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Research Article

Evaluation of salt tolerance in local varieties and foreign collection samples of chickpea (*Cicer arietinum* L.)

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Abstract
In this research, 20 samples, including local chickpea varieties and foreign accessions, were subjected to control treatment (distilled water) and varying concentrations of Na_2SO_4 (0.5%, 1%, and 1.5%) under thermostat conditions to assess their salinity tolerance. The results showed that plant growth, particularly the seedling development during germination, is highly sensitive to salt stress. According to the analysis, several local varieties—Guliston, Lazzat, and Iftikhor—as well as foreign accessions—SSA-2, SSA-10, SSA-11, SSA-12, SSA-16, SSA-18, SSA-19, SSA-34, SSA-35, and SSA-36—were identified as salt-tolerant. In Na_2SO_4 solutions with concentrations of 1% and 1.5%, significant reductions in germination rate, stem length, and root length were observed compared to the control and 0.5% salt concentration. In the above-mentioned salt-tolerant samples, the seedling vigour index decreased by 24.85% under low salinity (0.5% Na_2SO_4), by 73.13% under moderate salinity (1% Na_2SO_4), and by 89.82% under high salinity (1.5% Na_2SO_4). These reductions indicate that increasing salt concentrations substantially slow down the growth and development of chickpea plants, even in relatively tolerant genotypes.
Keywords: *Cicer arietinum* L., chickpea, salt-stress, germination, seedling

Introduction
In crops, the reduction in yield due to abiotic stresses such as salinity, drought, cold, and heat is one of the main problems in meeting the demand for food. Non-compliance with agrotechnical rules and the use of recycled water for irrigation are causing the expansion of soil salinity due to the increase in salt content (Kumar and Sharma, 2020). High salt concentrations in saline soils

inhibit plant growth and development. Calcium, sodium, and magnesium sulfates and chlorides are usually associated with the development of soil salinity, with Na salts having a higher harmful effect on plants (Bryla *et al.,* 2021; Wu *et al.,* 2023).

Chickpea (*Cicer arietinum* L) is a legume cultivated in arid and saline regions worldwide. Chickpea cultivation is important in maintaining soil fertility, especially in arid regions. Chickpea seeds contain 40-55% carbohydrates, 13-33% protein, and 4-10% fat (Stallknecht *et al.,* 2006). Compared to cereal crops, chickpeas are more sensitive to salt, and salinity causes osmotic imbalance in tissues due to the toxicity of specific ions, and disruption of nutrient absorption and hormonal interactions negatively affects plant growth and development (Patil, 2016). Increased salt concentration affects grain composition and yield, and increases necrosis and chlorosis in plant leaves, leading to a decrease in photosynthesis (Khan, 2017). Among all legumes, the drought and salinity tolerance of chickpea is also associated with the growth of leaf tissues, the xeromorphic structure, the presence of organic acids and a large amount of bound water (Germanseva *et al,* 2011). In saline soil conditions, plant growth and biomass depend on salt concentration, and the salinity tolerance of plants is not constant during the growth period and may vary at different growth stages depending on the plant species (Huang and Redmann, 1995). Some plants can adapt to this stress, which causes a decrease in normal plant growth and productivity (Gupta *et al.,* 2013). Although chickpea is sensitive to salinity stress, there are also resistant specimens in the chickpea gene pool (Turner, 2013).

To ensure the food security of the population and increase the efficiency of chickpea cultivation in Uzbekistan, it is important to select and introduce into practice high-yielding, large-grain, abiotic and biotic stress-resistant specimens.

It is necessary to assess the salt tolerance of cultivated crops for the arable lands of our region, where the soil is characterized by sulfate salinity. In our study, the salt tolerance of chickpea plants was assessed using solutions of different concentrations of Na_2SO4, and the germination and seedling vigor index were determined.

Materials and methods

The study was conducted in the Laboratory of Cereal Crop Genetics at the Institute of Genetics and Plant Experimental Biology. Under laboratory conditions, 10 seeds were selected from each sample. Chickpea seeds were sterilized in a 0.5% NaClO solution for 10 minutes using sterile distilled water, and then incubated in Petri dishes inside a thermostat at 25–26°C for 7 days. Seeds in the control group were treated with distilled water, while seeds in the experimental groups were treated with three different concentrations of Na_2SO_4 solutions: 0.5%, 1%, and 1.5%. Seed germination was assessed using the method described by Ramana et al. (2002), and the seedling vigour index (SVI) was calculated using the formula proposed by Abdul-Baki and Anderson (1973):

Seedling Vigour Index (SVI)=Total Seedling Length (cm)×Germination Percentage

The resulting data were analyzed using the ANOVA STATGRAPHICS-18 statistical software (www.statgraphics.com).

