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Original Research Article

ASSESSMENT OF DIVERSITY AMONG OKRA (*ABELMOSCHUS ESCULENTUS*) GENOTYPES UNDER SALT STRESS

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Abstract *Okra is a summer annual, often cross-pollinated main vegetable of the tropical and subtropical areas The experiment was performed using 10 different Okra genotypes of unknown salt tolerance perspective sent to the salt state, to divide them into salt-tolerant, moderate-tolerant, and sensitive groups, based on their salt-tolerant ability. The tested genotypes were exposed to various growth stages such as germination and emergence, and seedling growth under high salt levels i.e. 0mM, 25 mM, 50mM, 75 mM, and 100mM to test the effects of salt pressure on low-salt okra genotypes. Vertical seedlings follow a pattern that reduces energy in terms of seedling roots and shoot lengths with fresh and dry weight. Examination of okra seed emergence revealed a declining trend in the percentage of emergence; plant biomass (fresh and dried) with seedling roots and shoot length. Based on the strength of the Okra genotypes of salt tolerance and results, okra genotypes OH-713, OH- 139, OH-138, and OH-001 were among the most tolerant and middle-tolerant groups including OH- 152, OH -597, and MD-02. The low-end middle-aged group was identified as including Sabzpari, Okra-7100 and Okra-7080. Following the results of our test. Therefore, from the final results these species of Okra are divided above the salt tolerance in saline soils and are suitable for salt-affected regions.*

Keywords: *okra; salt tolerance; genotypes; shoot length; roots*

Introduction

Okra (*Abelmoschus esculentus* L.) is an annual, often cross-pollinated main vegetable of the tropical and subtropical areas. It originated in India (Masters, 1875) and has now grown in many parts of the world including the Middle East, Africa, Brazil, Turkey, and southern states of the USA (IBPGR, 1990; Jideani and Adetula, 1993; Acquistucci and Francisci, 2002). Okra seedlings at prior development stages are extra liable to salt stress (Cedra *et al*., 1982), as it influences water associations and nutrient use in the plants. Whereas shortly the ionic pressure in turn shrinks leaf development. Throughout the long term, salt stress plants associate the ionns' stress which can escort to the early death of mature leaf and thus decline in photosynthetic velocity ordinary inspection (Cramer and Nowak, 1992). Salt stress modifies the photosynthetic part (Nadeem *et al*., 2006), with osmotic and water perspective (Sarwar et al., 2017; 2021; 2022; Azevedo-Neto *et al*., 2004), transpiration rate (Karlberg *et al*., 2003), leaf temperature (Maricle *et al*., 2007), and virtual leaves water fulfilled (Lee *et al*., 2005). The plan of trial was conducted to check the effect of salt stress on some morphological and physiological characteristics of different okra genotypes. The Okra plant's whole parts are used like immature okra fruit are used as a vegetable for cooking and stems are also used for clearance of the juices (Chauhan, 1972) the okra plant leaves are used for the manufacture of fiber and ropes (Jideani, 1993). Okra seeds are utilized to compete with other protein sources because they have excellent grades for nutrient content (Bryant *et al*., 1988). Mucilage, which is made up of a combination of pectin and carbohydrates, is found in the okra pods and is utilized as a thickening in the food industry. (Nilufar *et al*., 1993). Okra flour is a helpful chow

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preservative in okra flour for baking biscuits that has good scientific and senesce characteristics. (Acquistucci and Francisci, 2002).

Okra is usually planted for its sensitive pods in all tropical and Mediterranean climates around the world (Doymaz, 2005). It is one of the mainly large vegetables in Pakistan and it is extensively dispersed throughout Soft fruits and young leaves are prized in European and Asian countries. (Khomsug *et al*., 2010). The okra foliage is eaten by many people in several parts of the world. Vitamins and mineral salts, particularly calcium, are the main components of okra, which are typically insufficient in the diets of public living in small nations (IBPGR, 1990). It has been used to cure a variety of ailments due to its vast range of therapeutic properties. In normal the polysaccharide from okra fruit has anti-complementary and hypoglycemic properties (Tomoda *et al*., 1989). The antioxidant actions of okra were established in the study in vitro (Reddy *et al*., 2010). Antioxidants are likely molecules to forage the liberated radicals from their harmful effects. Antioxidant enzymes such as superoxide, dismutase, glutathione peroxidase, catalase, and vitamin A, C, and E, which repress lipids and scavenge damaging the oxygen liberated radicals, are prevalent in the human body (Sarwar et al., 2017; 2021; 2022; Maritim *et al*., 2003). There are lots of plants used for food and health reimbursement, there is a link between nutrition and health (Pieroni and Price, 2006). The antioxidant value of feral, less cultivated, and cultured vegetables is a hot topic in nutritional and phytotherapy studies around the world (El and Karakaya, 2004). Natural medicine is gaining popularity these days due to its low risk of adverse effects and numerous health benefits. As a result, plants are regarded as an advantageous dietary supplements in a diversity of conditions, including but not restricted to diabetes, where medicinal compound help to regulate blood sugar levels and stop the long period metabolic problems (Sarwar et al., 2017; 2021; 2022; Gallagher *et al*., 2003). Furthermore, medical flora is famous due to its beneficial property, which are frequently credited as an antioxidant characteristic (Zhang *et al*., 2001). Okra plants, which are glycophytes like most crop species, respond to salinity in a range of ways, from very salt-sensitive to somewhat anti-salt.

The higher salinity, which is often recognized by the salt and Na+ ions that brutally concern development and acquiesce, okra plants generally show undersized expansion through small or no growth (Ashraf and Harris 2004). However, growing salinity has severely impacted roughly 100 million ha1 of worldwide land due to increased irrigation on salinized arable land soil (Gunes *et al*., 2007). A link has been found between saline surroundings and the internal level of water-soluble enzymes (Sheteawi, 2007). Salt affected region in Pakistan concerning 6.68 Mha (Khan, 1998), and output fatalities with okra to salt -onceited soil are 65.01% (Sarwar et al., 2017; 2021; 2022; Afzal *et al*., 2005). Critically, the trouble in Stalinizations that is growing, is due to lessening the ease of use the fresh water and precipitation. These factors, which might be the matchlessness inside the tropical region and sub-tropical regions as well-known in Sindh and Southern Punjab, are adverse for yield capability. The early sowing of okra germplasm showed the development set firm to no salty area (Khan, 1992) and also in the saline areas (Ashraf and Rauf, 2001; Basra *et al*., 2005) by mounting salts acceptance for the period of seedling and premature development stage (Sivritepe *et al*., 2005). The optimistic belongings to treat with NaCl account for increase and yield of recognized tomato plants when salt treatment was purposeful with seed sowing (Cano *et al*., 1991).

Salt, deficiency, and soaring temperatures are the main ecological pressures for crop cultivation in warm and dry regions but in dry and humid areas which caused the salt to be extremely lethal (Meigs, 1968). The 8.00% of the earth and 6.00% of the world's arable land are already too salty (Flowers *et al*., 1997), mainly with inadequate water and flooding water (Binzel and Reuveni, 1994). In addition, present is a great deal of pressure on agricultural countries to turn out extra to feed young people, particularly in rising countries, and as a result low-income countries have not been cut off appropriately and high levels of likely salt or other toxins (Flowers and Yeo, 1995). Our country is located in a tropical region with dry and typical weather. According to the report organized from WAPDA the whole area in Pakistan is 16,795.11M ha, divided into non-saline (73%) low salt (10%), medium salt (4%), strong salt (7%), and mixed soil type (6%) %). Therefore, keeping in view the increasing salinity level of irrigated land and its deleterious effects on vegetable crops, especially Okra, a project was designed to screen out the salt-resistant okra genotypes.

