Study on Tolerance of Common Tomato Varieties in North China to Different Salt Solutions

Linxuan Zhang[a], Jing Jiang[*]

College of Management, Gansu Agricultural University, Anning, Lanzhou, Gansu, China

[a] 18732822939@163.com; *18693123776@163.com

Abstract. Soil salinization is a global agricultural and ecological problem and one of the main factors affecting plant growth and development. As a common vegetable crop and cash crop in northern China, tomato is widely grown in arid and semi-arid areas in northern China. In this paper, the differences of germination rate, germination potential, radicle length, germ length, fresh weight and dry weight of ginkgo Qiangfeng, Zhongshu4, Hehe 903 and Maofang 802 tomato varieties were analyzed by different concentrations of salt stress treatment. The results showed that the tolerance of different varieties of tomato to different salt solutions was different, and the growth characteristics of different varieties were significantly different. In this paper, by analyzing the related factors of the test results, the corresponding countermeasures were put forward to improve the crop salt tolerance, in order to provide theoretical support for the identification, screening and breeding of salt-tolerant tomato varieties.

Keywords: salt stress; Tomato varieties; Seed germination; Variety breeding

1 Introduction

1.1 Research Background

Soil salinization is a global environmental and resource problem that seriously threatens human existence and development. According to FAO statistics, there are 954 million hm^2 of saline-alkali land in the world, which is an important factor limiting the sustainable development of agriculture and animal husbandry[1]. The restoration and management of saline-alkali land on a large scale is an important way to solve the problem of land resources in China's agriculture and animal husbandry[2].

The main components of salt stress are sodium chloride, sodium sulfate, and sodium bicarbonate, and the soil with a high content of sodium chloride and sodium sulfate is called saline soil[3]. Under normal circumstances, the salt content of soil is 0.2% ~ 0.5%, higher than this salt content is not conducive to plant growth and damage the soil structure[4].

Tomato (*Solanum lycopersicum*) is an annual solanum family herb, plant height 0.6-1.5 meters, all the glandular hair, a strong odor, stem easy to fall, with warm happy light, semi-drought tolerance biological characteristics[5] . Due to the large amount of

K. Bellitürk et al. (eds.), *Proceedings of the 2025 2nd International Symposium on Agricultural Engineering and Biology (ISAEB 2025)*, Advances in Biological Sciences Research 50,
https://doi.org/10.2991/978-94-6463-910-0_6

chemical fertilizer used by Chinese farmers in the production process in recent years, the secondary salinization of soil is intensified, which has a great impact on the yield and quality of processed tomatoes. In this paper, four kinds of tomato varieties widely planted in north China were selected to analyze their germination and growth differences through salt stress treatment, in order to select high-quality varieties suitable for planting in saline-alkali land.

1.2 Research Status

1.2.1 Foreign Research Status. In recent years, with the continuous expansion of saline-alkali land area in various countries, food reserves and food security of various countries are facing great challenges. The research direction of foreign researchers is to change plant genes and cultivate new saline-alkali and drought-tolerant varieties in order to ensure food supply. In 2022, M N et al[6] inoculated rhizosphere growth-promoting bacteria (PGPR) to improve physiological, biochemical and molecular aspects to reduce the damage of salt stress on rape, improve the antioxidant defense ability of rape, and increase the expression of salt-resistant genes. In 2023, M M H et al[7] analyzed the adaptation of different varieties of mustard to saline-alkali land through the experimental study of planting mustard in coastal saline land areas of Bangladesh, analyzed the relationship between the growth and yield of mustard varieties at different sowing dates, and adopted appropriate sowing dates to reduce crop yield loss.