The objects of the study were chickpea accessions from the CIEN-SSA (Chickpea International Elite Nursery for Sub-Saharan Africa) world collection provided by the international organization ICARDA, and five local varieties — Guliston, Lazzat, Lalmikor, Iftikhor, and Xalima — selected from a competitive variety trial nursery consisting of 15 samples. The CIEN-SSA collection mainly comprises genotypes adapted to hot and dry climatic conditions, typical of sub-Saharan Africa — a region known for extreme heat, soil erosion, and desertification issues (Table 1).

Table 1. Local varieties and foreign collection samples of chickpea (*Cicer arietinum* L.).

Origin	Accession Code	Collection	№	Origin	Accession Code	Collection
Uzbekistan	Guliston	IGPEB	11	CIEN-SSA-11	FLIP14-53C	ICARDA
Uzbekistan	Lalmikor	IGPEB	12	CIEN-SSA-12	FLIP14-55C	ICARDA
Uzbekistan	Lazzat	IGPEB	13	CIEN-SSA-16	FLIP14-67C	ICARDA
Uzbekistan	Iftikhor	IGPEB	14	CIEN-SSA-17	FLIP14-68C	ICARDA
Uzbekistan	Xalima	IGPEB	15	CIEN-SSA-18	FLIP14-71C	ICARDA
CIEN-SSA-2	FLIP14-05C	ICARDA	16	CIEN-SSA-19	FLIP14-75C	ICARDA
CIEN-SSA-3	FLIP14-07C	ICARDA	17	CIEN-SSA-27	FLIP14-113C	ICARDA
CIEN-SSA-8	FLIP14-44C	ICARDA	18	CIEN-SSA-34	ILC 3279	ICARDA
CIEN-SSA-9	FLIP14-48C	ICARDA	19	CIEN-SSA-35	FLIP88-85C	ICARDA
CIEN-SSA-10	FLIP14-49C	ICARDA	20	CIEN-SSA-36	Local check	ICARDA

Results

As a result of changes in metabolites associated with active plant growth in saline environments, the growth process during the germination period becomes very sensitive to salt concentration.

It is important to determine the salinity tolerance of plants during the germination period of pea seeds (Cuartero *et.al.*, 2006). In our study, germination, root length, stem length, seedling length, and seedling vigour index were analyzed in laboratory conditions by treatment with Na_2SO_4 solutions. According to the results of the analysis, root length, stem length was relatively stable in salt-tolerant samples, while in salt-sensitive samples, a decrease in germination and a decrease in root and stem length indicators were observed.

The main physiological and biochemical processes in plants begin when plants germinate from seeds. In our experiment, changes in germination were observed in chickpea plant varieties and samples under salt stress. Germination in the control variants was 80-100%, in 0.5% Na_2SO_4 it was 40-100%, in 1% Na_2SO_4 it was 10-70%, and in 1.5% Na_2SO_4 it was 0-40%.

