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Appraisal of varieties in development and ionic concentration of salt tolerant and delicate cotton genotypes

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This research compared the performance of 10 cotton genotypes against salinity when grown in solution culture using Hoagland's nutrient solution. There were three treatments in a two-factor factorial statistical setup: control, saline (100 and 200 mol m-3 NaCl), and three replications. Salinity levels of 100 and 200 mol m-3 NaCl reduced shoot and root length, shoot fresh and dry weight, root fresh and dry weight, chlorophyll contents, water potential, leaf area, and Na+ and K+ in leaf sap substantially. Based on physical and chemical criteria, it was determined that BH-172 was salt tolerant, whereas VH-277 was susceptible.

Keywords: cotton genotypes, salinity, hydroponic (solution culture)

INTRODUCTION

Salinity is a key issue that reduces agricultural productivity globally. Salinity affects agricultural production on 77 million hectares of land, with 45 million hectares (20 percent of irrigated area) irrigated and 32 million hectares (2.1 percent of dry land) unirrigated (Ashraf and Bhatti 2000, Gholamin and Khayatnezhad 2020, Li, Mu et al. 2021, Sun, Lin et al. 2021). Ashraf and Bhatti., 2000 Excessive salt buildup in semi-arid and dry soils is a possible factor limiting irrigated agricultural yield. Low precipitation combined with excessive evapotranspiration causes salt buildup in the root zone, impeding plant development. The salt-affected irrigated districts of the Indus Basin have been expected to lose 20 billion rupees due to lower agricultural output (Anonymous. 2007-2008). Reclamation can be used to manage salt-affected soils, however owing to a lack of excellent quality water, limited soil permeability, and the high cost of additives, this strategy is not practicable on a broad scale (Khayatnezhad and Gholamin 2021, Yin, Khayatnezhad et al. 2021, Zheng, Zhao et al. 2021). Biosaline techniques are more beneficial to both the soil and the ecosystem. Salinity tolerance varies amongst plant species. Some plant species are salt resistants, such as barley, cotton, and sugar beet; others are moderately tolerant, such as rya, sunflower, sorghum, and soyabean; and yet others are salt sensitive, such as carrot, okra, onion, and peas (Curtis and Läuchli 1985). Cotton (Gossypium hirsutum L.) is one of Pakistan's major economic crops. It has been instrumental in industrial growth and job creation. It is often regarded as the backbone of Pakistan's economy. Pakistan is one of the world's oldest cotton cultivators, the fourth biggest producer, and third-largest exporter of yarn. Pakistan is primarily a mono-crop economy, with cotton accounting for 7.5 percent of agricultural value added and around 1.6 percent GDP. In 2008-09, three Asian nations (China, India, and Pakistan) are predicted to produce more than half (59%) of the world's cotton (Anonymous. 2007-2008). Cotton may be grown on moderately salty soils, although its yield and quality are much lower than typical soils. Although cotton is thought to be reasonably resistant of salt, its production is significantly decreased in saline circumstances due to poor germination and subsequent aberrant plant growth (Khan, 1998). In saline soils, Na+ and Cl- are the dominant ions affecting plant growth (Gholamin and Khayatnezhad 2020, Bi, Dan et al. 2021, Ren and Khayatnezhad 2021). Under saline conditions, the activities of some essential nutrients may also be reduced (Gorham, McDonnell et al. 1984, Gregorio and Senadhira 1993) and the plant itself may suffer from nutrient deficiencies. It is now well established that some plant species can withstand high salt (Si, Gao et al. 2020, Khayatnezhad and Gholamin 2021, Xu, Ouyang et al. 2021). In some agricultural plants, low sodium absorption is associated with salt tolerance (Karasakal, Khayatnezhad et al. 2020, Hou, Li et al. 2021, Huang, Wang et al. 2021). Significant variations have also been documented across varieties of many species, including wheat (Habib, Akram et al. 2014, Hussain, Shah et al. 2020) and cotton (Karasakal, Khayatnezhad et al. 2020, Hou, Li et al. 2021, Huang, Wang et al. 2021, Sun and Khayatnezhad 2021, Tao, Cui et al. 2021). By decreasing inputs, increasing plant tolerance to salt may help maintain production stability in subsistence agriculture and prevent salinization caused by irrigation (Khayatnezhad and Nasehi 2021, Zhang, Khayatnezhad et al. 2021). Ibrahim (2003) discovered that salt tolerance in cotton (*Gossypium hirsutum* L.) appears to be connected to the buildup of Na+ and Cl- in the shoot. This research is planned to;

1. To look at a different set of cotton genotypes to see if they are tolerant to salinity stress.
2. To figure out what plant traits make cotton genotypes more resistant to salinity stress.