1.2.2 Domestic Research Status. The researches on the effects of saline-alkali land on plants mainly focus on physiological indexes and physiological characteristics. Domestic scholars studied the tolerance of crops to different salt and alkali stress by studying the seed germination and seedling growth of crops under salt and alkali stress. Xu J L et al[8] studied the salt tolerance of wild soybeans, photosynthesis and leaf growth of wild soybeans under salt stress, and used chlorophyll fluorescence reflection to study the effects of salt stress on the chemical activity of the photosynthetic system. It was found that the content of chlorophyll a in wild soybean plants decreased significantly under salt stress, and the content of malondialdehyde (MDA) increased significantly. It was accompanied by changes in the activity of osmoregulatory substances and antioxidant enzymes. Li J et al[9] planned to take 6 different types of chicory as test subjects and explore the change rules of seed germination of chicory under different NaCl concentrations through correlation analysis, so as to determine the optimal salt tolerance concentration. The results showed that salt stress inhibited the germination and seedling growth of 6 chicory varieties, and the salt concentration of 200mmol/L was significantly different from other concentrations. It could significantly inhibit the seed germination of chicory.

1.3 Research Purpose and Significance

Through experiments, tomato varieties with high tolerance to salt stress were selected in order to popularize planting in saline-alkali areas and improve the stability and yield of agricultural production. By studying the mechanism of tomato salt tolerance, we can provide a theoretical basis for further improvement of tomato varieties, and cultivate new varieties with more salt tolerance by traditional breeding or modern biotechnology.

Understanding the response of different tomato varieties to salt stress can provide scientific basis for agricultural production, adjust planting structure and production mode, and guide farmers to choose appropriate planting locations and planting methods, so as to reduce the impact of salt damage on tomato production and achieve sustainable agricultural production mode.

In the northern areas with high salinization of land, cultivating salt-tolerant tomato varieties can promote soil improvement and ecological restoration, improve the utilization rate of land resources, reduce the use of fertilizers and pesticides, reduce the damage to natural ecosystems, and protect biodiversity. Improving the success rate of tomato planting in saline-alkali land can increase the income of farmers, while providing a stable and reliable supply of tomatoes for the market to meet the needs of people's lives.

2 Research Contents and Methods

2.1 Research Content

The seed germination and seedling growth of ginkgo Qiangfeng, Zhongshu4, Hehe 903 and Maofang 802 tomato varieties (all selected from Cangzhou Jinke Lifeng Seedling Co., LTD.) under different concentration and salt stress were analyzed through the experimental study of common tomato varieties in North China under different concentration and different salt solution stress. The data of seed germination potential, germination rate, root length, bud length, dry weight and fresh weight of seedlings were analyzed, and the mechanism of salt tolerance of four tomato varieties was compared.(The four varieties are represented by A, B, C, and D respectively).

2.2 Experimental Process

Prepare sodium chloride solutions at 0 mol/L, 0.3 mol/L, 0.6 mol/L, 0.9 mol/L, and 1.2 mol/L (neutral salt solution) and sodium bicarbonate solution (alkaline salt solution), and select 20 seeds each of full and healthy ginkgo Qiangfeng, Zhongshu4, Hehe 903, and Maofang 802 tomato. The seeds were disinfected with 10% sodium hypochlorite for 15 minutes, washed repeatedly with distilled water, and then soaked in distilled water for 6 hours before placing the seeds on a plate lined with double filter paper. Different kinds of tomato seeds were treated with sodium chloride solution and sodium bicarbonate solution of different concentrations, and the germination test was carried out in a constant temperature incubator. The data were recorded regularly every day for 10 days, and the total data were recorded and analyzed after 10 days. The experiment was repeated three times.