Materials and Methods

Experimental Site and treatments

The Present experiment was conducted at the Horticulture Nursery, Department of Horticulture, University of Layyah, Layyah, Pakistan during two growing seasons (2021-2022 to 2022-2023), for Screening of different okra genotypes under salt stress. The experiment was conducted in a Complete Randomized Design (CRD) arrangement with a total of four treatments which were replicated thrice NaCl Solution was used as treatment. The seeds of okra cultivars for the experiment were taken from Ayub

Agricultural Research Institute (AARI), Faisalabad, and NARC, Islamabad. Different treatments of NaCl (25mM 50mM, 75mM, and 100mM) were prepared in distilled water. The Seeds of okra were sown in pots and after sowing of okra seeds the Salinity was created by applying NaCl solution was applied to each experimental unit after 03 days of sowing okra seed.

Data Collection

Data regarding different growth characters was recorded using standard procedures. Germination percentage was calculated by counting the seeds germinated through the following equation (1)

$$\text{Germination percentage} = \frac{(\text{Number of Total seed Germinated})}{(\text{Number of Total seed Grown})} \times 100$$

(1)

Emergence percentage is the number of seeds that emerged from the sand were counted and the emergence percentage was calculated by using the following formula (2)

$$\text{Emergence percentage} = \frac{(\text{Number of Total seed Emerged})}{(\text{Number of Total seed Grown})} \times 100$$

(2)

Randomly selected 5 plants for each parameter then average was calculated. The plant height of randomly selected 5 plants was deliberate through a meter rod in centimeters from the top of the leaves to the base end of the plant and the average was calculated. Root length was measured by a meter rod in centimeters from the emergence point to the end of the root tip and the average was calculated. Shoot length was measured by meter rod in centimeters from the emergence point to the end of the shoot tip and the average was calculated. The fresh weight of shoots was taken on electric balance, immediately after harvesting the plant, and the average was computed. The dry weights of shoots were taken after complete exposure to air the shoots were in the oven for 70 hours at 65°C temperature and then measured the weight with the help of electric balance and the average was calculated. The fresh weight of the roots was taken on electric balance, immediately after harvesting washing the roots, and drying the water, and the average was calculated The dry weights of the roots were taken after completely drying the roots in an oven for70 hours at 65°C temperature and then measured the weight with the help of electric balance and average was computed. For Na+, K+ Concentration, and Na+/K+ion ratio, the leaves of seedlings were collected from each genotype separately, washed with distilled water, placed in 1. five ml microfuge, and saved in a freezer at -80 °C for one week. The mobile sap is extracted by crushing the leaves in microfuge tubes with the help of small iron balls using a trendy method of centrifugation. The dilutions were prepared in deionized water. The Na+ and K+ contents inside the sap have been measured with a flame photometer (Jenway PFP7). A graded collection of standards starting from 5 to 25 mg/l of Na+ and k+ has been prepared and fashionable curves have been drawn. The values of Na+ and k+ from the flame photometer were compared with a widespread curve and total quantities were computed.

Statistical analysis

The data collected for all experiments was analyzed with the Fisher's analysis of variance and LSD test at 5% probability was used to evaluate the treatment means (Steel *et al*., 1997).

Results and Discussion

The studied genotypes have shown a range of phenotypic variability for germination, emergence (%), root length, and shoot length of different levels of salt stress, and the interaction of salt stress and genotypes were also significant (p <0.01) for all the traits (Table 1). Increased NaCl concentration was significantly greater (P ≤ 0.01) affecting the germination of genotypes (Tables 1-3). Figure 1 shows the result of diverse treatments of salinity on germination (%) of singular okra genotypes. In control (0 mM) the entire the cultivars showed highest germination and varied from 85 to 90 %. As the salinity levels improved the germination percentage of genotypes decreased. A minimum germination percentage was observed in all the genotypes at 100 mM NaCl salt stress. Based on the Okra genotype's capacity of salt tolerance and final results, after the application of salt treatments i.e. 25mM NaCl, 50mM NaCl, 75mM NaCl and 100mM NaCl the Okra genotypes OH- 713, OH-139, OH-138, and OH-001 were among the the majority tolerant group and average tolerant group included OH-152 and OH-597. Low germination percentage was observed in Okra-7100, Sabzpari, Okra-7080, and MD-02. So it shows that at excessive ranges of salt concentration in one of a kind genotypes of Okra specifically Okra-7080 and MD-2 show low germination percentage and are rather touchy to salt pressure. Salinity considerably confined the germination and emergence percentage. This discount in germination and emergence might be related to the condensed water absorption potential of germinating seeds below saline regimes. The method of reserve of germination and seedling growth by NaCl, may be connected toward radical emergence due to insufficient water absorption, or may be ascribed to toxic consequences in the embryo Our consequences also showed the findings of (Zhang, et al. 2012). For Emergence Percentage **t**he maximum germination percentage (85-90%) was

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obtained in T0 (Control), and salt stress levels at a concentration of 25mM NaCl in) OH- 713 whereas other treatments were statistically at par except for control T4 (100mM NaCl) which showed the lowest germination percentage in MD-2 (66%). Salt stress drastically compacted the absolute germination % in all tested okra cultivars but the highest reduction in final germination percentage was renowned in plants exposed to 100mM NaCl stress as compared to other concentrations of salt stress level i.e. 25mM NaCl, 50mM NaCl, and 75mM NaCl (Figure 2). Plants grown under Control treatment and low salt levels condition exhibit maximum germination% as compared to those present with a variety of high levels of salinity levels. The statistical analysis of different concentrations i.e. 25mM NaCl, 50mM NaCl, 75mM NaCl, and 100mM NaCl the okra genotypes OH- 713, OH-139, OH-138, and OH-001 had been the various most tolerant group and medium tolerant group include OH-152, and OH-597. The lower or salt-sensitive groups include Okra-7100, Sabzpari, Okra-7080, and MD-02. The means of germination and sprout increase through NaCl, may be related to radical emergence because of inadequate water absorption, or may be ascribed to toxic results at the embryo(Uhvits in 1964) found in agronomic flowers including alfalfa that seeds engrossed a poor amount of water and acquire a massive quantity of Cl while the osmotic strain of the substance changed into advanced salinity and as a quit result, the seeds emerge gradually that has turn out to be managed at superior salinity amount (Waisel *et al*. 1982) found that growing salinity cognizance frequently reasons osmotic or precise ionic lethality which may also lower or stop seed germination.

Table 1: **Summaries of analysis of variance (mean squares) of the data for germination, emergence (%), root length (cm), and shoot length (cm) of different levels of salt stress on different okra genotypes**.

Source variation	**Df**	**Germination (%)**	**Root length (cm)**	**Shoot length (cm)**	**Emergence (%)**
Salt stress (S)	4	35097.2 *	74.29 *	26.78 *	**36896.4 ***
Genotypes (V)	9	1093.5 *	13.33 *	9.88 *	**1175.9 ***
S × V	36	197.5 *	0.90 *	0.97 *	**191.5***
Error	**418**	**2.4**	**0.03**	**0.01**	**3.4**

NS: Non-significant, ***:** significant at 5% probability level

Table 2: Summaries of analysis of variance (mean squares) of the data for Plant (cm), root and shoot fresh weight (g) and root and shoot dry weight (g) of different levels of salt stress on different okra genotypes.

Source of variation	**df**	**Root and shoot fresh weight (g)**	**Root and shoot dry weight (g)**	**Plant height (cm)**
Salt stress (S)	4	978377 *	2741.66 *	**181.40 ***
Varieties (V)	9	411659 *	2689.75 *	**38.60 ***
S × V	36	29306 *	248.96 *	**2.24 ***
Error	**418**	**5.0**	**0.74**	**0.06**

NS: Non-significant, ***:** significant at 5% probability level

Table 3: Summaries of analysis of variance (mean squares) of the data for seed Na^+ concentration and K^+ concentration of different levels of salt stress on different Okra genotypes.