MATERIALS AND METHODS

During 2018, the experiment was carried out under natural settings in a wire house at the Semnan Agriculture Research Centre, University of Semnan, Iran. Ten cotton genotypes were studied for salt tolerance: GS-14, MG-06, NIAB-852, CIM-496, CIM-557, BH-172, NIAB-2008, RH-620, NIAB-777, and VH-277. Cotton genotypes' delinted seeds were sowed in polythene-lined iron trays (60 x 30 x 5 cm) containing washed sand. For the first three days, tap water was utilized to keep the soil wet enough for germination and seedling. After emergence, seedlings were dusted with Hoagland's nutritional solution at half strength. Plants were transplanted in rectangular 200 L capacity iron tubs coated with polythene sheets at two-leaf stage (nearly ten days old nursery) in foam blocked holes in polystyrene sheets floating over half-strength Hoagland's Nutrient solution (Lauchli and Stelter 1982, Kent and Läuchli 1985). The experiment was designed in a factorial layout with three repetitions and was totally randomized. Salinity was produced progressively in three equal increments using NaCl salt after three days after transplanting, with ultimate salinity values of 100 and 200 mol m-3. The ph was adjusted at 6.00.5 by regularly adding HCl (1N) or NaOH (1N). Throughout the trial, solutions were changed every 15 days. Every day, the solution was aerated for eight hours. Plants were gathered five weeks after salinity was imposed. Shoot length, root length, fresh and dry weights of the shoots, root fresh and dry weights, and leaf area were all measured. Younger leaves that had fully expanded were gathered and preserved in the freezer. The leaf samples were thawed, smashed with a metal rod, and centrifuged to get the leaf sap, which was used to determine Na+ and K+ (Gholamin and Khayatnezhad 2020, Ma, Ji et al. 2021, Zhu, Liu et al. 2021). The experiment's data were statistically analyzed (Rehman, Harris et al. 1998).

RESULTS AND DISCUSSION

Effect of Salinity on Shoot Growth

Figures depicting the impact of salinity on shoot growth are shown below. Figure 1 revealed that salinity reduced the shoot length of all cotton genotypes compared to the control, as shown in the figure.

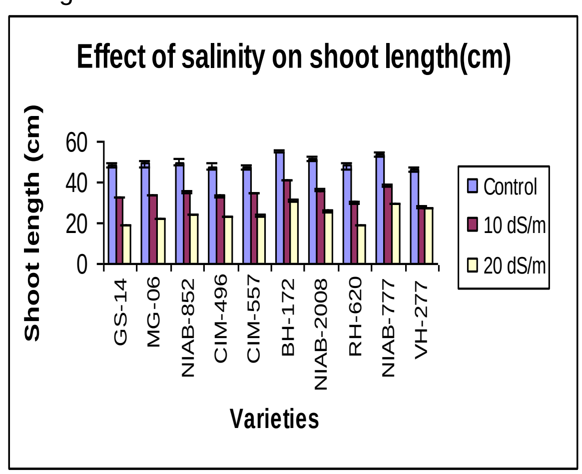

Figure 1: Effect of salinity on shoot length (cm)

Fig. 1 indicated that BH-172 had the longest shoots, whereas VH-277 had the shortest shoots among the various genotypes. Due to the high salt content in the soil, the cell wall of plants becomes more rigid as they mature, which may explain why plants cultivated in seawater have a lower elasticity than those grown in freshwater. The turgor pressure efficiency of cell expansion decreases when secondary cell walls form sooner and become stiff (Jia, Khayatnezhad et al. 2020).

