNaCl (4.38g salt with 500 ml water)
T_4	200 mMNaCl (5.85g salt with 500 ml water)

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Application of Fertilizers
Triple Super Phosphate (TSP), Muriate of Potash (MOP) and Gypsum fertilizers were mixed with soil before sowing of seed. However, Urea was applied at the middle stage of planting (Table 03).

Table 03. Doses of fertilizer

Fertilizer name	Dose per pot (gm.)	Total (gm.)
Urea	20	300
TSP	50	750
MOP	36	540
Gypsum	10	150

Sowing of Seed
Six healthy seeds were sown in each pot and covered properly with soil and were kept in epiphytic conditions that provide seeds minimal temperature, water, and oxygen. In each pot, there were three plants allowed to grow after germination of seed.

Experimental Design
The experiment was laid in Latin Square Design (LSD) with one variety and five (5) treatments and the experiment was replicated three (3) times. The total number of pots used was 15 (5*3).

Morphological Parameter
The numbers of germinated seeds were counted daily commencing from 2^{nd} day till 12^{th} days; final count was done and the following formula calculated germination percentage of each day:

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

The height of plants were measured from the base of the plant to the tip of the longest apex. All the primary and secondary developed branches in each plant were counted before harvesting. At the ripening stage, pods were counted in each plant, while pod length was recorded before harvesting. During enlisting data, three pods per plant and number of seeds per pod were selected randomly. The highest root length of each plant was measured and recorded after harvesting.

Statistical Analysis
The data were subjected to the Analysis of Variance (ANOVA) procedure and $P<0.05$ was considered statistically significant.

III. Results and Discussion
Response of salinity on germination percentage
Results showed that the maximum germination percentage obtained in control treatment. Increased salt stress level, declined soybean germination percentage. The highest seed germination, 83.33%, was obtained from control treatment, whereas minimal was null, which observed in 200mMNaCl salinity level (Figure 02). The gradual descent of germination percentage had adverse effects on the physiological processes in seed germination. The findings found from our experiment was confirmed by following research works particularly Hasheem et al. (2019), where they evaluated that the germination of Soybean seed was reduced with the increasing level of salinity and results were revealed a large variability for salt tolerance at the growth stages. Germination percentage was significantly diminished with the soaring concentrations of salinity (El Sabagh et al., 2015a). Salt stress decrease the germination rate and germination percentage of Soybean as negative effects of osmotic and ionic Na^+ on seedling growth and development as the reason of this observation (Farhoudi and Tafti, 2011).

Response of salinity on the time duration of germination
According to Figure 03, the average time required for Soybean seed germination were 6.67 days, 8 days, 10 days, 11.67 days individually at several saline concentrations, i.e., T_0 (control), T_1 (50mM), T_2 (100mM) and T_3 (150mM) respectively. Farhoudi and Tafti (2011) assessed that NaCl induced salinity

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stress ultimately led to an increased mean germination duration and mentioned that Na+/ K+ ratio could also measure salt stress tolerance.

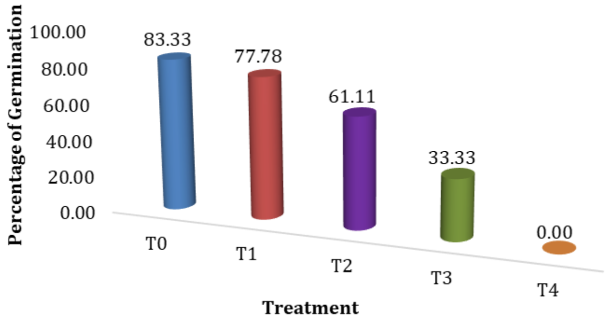

Figure 02. Effect of salinity on germination percentage at the treatments

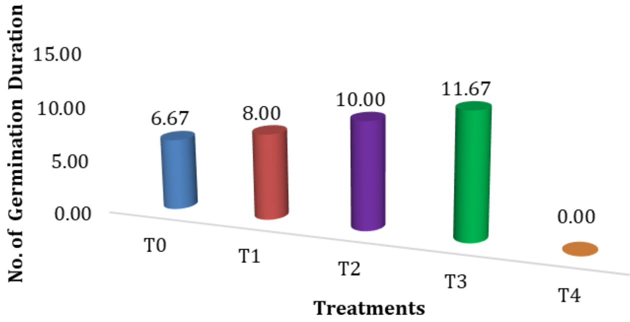

Figure 03. Effect of salinity on duration of germination on the treatments

Response of salinity on the plant height

Applied salinity of 0, 50,100,150 and 200mMNaCI respectively on Soybean observed that plant height of this crop was induced with the increasing salinity levels. The experimental research found that the highest plant height 34.22 cm was obtained from control treatment while minimum plant height of 5.67 cm was recorded at 150mM salinity level (Figure 04). El-sabagh et al. (2015a) found from their work that the highest plant height observed in control condition, which was 18.4cm, is similar to our research outcome as salt stress significantly influenced the height of Soybean plant.