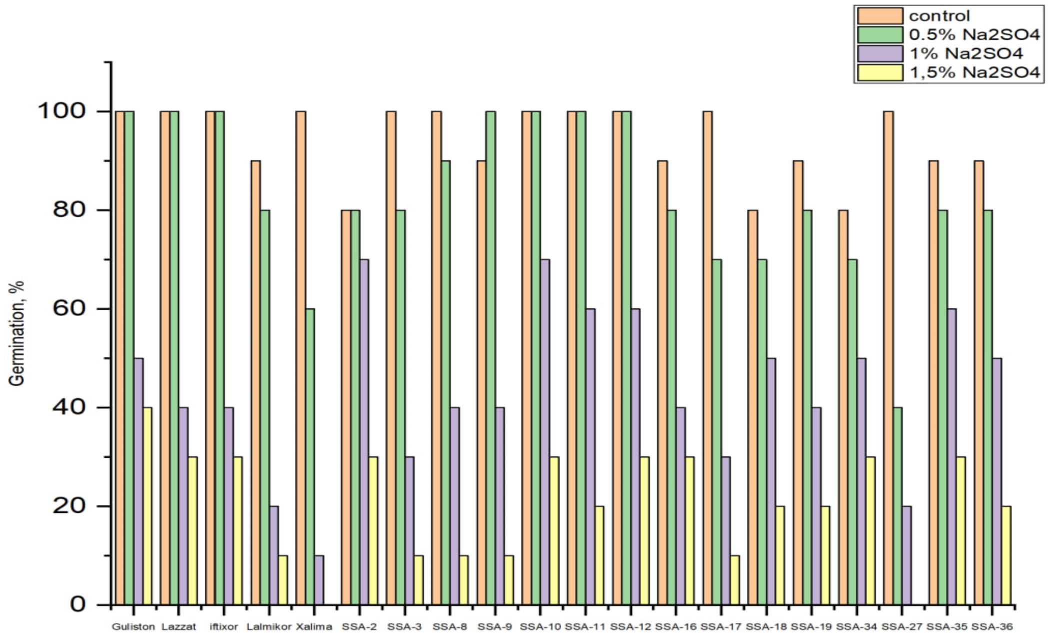


Figure 1. Seed germination of chickpea plants, %

It was observed that the germination index of the chickpea varieties Gulistan, Lazzat, Iftikhor, and SSA-10, SSA-11, and SSA-12 remained unchanged under the influence of 0.5% Na_2SO_4, while the germination index of the Xalima variety and the SSA 27 sample decreased sharply. Seed germination was significantly reduced at 1.5% Na_2SO_4. In this case, seed germination was 10% in the Lalmikor variety, SSA-3, SSA-8, SSA-9, and SSA-17 samples. In the Xalima variety and the SSA 27 sample, seeds did not germinate at 1.5% Na_2SO_4 (Figure 1). The root length of chickpea plants was 4.2-7.05 cm in the control variants, 2.13-6.25 cm in 0.5% Na_2SO_4, 1.1-5.75 cm in 1% Na_2SO_4, and 0-3.12 cm in 1.5% Na_2SO_4. A sharp decrease in root length was observed in the Lalmikor variety of chickpea and SSA-3, SSA-8, SSA-9, and SSA-17 samples under salt stress (Fig. 2).

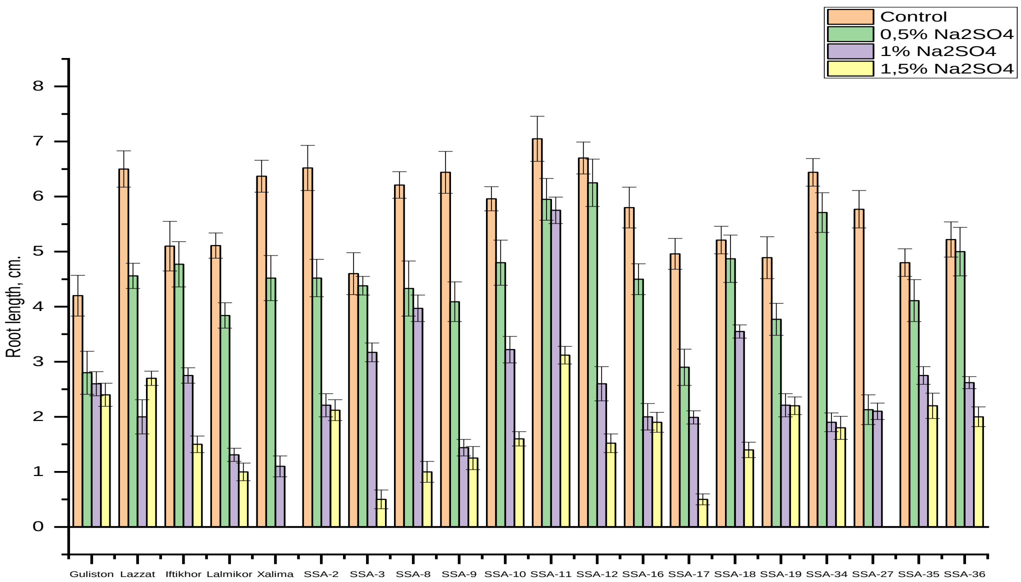


Figure 2. Root length in chickpea plants, cm.