Source of variation	**df**	**Na^+ concentration**	**K^+ concentration**	**Na^+/K^+ ratio**
Salt stress (S)	4	96.2214 *	548.635 *	**9.48298 ***
Varieties (V)	9	1.7900 *	15.708 *	**0.53973 ***
S × V	36	0.166 NS	0.057 NS	**0.08449 ***
Error	**418**	**0.0260**	**0.053**	**0.00275**

NS: Non-significant, ***:** significant at 5% probability level

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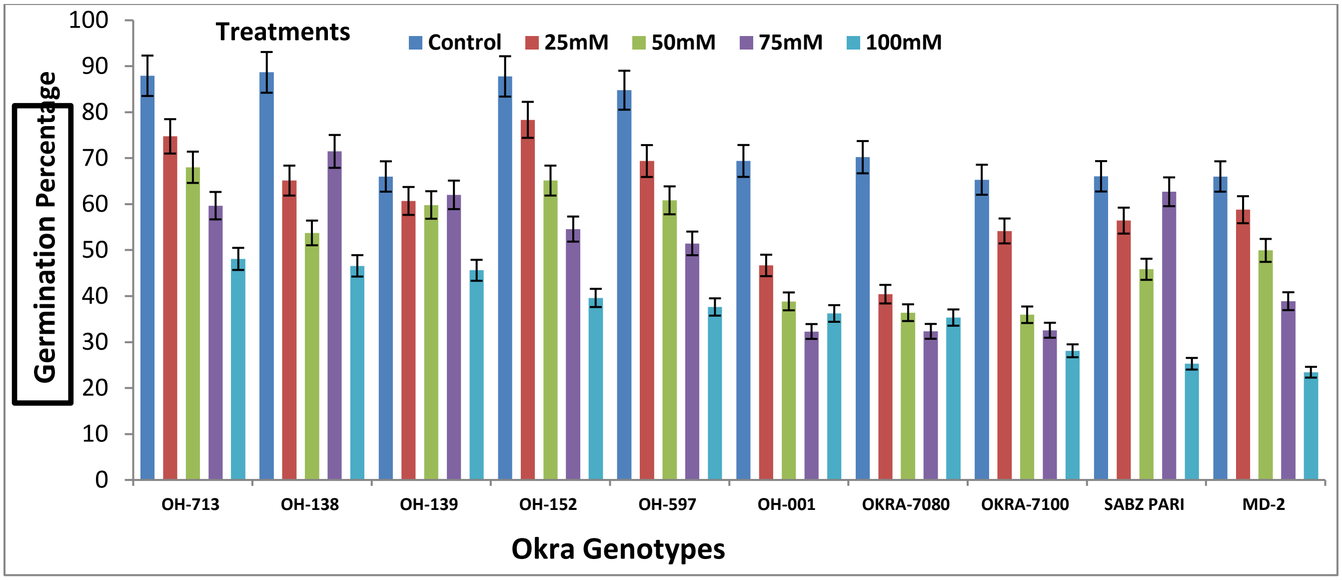

Figure 1: Effect of different levels of salt stress on germination (%) of different okra genotypes

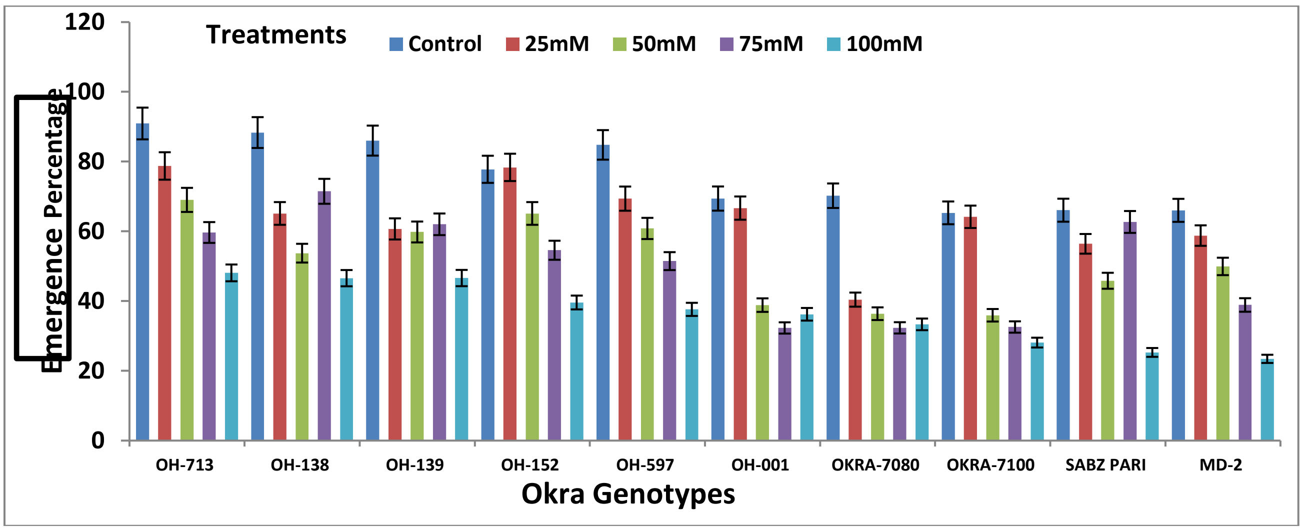

Figure 2. Effect of different levels of salt stress on emergence (%) of different okra genotypes

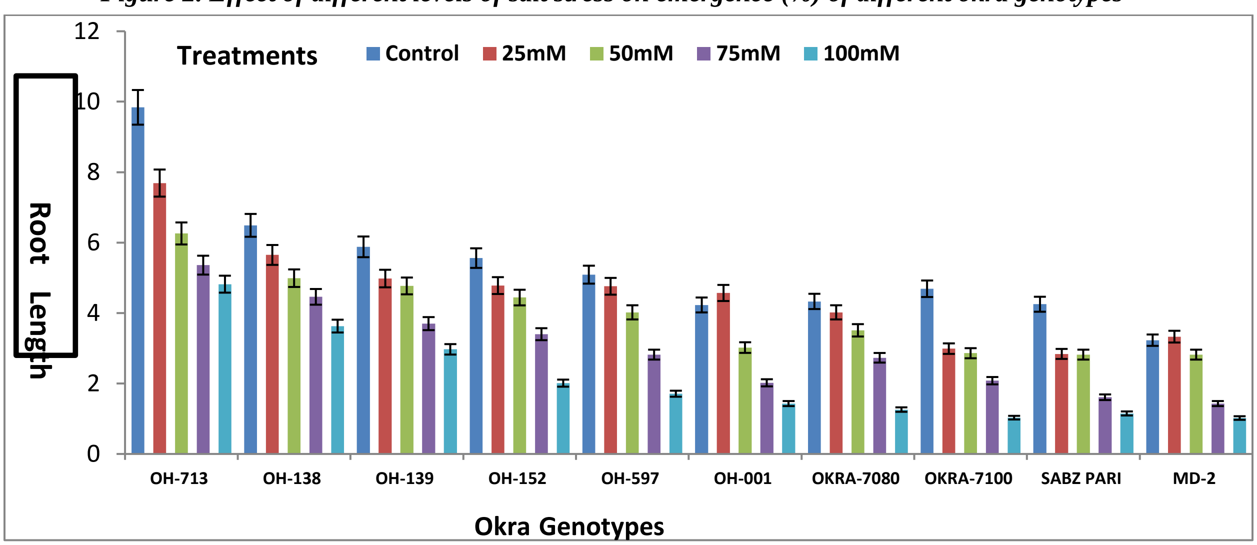

Fig 3 Effect of different levels of salt stress on root length of different okra genotype