Response of salinity on the number of branches

Branches per plant varied noticeably in saline stress conditions. Average number of branches per plant found were 3.44, 2.78, 2.11, 0.89 and 0 respectively applicable for control T_0 , T_1 (50mM), T_2 (100mM), T_3 (150mM) and T_4 (200mM) NaCl concentrations. The higher number of branches per plant was 3.44 that was obtained from control level whereas lower was 0.89 that noticed at 150mM salinity level condition (Figure 05). El-sabagh et al. (2015b) observed in control condition, the highest number of branches per plant (5.7) obtained and they also found that salinity stress led to significant reduction in number of branches per plant over control. Islam et al. (2012) that decrement of branch number of Soybean under salinity level and our work result were supported by their results. This might be due to salinity that inhibits the formation of new branch and facilitating the aging of old branches at various degrees.

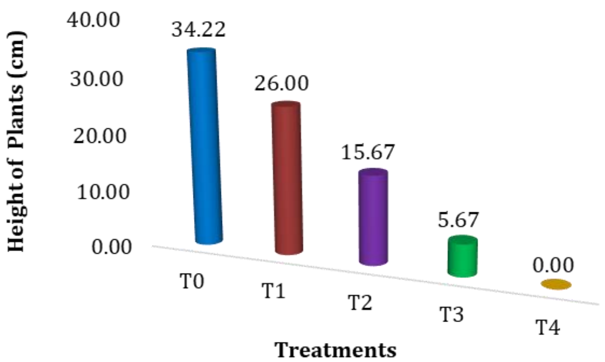

Figure 04. Effect of salinity on the height of plants on the treatments

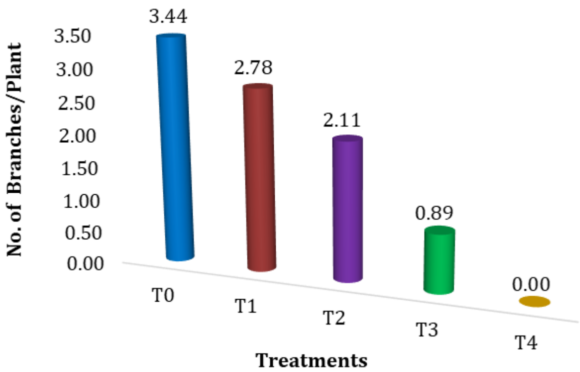

Figure 05. Effect of salinity on the number of branches per plants during different treatments

Response of salinity on the number of leaves

Number of leaves per plant also decreased with the increasing standard of saline concentrations. Increased salinity levels 0, 50, 100, 150 and 200mMNaCl resulted in a reduction of number of leaves per plant which were 13.56, 12, 9.11, 3.56, and 0, respectively. The maximum leaves per plant 13.56 was found at the control level; hence, fewer leaves per plant were recorded from 150mM salinity level that was 3.56 (Figure 06). The gradual reduction of number might be occurred due to less nutrient availability caused by the increased salinity level. The results from the experiments of El-sabaghet al. (2015b) and Islam et al. (2012) agreed with our outcomes as they also found that maximum number of

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leaves per plant in control treatment. A study conducted by Mishra et al. (1995) mentioned that the low NaCl concentration had no prominent effect on the number of leaves but higher concentration of soluble salt in water had an influential effect on the number of leaves.

Response of salinity on the number of flowers

From Figure 07, it can be said that the number of flowers per plant noticeably became less with the rising level of salinity in where the average number of flowers per plant was obtained 24.33, 19.56, 14.78, 4.56 and 0 respectively for T_0 (control), T_1 (50mM), T_2 (100mM), T_3 (150mM) and T_4 (200mM) NaCl concentration. Among the treatments, the peak number of flowers per plant 24.33 was recorded from control treatment, whereas 4.56 was noticed as the lowest number found from 150mM level. The outcome was agreed with the findings found by Tayyab et al. (2016) and Ventura et al. (2014) that salinity significantly diminishes the number of inflorescences and flowering branches.