The stem length of chickpea plants was 2.63-4.85 cm in the control variants, 1.62-3.56 cm in 0.5% Na_2SO_4, 0.5-3.03 cm in 1% Na_2SO_4, and 0-1,6 cm in 1.5% Na_2SO_4. A sharp decrease in stem length was observed in the Lalmikor variety of chickpea and SSA-3, SSA-8, SSA-9, and SSA-17 samples under salt stress (Fig. 3).

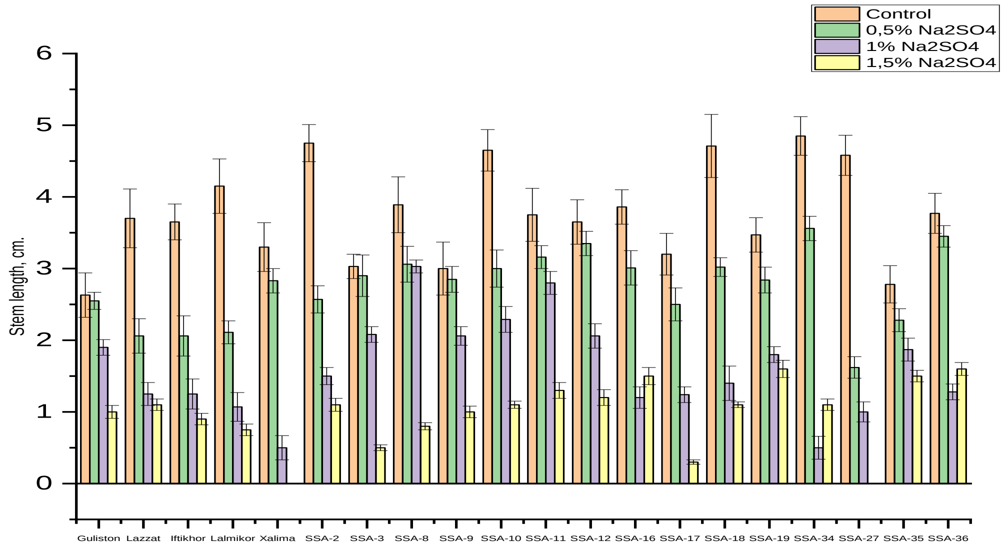


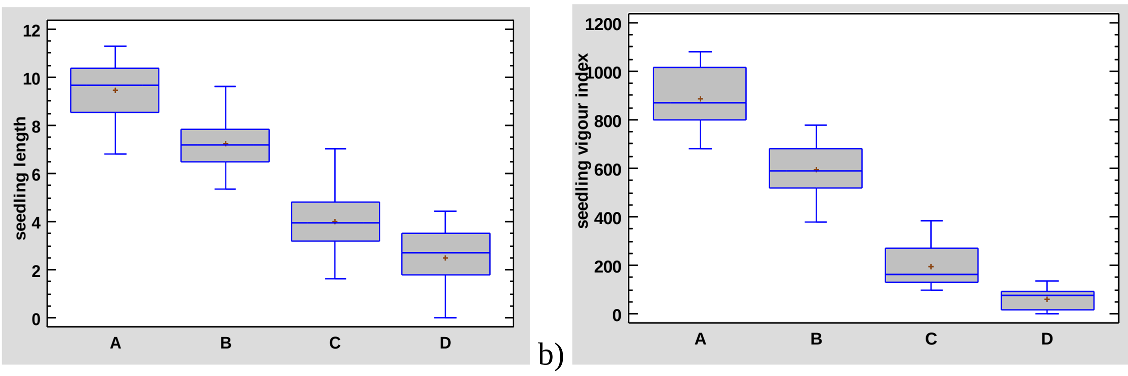
Figure 3. Stem length in chickpea plants, cm.

Box plots were used to analyze seedling length and seedling vigor index in chickpea varieties and samples under salt stress (Fig. 4).

The total indicator of seedling length of the 20 studied samples was 9.46 cm on average in the control variant. In local pea varieties, the total indicator was 8.94 cm, which was lower than in foreign collection samples, while in foreign collection samples it was 9.63 cm, 1.8% higher than the total average indicator. In 0.5% Na_2SO_4 solution, it was slightly lower than in the control, and was 7.12 cm, respectively. The fact that in 50% of the studied samples, the seedling length was 13.76% higher than the total indicator indicates that the varieties are tolerant to moderately saline environments. It was found that the average seedling length of chickpea seeds germinated in a 1% Na_2SO_4 solution was 4.16 cm, which was 56.03% less than the control background, and 73.46% less than the control variant when exposed to a 1.5% Na_2SO_4 solution. It was observed that the seeds of the Xalima and SSA-27 varieties did not germinate at all, and 25% of the studied samples had a seedling length of 1.52 cm in a highly saline environment, which was determined to be intolerant samples.