3 Results Analysis

3.1 Effects of Salt Stress on Germination Potential of Different Tomato Varieties

Germination potential refers to the percentage of the number of germinated seeds in the number of seeds to be tested when the number of seeds germinated daily reaches the peak in the process of crop germination. Generally, the percentage of the number of seeds germinated in the total number of seeds tested within the initial 1/3 period specified in the germination test is the standard. The germination index of the fourth day was selected to measure the germination potential. There was obvious difference between D and the other three varieties in 0 concentration control group, and its germination potential decreased significantly. Under the concentration of 0.3mol/L, 0.6mol/L and 0.9mol/L NaCl, C varieties were significantly different from the other three varieties, and the germination potential was lower than the other concentrations. At the concentration of NaCl1.2mol/L, the germination potential of B and C varieties decreased significantly. At the concentration of $NaHCO_3$0.3mol/L, there was no significant difference between B and C, but there was a significant difference between it and other varieties, and the germination potential of A varieties under the concentration of 0.3mol/L was significantly lower than that of other tomato varieties. At 0.6mol/L concentration of $NaHCO_3$, there was no significant difference among varieties, and the germination potential of D was slightly higher than that of other varieties. At 0.9mol/L and 1.2mol/L, there was no significant difference between A and D varieties. Under this concentration stress, the germination potential of A, B and C varieties significantly decreased with the increase of concentration, and the germination potential of D significantly increased compared with other varieties. According to the above table, except for C variety, low concentration of two kinds of solution stress can promote the germination of different tomato seeds at the early stage, high concentration stress can inhibit the seed germination of different tomato varieties at the early stage, and the germination potential of different varieties shows a trend of first increasing and then decreasing with the increase of concentration. As show in table 1.

Table 1. Determination of germination potential of different tomato varieties under different stresses

Variety / Handle	A	B	C	D
CK	66.67±2.89cd	76.67±10.41a	88.33±5.77a	56.67±2.89d
NaCL0.3mol/L	73.33±5.77bcd	89.83±43.88a	68.33±7.64b	85.00±5.00ab
NaCL0.6mol/L	71.67±2.89bcd	83.33±2.89a	66.67±5.77b	88.33±5.77ab
NaCL0.9mol/L	80.00±8.66ab	81.67±2.89a	65.00±8.66b	78.33±7.64bc
NaCL1.2mol/L	76.67±10.41abc	53.33±7.64a	41.67±5.77c	71.67±5.77c
$NaHCO_3$0.3mol/L	71.67±5.77bcd	81.67±7.64a	83.33±7.64a	80.00±8.66bc
$NaHCO_3$0.6mol/L	86.67±5.77a	86.67±5.77a	85.00±5.00a	91.67±5.77a
$NaHCO_3$0.9mol/L	63.33±10.41cd	63.33±10.41a	68.33±10.41b	91.67±2.89a

$NaHCO_3$1.2mol/L	61.67±2.89cd	66.67±7.64a	63.33±7.64b	86.67±5.77ab

3.2 Effects of Salt Stress on Germination Rate of Different Tomato Varieties

The germination rate represents the proportion of the germination number of different varieties of tomato seeds in different petri dishes with different solutions, that is, the percentage of the germination number of seeds in each petri dish in the total number of days after the test. Compared with the 0 concentration control group, it was concluded that the increase of NaCl solution and $NaHCO_3$ solution concentration could promote the seed germination of different tomato varieties. When the concentration of NaCl and $NaHCO_3$ solution reached 0.9mol/L, the salt stress deepened the degree of seed germination, and the seed germination rate showed a downward trend, which had an inhibitory effect on seed germination. Under the treatment of 0.3mol/L NaCl, there was a great difference in germination rate between B and C, and there was a significant difference between C and other varieties. At 0.6mol/L and 0.9mol/L NaCl, the germination rate of C decreased significantly. The lowest value was reached at 1.2mol/L. At the concentration of NaCl 1.2mol/L, the germination rate of B decreased significantly compared with other varieties. Under the stress of $NaHCO_3$, there was no significant difference in the germination rate of all varieties at 0.3mol/L concentration, and there was significant difference in the germination rate of B at 0.6mol/L concentration, which was significantly lower than other varieties. When the concentration of $NaHCO_3$ reached 0.9mol/L and 1.2mol/L, the germination rate of D was significantly higher than that of other varieties. According to the germination rate, B and C varieties had poor adaptability to high concentration salt solution, while A and D varieties had strong adaptability to high concentration salt solution. As show in table 2.