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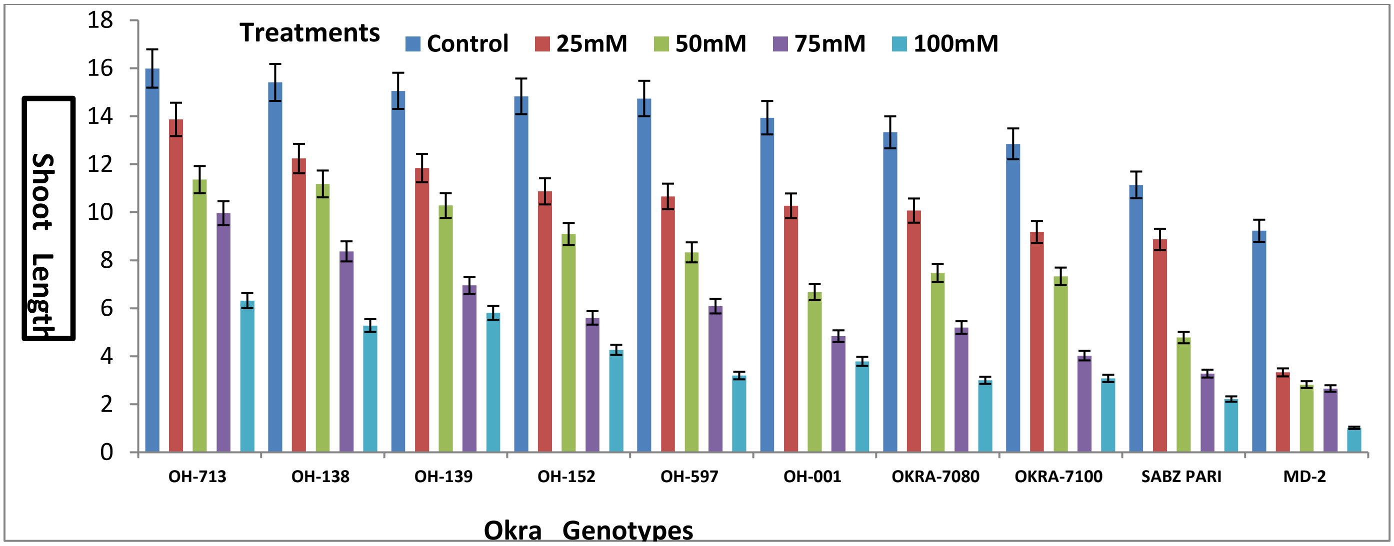

Figure 4 Effect of different levels of salt stress on shoot length of different okra genotype

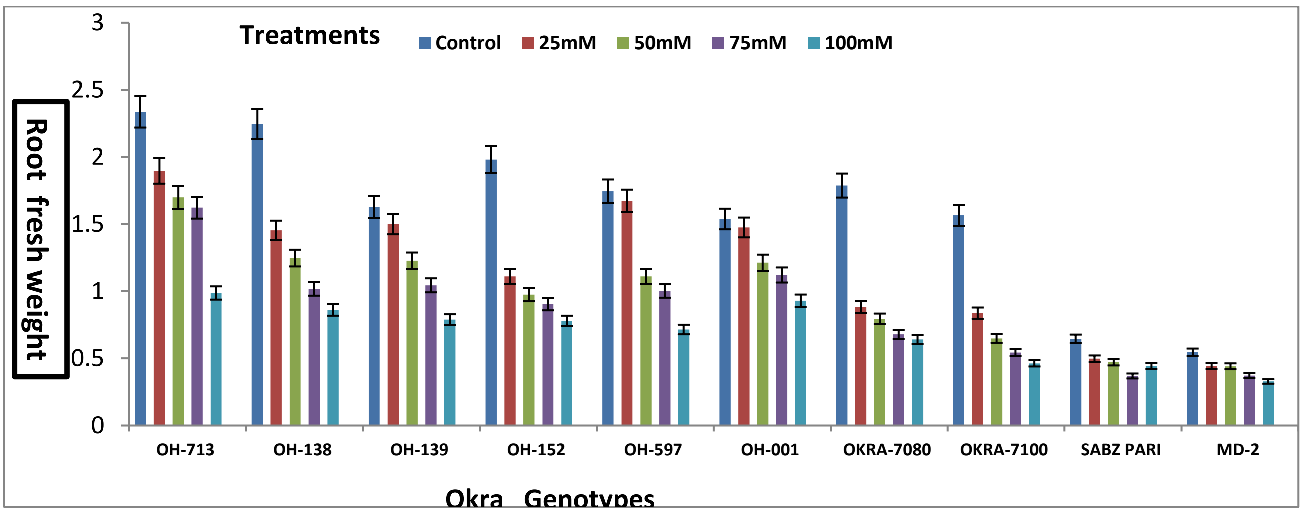

Figure 5 Effect of different levels of salt stress on root fresh weight of different okra genotypes

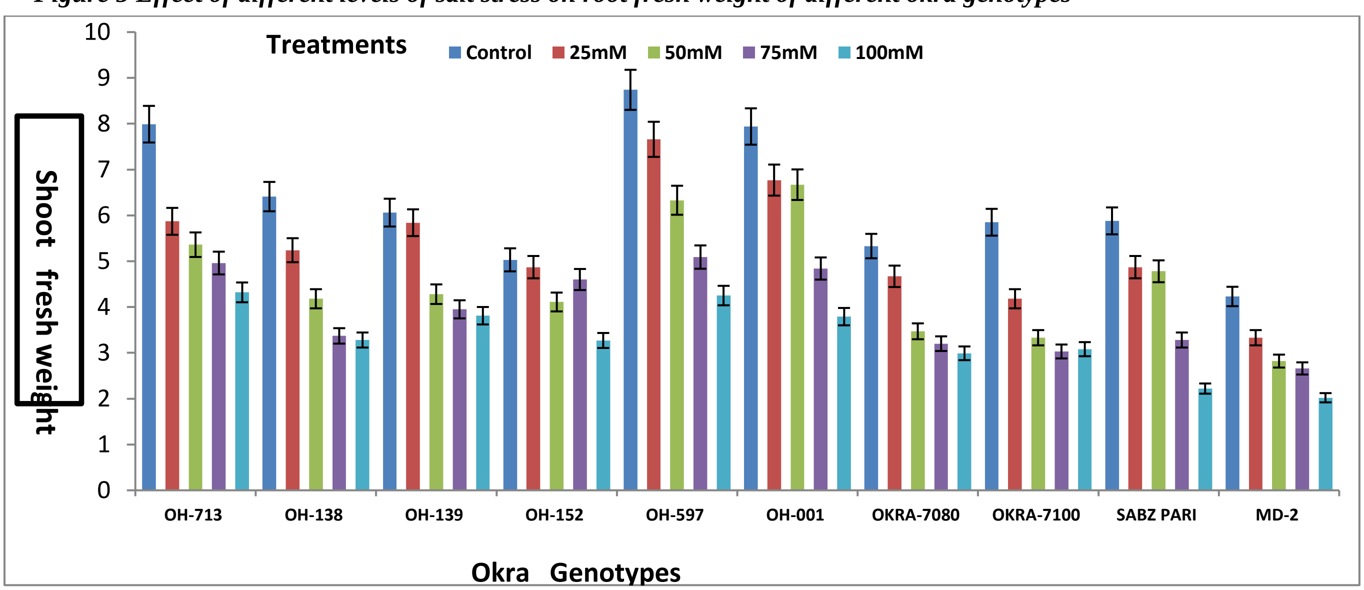

Fig 6 Effect of different levels of salt stress on shoot fresh weight of different Okra genotypes

[Citation: Ahmad, W., Raza, M.H., Azeem, A., Abbas, T., Anjum, S., Wahocho, N.A., Jamali, M.F., Sultan, S.M. (2024). Assessment of diversity among Okra (*Abelmoschus esculentus*) genotypes under Salt stress. *Biol. Clin. Sci. Res. J.*, **2024***: 1387*. doi: https://doi.org/10.54112/bcsrj.v2024i1.1387]