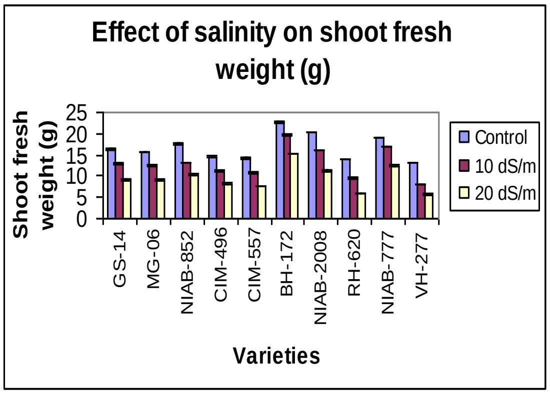

Figure 2: Effect of salinity on shoot fresh weight (g)

As stated by (Kent and Lauchli, 1985)(Gholamin and Khayatnezhad 2021), other possible explanations of this decline include cell content shrinkage, decreased tissue growth and differentiation, imbalanced nutrition, membrane damage, and a disrupted avoidance system. Compared to the control, salinity considerably reduced the fresh shoot weight of all genotypes, as shown in fig. 2. The most considerable shoot fresh weight was generated by BH-172, while VH-277 produced the least. High salt and chloride concentrations in the rooting media may inhibit K+ and Ca2+ absorption and, as a result, growth. Gorham and Wyn Jones (Karasakal, Khayatnezhad et al. 2020).

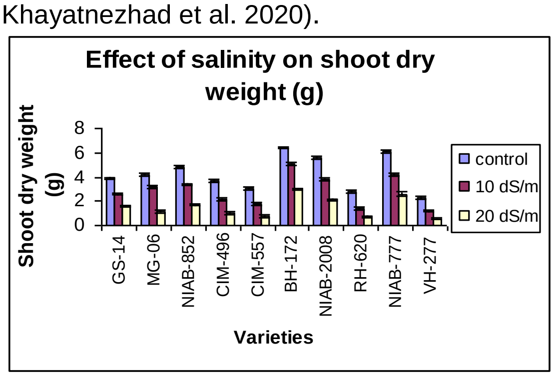

Figure 3: Effect of salinity on shoot dry weight (g)

Another potential explanation for the decrease in shoot fresh weight with increased salt is decreased leaf emergence (Khayatnezhad and Gholamin 2020), leaf expansion, and final leaf area (Wang, Shang et al. 2021). Salinity also reduced the shoot dry weight of all genotypes considerably when compared to the control, as seen in fig. 3. The greatest shoot dry weight was created by BH-172, while the smallest shoot dry weight was produced by VH-277. This drop in shoot dry weight under salty circumstances was related to decreased growth as a consequence of decreased water intake, sodium and chloride toxicity in the shoot cell, and decreased photosynthesis (Saqib, Akhtar et al. 2002). Osmotic synthesis to endure salt stress consumes a large amount of carbon and inhibits metabolite synthesis, resulting in a drop in biomass output (Cheng, Hong et al. 2021).

Effect of Salinity on Root Growth

The data supplied represented the root length of several cotton genotypes at various NaCl concentration levels, as seen in the figures. Overall, all genotypes' root length (RL) reduced considerably as NaCl salinity increased.

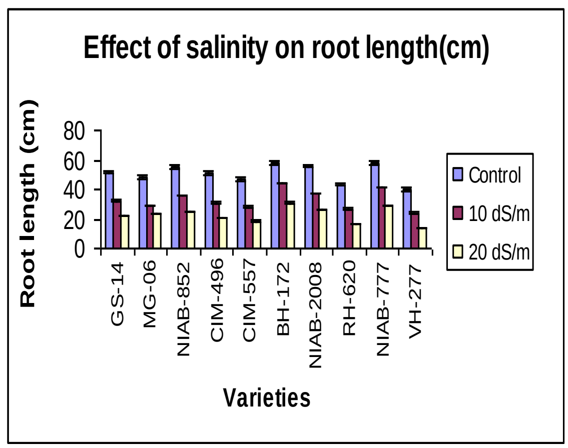

Figure 4: Effect of salinity on root length (cm)

Figure 4 indicates that when salinity levels rose, root length decreased drastically. The greatest root length was found in BH-172, while the lowest was found in VH-277. According to their results, salt has a detrimental influence on water transport and lowers hydraulic conductivity (30-60%), both of which limit root length. Na+ and Cl- in the fertilizer solution may induce root length decrease in reaction to salt.