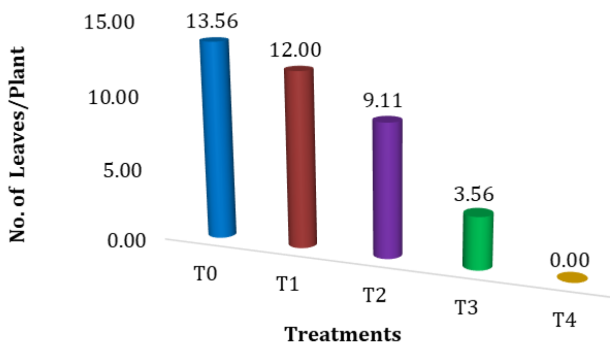

Figure 06. Effect of salinity on the number of leaves per plant at the treatments

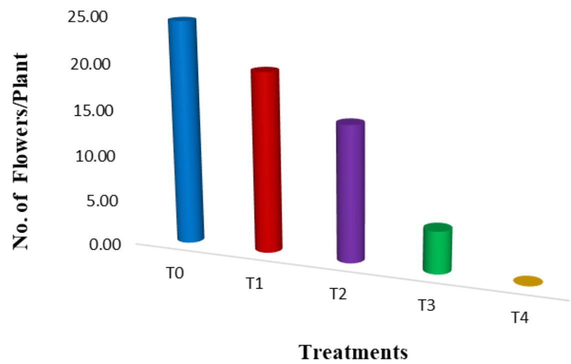

Figure 07. Effect of salinity on the number of flowers per plant at the treatments

Response on the length of root

The gradually decreased root length in Soybean happened due to the toxic effect caused by increased salinity levels. Chowdhury et al. (2018) noted that the growing concentration of NaCl remarkably reduced the length of root and shoot of plants that agreed with our experimental research as in our works, we also observed descending of the length in plant root. Even the peak length (15.89 cm) was obtained from control (T_0) condition though the shortest length (3.33 cm) was found from 150mM (T_3) salinity level which ultimately indicated that diverse reduction of root length (Figure 08). In addition, the result of the investigation conducted by Islam et al. (2012) also supports our outcome as they said that salinity reduced the shoot and root length of Soybean cultivars.

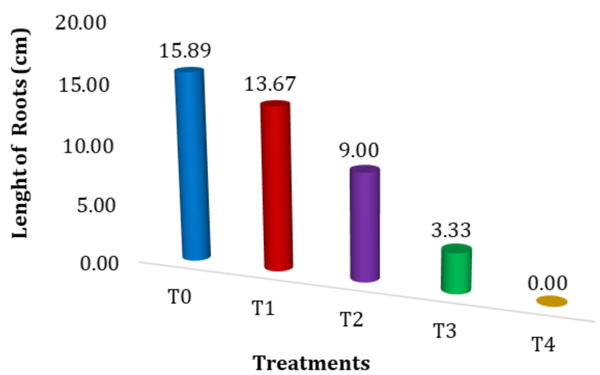

Figure 08. Effect of salinity on the length of roots of plant at different treatments

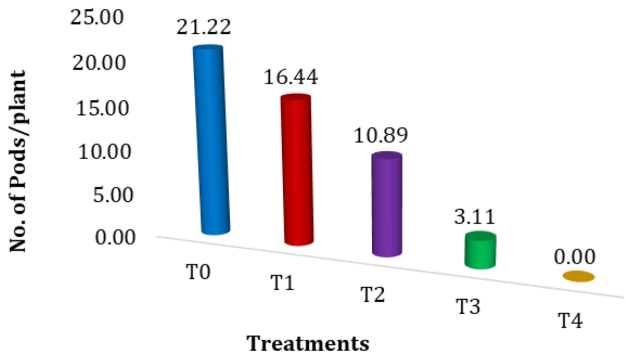

Figure 09. Effect of salinity on the number of pods per plant at the treatments

Response of salinity on the number of pods

The number of pods in each plant influenced by the salinity stress (Figure 09). Average number of pods per plant were 21.22, 16.44, 10.89, 3.11, and 0 respectively that applied for T_0 (control), T_1 (50mM), T_2 (100mM), T_3 (150mM) and T_4 (200mM) NaCl concentrations. The maximum number of pods per plant 21.22 was found from control treatment, while the minimum was 3.11 recorded at150mM salinity level. Salinity stress significantly reduced pods per plant in Soybean. Number of