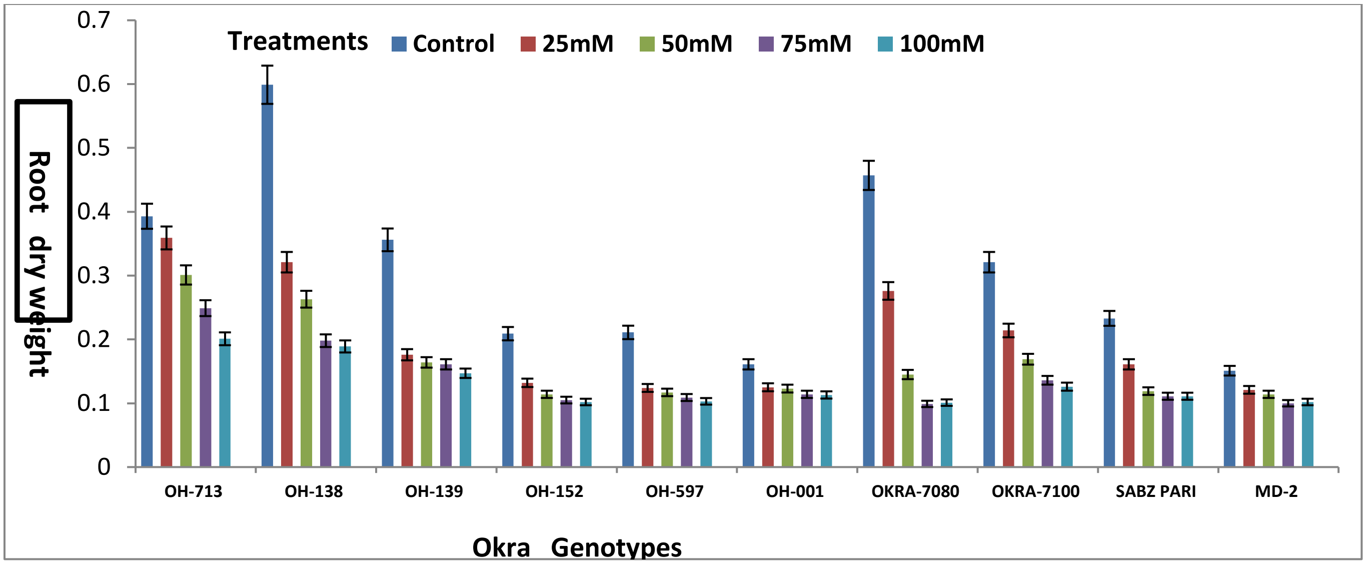

Fig 7 Effect of different levels of salt stress on root dry weight of different okra genotype

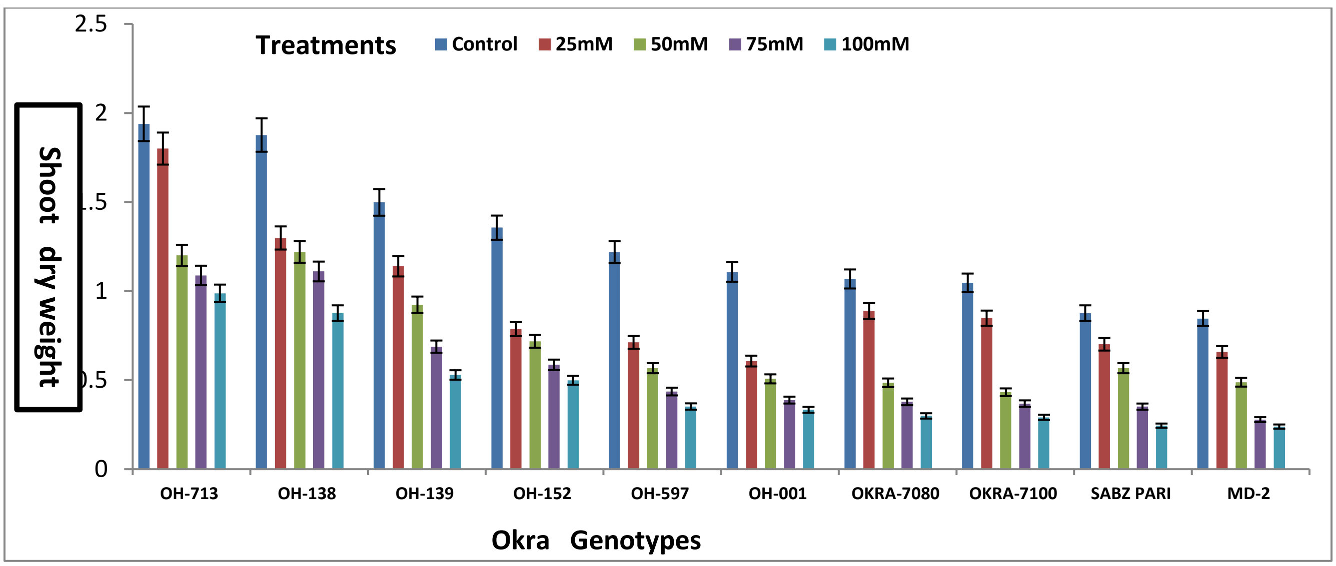

Fig 8 Effect of different levels of salt stress on shoot dry weight of different okra genotypes

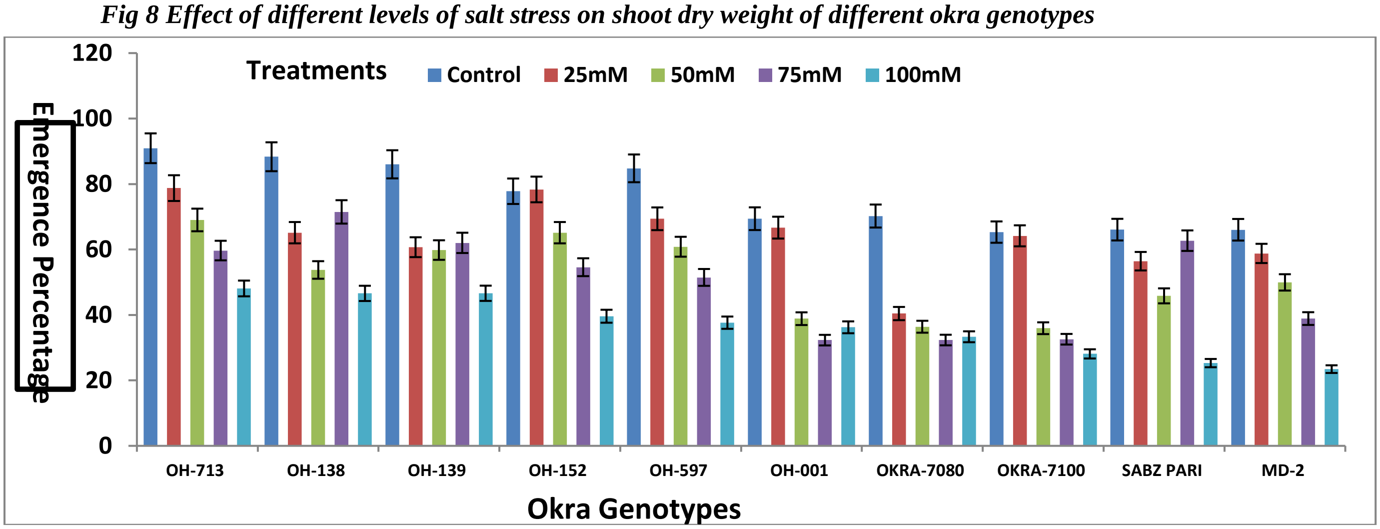

Fig 9 Effect of different levels of salt stress on plant height of different okra genotypes