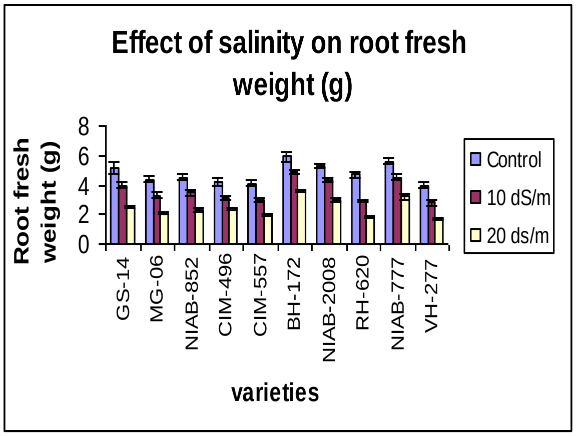

Figure 5: Effect of salinity on root fresh weight (g)

High Na+ concentrations reduce root permeability and integrity by displacing Ca+2 from the plasmalemma, restricting root development and length. Ibrahim et al. (2003) and Ashraf (2000). Salinity affects root fresh weight, as seen in fig. 5. The highest root fresh weight was found in BH-172, while the lowest was found in VH-277. The decrease in fresh root weight caused by salinity may be attributable to a reduction in water availability to plants caused by a drop in osmotic potential at the root surface (Gholamin and Khayatnezhad 2020, Guo, She et al. 2021). The decrease in fresh root weight might potentially be linked to ion toxicity and nutritional imbalance (Peng, Khayatnezhad et al. 2021). Salinity also reduced root dry weight, as illustrated in fig. 6.

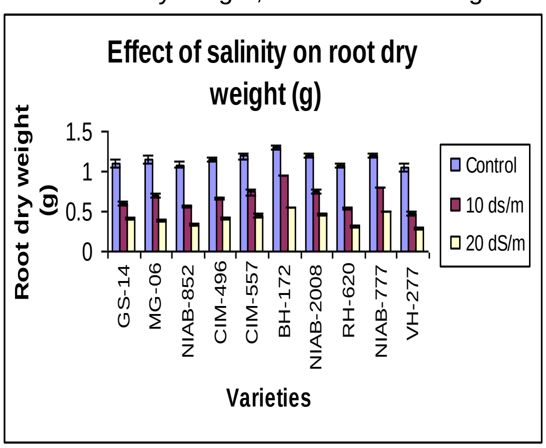

Figure 6: Effect of salinity on root dry weight (g)

At all salinity levels, genotype BH-172 had the highest root dry weight, whereas genotype VH-277 had the lowest root dry weight. Saqib (1999), Ashraf and Ahmad (2000), and Ibrahim et al. (2003) all showed reduced root dry weight (RDW) with increasing salinity in cotton. The decrease in root dry weight (RDW) under saline circumstances was caused by decreased growth as a consequence of decreased water intake, as well as toxicity of Na+ and Cl- in root cells (Zhu, Saadati et al. 2021). Reduced root dry weight (RDW) was associated with decreased root fresh weight (RFW). High Na+ and Cl- concentrations in rooting media may inhibit K+, Ca+2, and NO-3 absorption and, as a result, growth (Gorham and Wyn Jones, 1984).

Effect of Salinity on Na+ and K+ Concentration (mol m^{-3}) in leaf sap of Cotton genotypes

Figures depict the influence of salinity on the chemical composition of leaves. The findings revealed that the salt content in the leaves of all cotton genotypes rose with increasing salinity, as shown in fig. 7. Compared to the control, the saline treatment had the highest sodium concentration. The highest sodium content in leaf sap was found in VH-277, while the lowest was found in BH-172. The rise in sodium content in leaves with increasing salinity was linked to an increase in sodium ion in rooting media, passive Na+ diffusion via damaged membranes and a reduction in exclusion mechanism effectiveness.