According to the results of the analysis, the seedling vigour index of the selected samples was 886.97 on average, while in 0.5% Na_2SO_4 this indicator was 600.13. In a weakly saline environment, the seedling vigour index of 50% of the chickpea samples was in the range of 600-

960, and the seedling vigour index decreased by 32.34% compared to the control variant, indicating that these environmental conditions partially affected the germination and development of chickpea seeds. In a moderately saline environment, the seedling vigour index decreased slightly, depending on the germination of chickpea seeds. The decrease in the seedling vigour index by 78.1% compared to the control variant in a moderately saline environment can be explained by the sensitivity of the pea plant to salt stress. The relative tolerance of chickpea samples to 1.5% Na_2SO_4 solution in 13 out of 20 analyzed samples was demonstrated by evaluating seed germination and seedling length even under severe stress conditions. Different concentrations of Na_2SO_4 significantly affected the seeds of chickpea varieties and samples. The germination and development of chickpea seeds, even in a highly saline environment, are related to the tolerance of these seeds to salt stress.

a) 

b)

Figure 4. Laboratory evaluation of salt tolerance in local varieties and foreign collection samples of chickpea

A-control; B-0.5% Na_2SO_4; C-1% Na_2SO_4; D-1.5% Na_2SO_4

a) seedling length b) seedling vigour index

Discussion

The main objective of this study was to evaluate the germination capacity and salt tolerance of chickpea seeds under varying concentrations of Na_2SO_4 and to identify salt-resistant cultivars and accessions. Increasing salt concentrations were found to negatively affect the germination percentage and germination rate of chickpea seeds, as previously reported by Krishnamurthy et al. (2007). In our experiments, seed germination, stem length, and root length were all significantly reduced in 1–1.5% Na_2SO_4 solutions compared to the control and the 0.5% concentration. This supports the conclusion that higher salt concentrations exert harmful osmotic pressure, which inhibits seed germination and root development, ultimately leading to seed damage.

Khajeh-Hosseini et al. (2002) reported that salinity negatively influences multiple seed traits, including reductions in cell expansion, leaf area, root length, biomass accumulation, and overall yield (Khajeh-Hosseini, 2002; Acevedo, 2002). In our study, seed germination in 0.5% Na_2SO_4 was greater than 600 in most chickpea samples, compared to the control. However, the seedling vigour index under low-salinity conditions was reduced by 32.34%, which corresponds to a decline in seed germination and seedling length relative to the control.

The relatively high seed germination and vigour index observed in 50% of the chickpea samples suggests that these genotypes possess strong vigour and tolerance to salt stress. Soil salinity not only affects crop yield and plant viability but also influences nutrient availability and uptake (Munns, 2015). H. Sadeghi et al. (2011) also showed that continuous exposure to various salt concentrations significantly affects seed germination, seedling vigour index, and electrical conductivity. In our findings, as salt concentration increased, the number of salt-tolerant chickpea accessions decreased. Root and stem elongation were markedly reduced, and some samples failed to develop entirely. Seed germination dropped significantly under 1% and 1.5% Na_2SO_4 conditions and showed considerable variation across the four different environmental treatments tested.

Conclusion

At the initial stage of plant development, particularly during the germination period, several chickpea samples demonstrated resistance to high salinity conditions. Among them, local varieties such as *Guliston*, *Lazzat*, and *Iftikhor*, as well as foreign collection accessions including *SSA-2*, *SSA-10*, *SSA-11*, *SSA-12*, *SSA-16*, *SSA-18*, *SSA-19*, *SSA-34*, *SSA-35*, and *SSA-36*, were identified as salt-tolerant.

It was found that the seedling vigour index (SVI) of these salt-tolerant samples decreased by 24.85% under low salinity conditions (0.5% Na_2SO_4) and by 73.13% under moderate salinity (1% Na_2SO_4) compared to the control. Under high salinity conditions (1.5% Na_2SO_4), the SVI was reduced by 89.82%, clearly indicating that increasing salt concentration significantly limits the growth and development of chickpea plants, even in genotypes showing relative tolerance.

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