[Citation: Ahmad, W., Raza, M.H., Azeem, A., Abbas, T., Anjum, S., Wahocho, N.A., Jamali, M.F., Sultan, S.M. (2024). Assessment of diversity among Okra (*Abelmoschus esculentus*) genotypes under Salt stress. *Biol. Clin. Sci. Res. J.*, **2024***: 1387*. doi: https://doi.org/10.54112/bcsrj.v2024i1.1387]

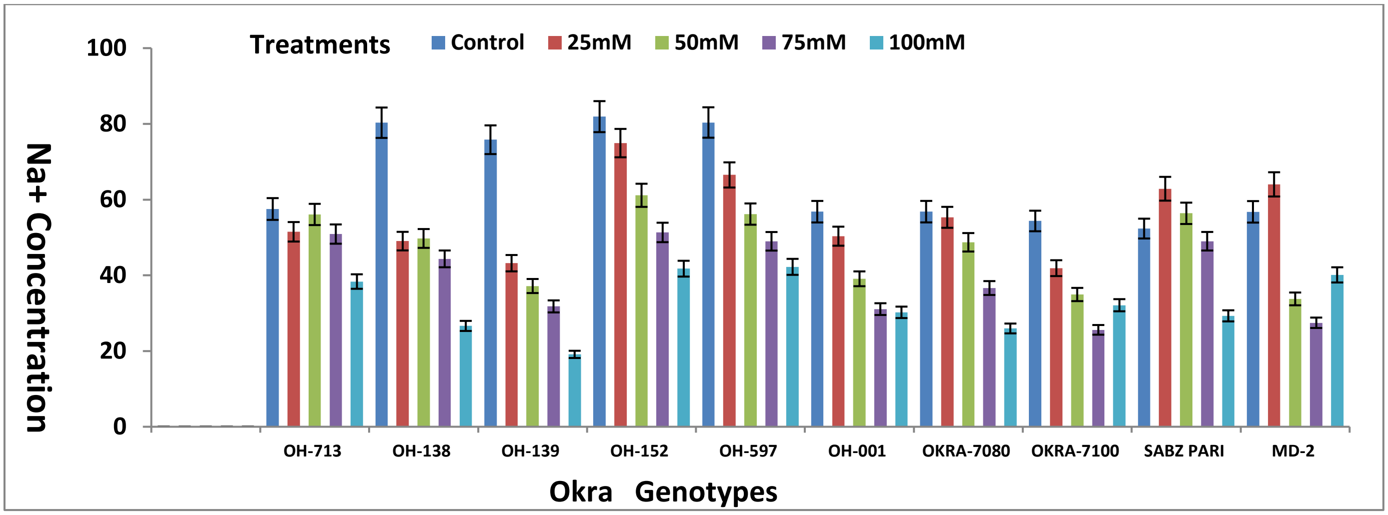

Fig 10 Effect of different levels of salt stress on Na+ concentration of different okra genotypes

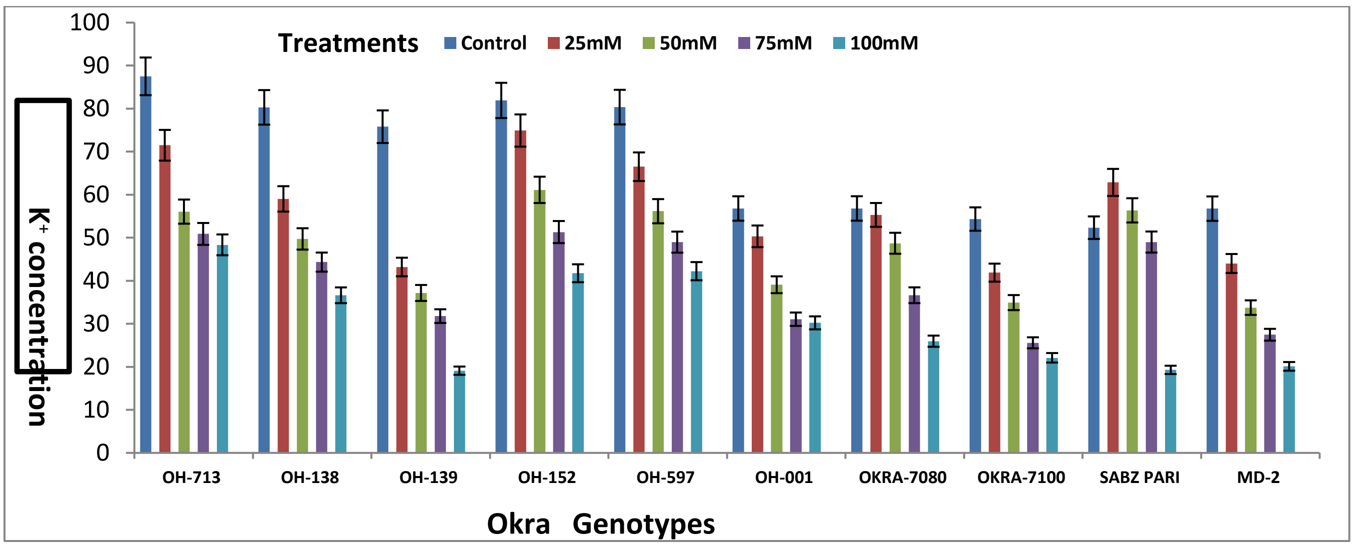

Fig 11 Effect of different levels of salt stress on K^+ concentration of different okra genotypes

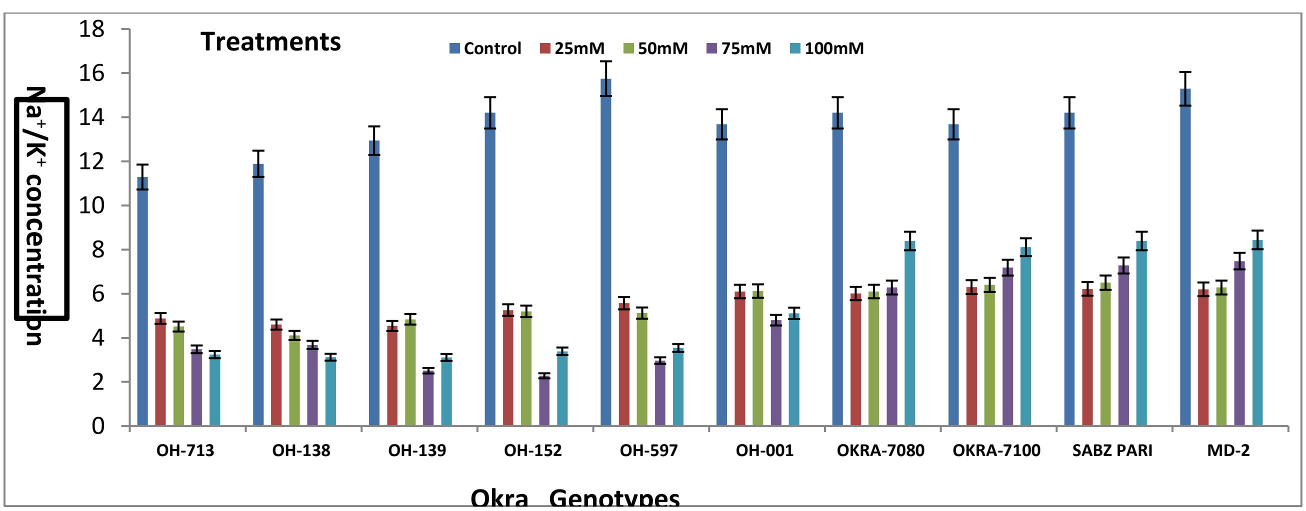

Fig 12 Effect of different levels of salt stress on Na^+/K^+ concentration of different okra genotypes

The maximum root length was 10.65 cm attained by 25mM of NaCl as compared to the others which