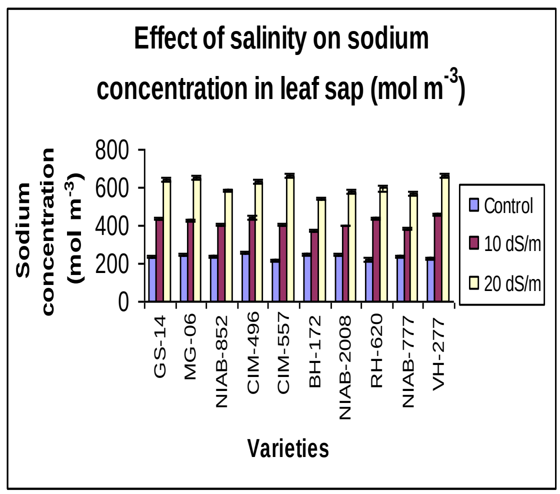

Figure 7:Effect of salinity on sodium conc. in leaf sap (mol m^{-3})

Furthermore, the rise in Na+ concentration might be attributed to increased sodium ion absorption to raise osmotic pressure. Because Na+ is a monovalent cation, it is particularly efficient for osmotic correction (Khayatnezhad and Gholamin 2020). Figure 8 shows that a significant reduction in potassium concentration in cotton genotype leaves in saline was observed compared to the control. The highest potassium content was found in BH-172, while the lowest was found in VH-277. Because high sodium concentrations displaced calcium from the plasmalemma, resulting in membrane integrity loss and cytosolic potassium efflux, potassium concentrations in leaves declined (Ma, Khayatnezhad et al. 2021). Potassium selectivity for absorption may explain the high potassium content in leaves (Steele and Torrie 1980).

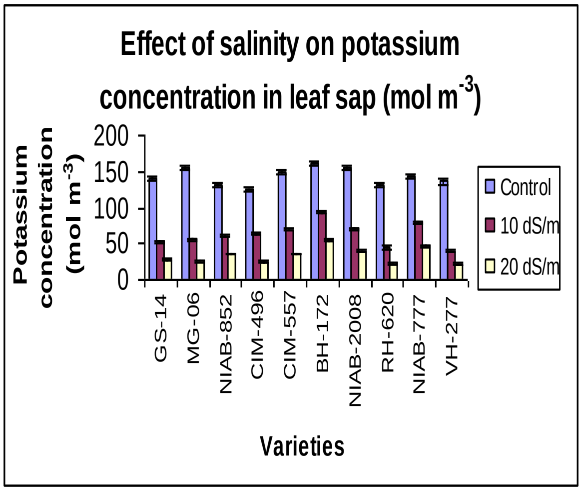

Figure 8: Effect of salinity on potassium conc. in leaf sap (mol m^{-3})

It's thought that salt tolerant cultivars' higher growth performance in saline circumstances was due to effective osmotic adjustment and a better ionic equilibrium in terms of Na+ and K+.

CONCLUSION

Following genotypes were shown to be resistant based on physical (shoot length, shoot fresh weight, shoot dry weight, root length, fresh root weight, root dry weight, and leaf area) and chemical (Na+ and K+) factors.

BH-172, NIAB-777, and NIAB-2008 were salt-tolerant at a NaCl concentration of 100 mol m-3, but VH-277 and RH-620 were salt sensitive. BH-172, NIAB-777, and NIAB-2008 were generally salt-resistant at 200 mol m-3 NaCl concentrations, but VH-277 and RH-620 were salt-sensitive once again.

In saline soils, BH-172 and NIAB-777 were the most effective. Its leaf sap had a greater K+ concentration and a lower Na+ concentration. It possessed a significantly superior Na+ mechanism, in other words. It possessed a superior K+ maintenance mechanism in its leaves simultaneously.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Masoud Radmanesh conducted, planned, Analyzed the data, wrote manuscript and interpreted the results and involved in manuscript preparation. All authors read and approved the final version.

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