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pods/plant deducted when the salinity level become erected. The results conformed to those of Islam et al. (2012) and Chang (1994) who reported increasing salinity standard decreased number of filled pods plant^{-1}. Islam et al. (2012) was found that increased number of pods in control condition and Chang (1994) also was said that the level of salinity reduced the pod number per plant in Soybean cultivars.

Response of salinity on the length of pod

Pod length values from the salinity experiment showed significant differences among treatments. From the experiment, we found that the average number of pods length was 5.44, 4.59, 2.86, 1.46, and 0, respectively those were applicable for T_0 (control), T_1 (50mM), T_2 (100mM), T_3 (150mM) and T_4(200mM) NaCl concentrations (Figure 10). The highest number of pod length 5.44 was obtained from control treatment while lowest number of pod length 1.46 was recorded from T_3 (150mM) concentration which was justified by Duzdemir et al. (2009) as they also found maximum length of pod in control condition which was 9.9cm and lowest one was 8.6 cm in another leguminous crop in salinity stress.

Response of salinity on the number of seeds/pod

From Figure 11, it is showed that the increasing level of salinity which was 0, 50, 100, 150 and 200mM resulting in a reduction of number of seeds per pod which were 3.33, 2.63, 2, 0.81 and 0, respectively in where the maximum number of seeds per pod (3.33) was collected in control (T_0) condition whereas lowest (0.81) was found from T_3 (150mM) salinity level. Our research result was supported by Ghassemi et al. (2011) as they have also been reported to reduce the number of seeds per pod due to salt stress for Soybean plant. In addition, the number of seeds/plants decreased with the increased level of salinity was confirmed by Islam et al. (2012) as they were noticed that maximum number of seeds per pod in control treatments similar to our outcomes.

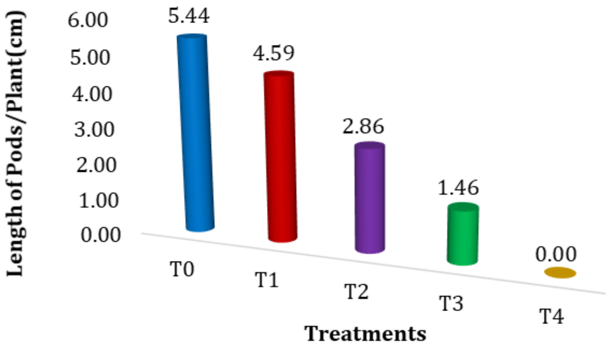

Figure 10. Effect of salinity on the length of pods per plant at the treatments

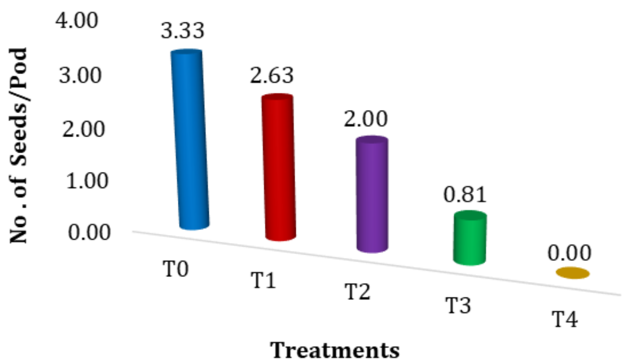

Figure 11. Effect of salinity on the number of seeds per pod at the treatments

IV. Conclusion

From the experiment, it was noticed that the characters (parameters) were gradually diminished with rising levels of saline concentrations. Significant reduction was observed at the higher level of salt concentration compared to control concentration. All the parameters were decreased gradually with gradual increase in salinity levels compared to the control concentration level. According to the results, salinity stress had detrimental effect on BINA Soybean 6 and ultimately reduced yield. Our work confirms that salinity in soil adversely influenced the different parameters of Soybean plant at all growth stages, whether it is morphological or physiological processes. It can be concluded from the above results that the performances of BINA soybean 6 was better in control treatment and it is a sensitive plant to different salinity stress levels.

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