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induced a positive effect on the root growth further 50mM showed 7.30cm and in 100mM root length is observed 5.85 cm. It showed that with increasing the salinity level the root length also decreased. Enhancements in cations and NaCl particularly in the soil generate exterior osmotic likely with the purpose to avoid or decrease the influx of water into the root therefore the growth of the root and plant is slow down. The ensuing water scarcity is related to deficiency circumstances and 17 moreover compounded via the existence of Na+ ions (Bohnert, 2007). Immoderate salinity influences flowers in major ways: excessive application of salts inside the earth upsets the capability of roots to take out water, and immoderate concentrations of salts within the plant itself can be poisonous, resulting in an inhibition of many physiological and biochemical tactics together with nutrient uptake and assimilation (Tester, 2008). The salt-precipitated inhibition of the uptake of important minerals vitamins, which encompass adequate+ and Ca2+, similarly reduces root cellular increase however amplify the adventitious roots for uptake of water below salt strain. (Larcher, 1980). Roots help to restore the plant optimistically inside the floor, consequently lending them guidance and strength. Roots absorb nutrients, water, and minerals from the soil and behavior them to the stem because they play a vital function inside the vitamins of a plant. The outcomes show that every consequence regarding root length have been notably vast in which through T0 (manage) and T1 (25mM NaCl) showed higher outcomes. Salt strain foundation an extensive lessen inside the sprout root length of the entire tested okra cultivars (figure 3). Cultivars i.e. OH- 713, OH 139, OH-138, and OH-001 have been with the most tolerant institution and middle tolerant organization blanketed OH-152, and OH-597. The lower medium tolerant group included Okra 7100, Okra-7080, and Sabzpari. Statistical analysis showed highly significant results regarding the effect of different levels of salt stress on the root length of okra at a 5% probability level (Figure 4). The result in terms of treatment use showed treatment height T4 (100mM NaCl) with a short Shoot length (6.32 cm) followed by T0 (control) and T1 (25mM NaCl). On the other hand, the highest root length (18.77 cm) was observed in T0 where NaCl Concentrations were used as a control distilled water treatment and T1 (25mM NaCl) (Fig. 5). Salt stress significantly affected on shoot length of pepper plants. The plants that were under control and 25 mM salt stress showed more length of the shoots 18.77 cm. The plants that received 50 mM salt showed a 16.00 cm shoot length and the plant under 100 mM salt stress showed a minimum shoot length of 9.22 cm. The results show that all results in terms of root length are very important whereas T0 (control) and T1 (25mM NaCl) showed better results. The salinity caused a significant reduction in seedling roots of the entire varieties of okra tested (Figure 6). OH-152 and OH-597. The lowest tolerant group included Okra 7100, Sabzpari, Okra-7080, and MD-02. Shoot blooming is extra sensitive than root development to salt- encourage osmotic pressure probable while a discount within the leaves place expansion absolute to root growth might lower the water use via the plant, therefore permitting it to preserve top soil humidity and save you salt attention in the soil (Munns and Tester, 2008). Reduction in shoot boom because of salinity is normally articulated by using a compact leaf vicinity and undersized shoots. Salinity influences each vegetative and reproductive improvement which has thoughtful inferences counting on whether or not the harvested organ is a stem, leaf, root, shoot, fruit, fiber, or grain. Salinity regularly reduces shoot growth greater than root growth (Lauchli and Epstein, 1990). However, in cutting-edge have a look at a contradictory reaction became noted which implemented most shoot periods at the same time as the maximum degree of salt pressure have become applied in vegetable plants. It is probably because of a beneficial effect of sodium.

The collected data about fresh weight of roots to be presented to statistical analysis and results of analysis of variance (ANOVA) were markedly significant (Table 2). Comparison of means at a 5% probability level showed that the highest fresh weight of roots NaCl levels and confirmed to be salt-sensitive cultivars (Figure 7). Maximum root fresh weight was experiential in OH-713 and minimum root fresh weight was noted in MD-2 in control (0 mM NaCl), 25 mM NaCl, 75 mM NaCl, and 100 mM NaCl levels of salt stress (Figure 8). The seedlings of flora grown beneath high NaCl surroundings exhibited a reduction in fresh weight as compared to those underneath manipulate and sodium chloride degrees situations, moreover, in the present observation this decrease changed in proportion to the growth in salinity stages from (25 mM) to better (100 mM). The interaction between salinity and cultivars became vast. From the results are obtained and made that below excessive NaCl conditions cultivars i.e. OH-597, OH- 713 are sensitive to salt even as MD-2 and Sabzpari are enormously sensitive to salt pressure. Salt stress significantly affected root weights in okra plants. The plant that was under 25mM salt stress showed more weight of roots as 2.336g. The plants that received 50mM salt gave roots with less weight of 1.669 g. The plant under 75mM and 100mM salt stress showed a minimum weight of roots 0.328g. Both osmotic and ionic stresses can cause short development and a compact plant yield, total weight of fruits and the irrigation with salty water is one of the principal factors that lead to salt gathering and front to a reduction in agriculture efficiency as plant weight and size (Munns, 2002). However, the level of stress applied significantly influences the plant characteristics fruit quality and morphological attributes.

The experimental data about the fresh weight of roots was subjected to statistical analysis where the results of the analysis of variance were greatly significant (Table 3). The maximum root fresh weight was noted in OH-597 which was 8.74 g and minimum root fresh weight was observed in MD-2 which was 2.02 g in control 0 mM NaCl, 25mM NaCl, 75mM NaCl, and 100mM NaCl levels of salt stress. Salt stress significantly affects the fresh weight of plants like shoot fresh weight plants. Okra plants that received 0mM and 25mM Salinity levels showed more weight of shoot fresh weight and showed less shoot fresh weight as compared to others so, 25mM proved to be an optimum salinity level regarding shoot fresh weight. Plants with 75 and 100 mM showed less fresh weight. With an increasing salinity level, the shoot fresh weight and the root fresh weight decreased drastically. There was 60-78% decline in shoot fresh weight at a different level of NaCl, However, 17- 53% of shoot fresh weight lessening at related high levels of NaCl against control in most plants (Shereen *et al*., 2001). It can be depicted from the results stated below that salt stress up to 75mM proved to be non-beneficial while a further increase in salt stress level reduced plant fresh weight. At higher levels of salinity, plants show many physiological effects in which stunted growth is most common due to the lack of availability of many vital nutrients that are necessary for usual plant growth and development. Consequently, accumulation of excessive salt ions can cause death of plant tissues, and organs which can cause reduced fresh weight of many plants. The data regarding root dry weight was collected and analyzed statistically at a 5% possibility level. The analysis of variance (ANOVA) showed better results. The results indicated that the okra genotype OH-138 shows a maximum root dry weight 0.599 g at different levels of salt stress e.g 0mM, 25mM, 50mM, 75mM and 100mM and genotype okra-7080 lies on the second number regarding root dry weight as its weight was 0.457g while OH-001 and MD-2 show least dry weight 0.161 and 0.152 g respectively. Roots of plants are continuously in touch with soils containing toxic salt ions, which hinders in proper growth and development of roots this exposure of roots to toxic ions ultimately reduces biomass production. Under salinity stress, absorption of CO_2 by plants is decreased, as it acts as a major source of energy for growth, so reduced CO_2 levels also reduce biomass production. An increase in salinity level decreases the plant's dry weight due to less availability of mineral nutrition. Roots of plants are continuously in touch with soils containing toxic salt ions, which hinders in proper growth and development of roots this exposure of root to toxic ions ultimately reduces biomass production. Salinity inflated together with fresh and dry weight of the shoot also osmotic potential showed a significant decline through the swell in concentration and duration of salt stress period, although many studies have sharp to the optimistic result of sodium chloride on the fresh and dry weight of plants (Jamil *et al*., 2007). Salt stress significantly influenced the dried mass of plants. The plants that were under less salt stress showed more dry weight. The plants that received more salt stress showed minimum root dry weight. The cultivars that showed a minimum reduction in dry weight can be classified as salt tolerant and those that showed maximum reduction can be designated as salt sensitive genotypes.

The data about shoot dry weight was collected and analyzed statistically at 5% possibility level (ANOVA) and showed results at 5% probability level. According to results presented in (figure 8), the treatment salt treatments i.e. 25mM NaCl, 50mM NaCl, 75mM NaCl and 100mM NaCl the okra genotypes OH-713 showed maximum shoot dry weight and other genotypes including Sabzpari & MD-2 and okra -7080 showed minimum shoot dry weight. The use of high salt stress treatments shows poor results in salt sensitive genotypes while salt tolerant genotypes perform well in high salt levels also. Shoot fresh and dry weight (leaves and branches) is a parameter used to evaluate the total biomass of plants which directly impacts the morphology, growth, quality and quantity (Golzarian *et al*. 2011). These results are in line with many scientists who reported that an increase in salinity causes reduced plant fresh and dry weight. Salinity is associated with alteration in many traits, which include osmotic stress, specific ion effect, ion imbalances, and nutrient deficiency, hence salinity affects many physiologically related to plant growth and development. At higher levels of salinity plants show many physiological effects in which stunted growth is most common due to the lack of availability of many vital nutrients that are necessary for regular plant growth and development. Consequently, accumulation of excessive salt ions can cause death of plant tissues, and organs which can cause compact fresh weight. The data about plant height was collected and analyzed statistically showing results at a 5% probability level (Table 4.6). Comparison of means at 5% probability level showed that maximum fresh weight of shoots NaCl levels and proved to be a salt sensitive cultivars Results regarding plant height of okra genotypes indicate that greatest plant height (18.02cm) was obtained in OH-713 genotype plants which were treated with control treatment 0mM distilled water, 25mM and 50mM, 75mM and 100mM NaCl salt levels while the lowest plant height was observed in Sabzpari and MD-2 (9.33cm to 1.99 cm) was seen in 25,50,75 and 100mM salinity (Figure 9). Okra genotype OH-713 showed the highest values of plant height (18.02cm) whereas MD-2 represented the minimum plant height (9.33cm). Interaction of salinity and okra genotypes showed that the highest plant height (18.33cm, 16.18cm, 14.29cm, 13.55and 9.44cm) was observed in OH-713 under control, 25mM, 50mM, 75 mM and 100 mM salinity respectively. A decline in height can be due to concentrated nutrients availably and water shipping to aerial parts of a plant, due to impaired and minimum root growth under salinity stress (Greenway & Munns R1980). In many scientific studies, it has been proved that growth characteristics like shoot length, height of plants, length of shoots and roots were badly affected by enlarged salinity levels and plants showed stunted growth. The decreased water potential in saline soils gives rise to lower cell turgor values, which causes minimal elongation and division of cells. The vegetative growth of a plant is a key factor that decides the salt sensitivity of plants. It is a proven fact that the height of a plant is controlled genetically but many environmental factors also control the manifestation of these genes. The present study demonstrates the said response of genes towards environmental conditions such as salinity. Lower plant height of okra plants at higher salinity levels indicates that plants were unable to adjust osmotically to growing conditions, due to which plants failed to uphold required cell growth.

Na^+ concentration and K^+ concentration and Na^+/K^+ ratio

In all genotypes, a rise in external NaCl concentration influenced the leaf K^+/Na^+ absorption ratio considerably, except the diversity between genotypes and duplication was non-significant. The 04 NaCl concentrations were statistically different from one each, and the relations expression among genotypes and NaCl concentrations was also significant. As expected, higher salinity negatively influenced the K^+/Na^+ ratio to varying degrees in various varieties. Results of current study revels increased amounts of Na+ Ion at higher levels of salinity i.e. 100, 75 and 50mM salinity. Maximum Na^+ Ion concentration (72.76, 69.35 and 64.34 mg/g) was obtained in Sabzpari, MD-2 and okra-7080 which was salt sensitive while salt tolerant okra genotypes like OH-713,OH-138, OH139, and OH-152 show minimum Na^+ Ion i.e.(45.51, 39.3,51.81 and 51.91 mg/g). Data concerning the interaction of genotypes and salinity reveals that salt sensitive genotypes showed maximum Na^+ whereas salt tolerant genotypes showed minimum Na^+ concentration at control, 25mM, 50mM, 75mM and 100mM salinity respectively. From the finding results it is observed that high salt concentration in soil increases the Na^+ Ion in leaves of okra plants. Na^+ Ion accumulation is common phenomenon in plants under saline conditions. Salinity stress causes a significant effect on a variety of ionic qualities. It was observed that salinity stress elevates Na^+ ion concentration in leaves. Plants that are tolerant to salinity have the lowest amounts of Na ions by a mechanism of deposition of toxic ions in roots and leaves (Shaheen S, *et al*., 2013). Figures 10-12 indicates higher K^+ concentration was observed in control (0 mM NaCl), 25mM, 50mM as stability to 75mM, and 100mM NaCl salt stress levels, while less K^+ concentration was reported at 100 mM NaCl salt stress level; among varieties greater K^+ concentration was observed in OH-713 and less K^+ concentration was trace in MD-2 while other genotypes were statistically not significant with each other. While at 0, 25, 50, 75, and 100 mM NaCl stress levels, increased saline pressure deliberation increased Na^+/K^+ ratio in all cultivars, interactive effect (salt stress varieties) revealed that statistically maximum Na^+/K^+ ratio was recorded in salt tolerant okra genotypes and minimum Na^+/K^+ ratio was recorded in salt sensitive okra genotypes. Plants maintain high K^+ concentrations when exposed to salt and low concentrations of Na^+ in the cytosol. Plants control the expression and activity of K^+ and Na^+ transporters, as well as H+ pumps, which create the required pressure for ion delivery (Zhu, 2003). A higher level of salt tolerance in plants was discovered to be linked to a more effective device for selective absorption of k^+ over Na^+ (Neill *et al*., 2002). In many plant species, preferential absorption of K^+ in contrast to Na^+ was thought to be one of the key physiological mechanisms leading to salt tolerance (Poustini and Siosemardeh, 2004). Less than salinity stress an antagonistic effect establish between toxic Na ions and useful ions. Due to this effect accumulation of Na ions renders the entry of other useful ions in plants from soil solution which results in a drop of K ions in plants.

Conclusion

The data regarding germination and emergence percentage showed the highest survival percentage (80.00% and 90.01%) when plants were treated with control, (T1)25 mM NaCl (T2) 50mM respectively as compared to other treatments. The maximum plant height (18.02 cm) was obtained in OH-713 and different levels of salt stress this perform well as compared to other varieties. Whereas other

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treatments were statistically showed the lowest height in Sabzpari and MD-2 (9.33 to 1.99 cm). Results regarding the application of treatment on root length showed superiority of treatment T1 (25mM) with maximum root length (10.65 cm) followed by T4 (100mM). Similarly, the maximum fresh weight of roots (1.96 g) was observed OH-713 at T1 (25mM) followed by T4 (100 mM) with 0.987 g of root fresh weight. Results indicated that Okra genotype OH-713 gave the maximum dry weight of root (0.321 g) as compared to other treatments. The Na+ and K+ concentrations also demonstrated that OH-713 Received fewer Na+ ions at different levels of salinity as compared to genotypes while Sabzpari and MD-2 got more Na+ ions which was not beneficial for plant growth. K+ ion concentration was high in OH-713 and low K+ concentration was found in Sabzpari and MD-2 so from this it is clear that the okra genotype OH-713 performs well in all parameters at all salt stress levels as compared to other genotypes.

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All authors contributed equally.

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