Table 2. Determination of germination rate of different tomato varieties under different stress

Variety / Handle	A	B	C	D
CK	71.67±5.77bc	78.33±12.58ab	88.33±5.77a	58.33±5.77d
NaCL0.3mol/L	81.67±2.89ab	90.00±5.00a	70.00±5.00d	78.33±16.07abc
NaCL0.6mol/L	83.33±2.89ab	83.33±2.89ab	73.33±2.89bcd	86.67±2.89ab
NaCL0.9mol/L	83.33±2.89ab	76.67±10.41abc	65.00±8.66d	73.33±2.89bc
NaCL1.2mol/L	78.33±7.64bc	48.33±7.64d	33.33±11.55e	66.67±7.64cd
Na-$HCO_3$0.3mol/L	78.33±2.89bc	83.33±5.77ab	85.00±5.00abc	80.00±8.66abc
Na-$HCO_3$0.6mol/L	90.00±5.00a	63.33±7.64c	86.67±5.77ab	91.67±5.77a

Na-$HCO_3$0.9mol/L	68.33±5.77d	70.00±5.00bc	73.33±7.64cd	91.67±2.89a
Na-$HCO_3$1.2mol/L	65.00±5.00d	71.67±5.77bc	65.13±5.01d	86.67±5.77ab

3.3 Effects of Salt Stress on Dry and Fresh Weight Under Different Stresses

Dry weight and fresh weight are important indexes for seed germination and early seedling growth. Dry weight reflects the measured weight of plant seeds and seedlings after losing water, which is the constant weight of drying at 80°C for a certain time, that is, the mass after losing water. According to the dry weight data in Table 3, there was a significant difference between B and control group only at the concentration of 0.9mol/L NaCl. Under NaCl treatment, the dry weight of A and D increased with the increase of concentration, while B and C showed a trend of first increasing and then decreasing with the increase of concentration. These results indicated that A and D had strong adaptability to high concentration NaCl stress. Under $NaHCO_3$ treatment, there was only a significant difference between 0.3mol/L A and 1.2mol/L D and the control group. The dry weight of D increased with the increase of concentration and reached the maximum value at the concentration of $NaHCO_3$ 1.2mol/L, indicating that D had a strong adaptability to high concentration $NaHCO_3$ stress.

Table 3. Dry weight measurement of different tomato varieties under different stresses

Variety / Handle	A	B	C	D
CK	2.00±0.00ab	1.67±0.58b	2.00±0.00ab	2.00±0.00b
NaCL0.3mol/L	2.00±0.00ab	1.33±0.58b	1.67±0.58ab	1.67±0.58b
NaCL0.6mol/L	2.00±0.00ab	2.33±0.58ab	2.00±0.00ab	1.67±0.58b
NaCL0.9mol/L	2.00±0.00ab	2.67±0.58a	2.33±0.58a	1.67±0.58b
NaCL1.2mol/L	2.67±0.58a	2.33±0.58ab	1.33±0.58b	2.09±0.16b
$NaHCO_3$0.3mol/L	2.67±0.58a	2.67±0.58a	2.67±0.58ab	2.33±0.58ab
$NaHCO_3$0.6mol/L	1.67±0.58b	2.33±0.58ab	2.33±0.58a	2.00±0.00b
$NaHCO_3$0.9mol/L	1.33±0.58b	1.67±0.58ab	2.00±0.00ab	2.33±0.58ab
$NaHCO_3$1.2mol/L	1.67±0.58b	2.33±0.58ab	1.33±0.58b	3.00±0.00a

Fresh weight indicates the weight of seeds and seedlings in their natural state, including the water content and chemical elements in the seeds and seedlings. According to the fresh weight data in Table 4, the comparison and analysis of the test results with the 0 concentration control group showed that under the concentration stress of 0.3mol/L, 0.9mol/L and 1.2mol/L, the fresh weight difference between B and the control group was obvious. There were significant differences between B and C and control group. Under $NaHCO_3$ stress, there were significant differences between A, C and D at different concentrations. There were no significant differences between B and control group at 0.3mol/L concentration, but there were significant differences between them at other concentrations stress. Fresh weight of all varieties under $NaHCO_3$ stress was lower than that under NaCl stress, indicating that $NaHCO_3$ stress had a strong inhibitory effect on fresh weight of all varieties.

Table 4. Determination of fresh weight of different tomato varieties under different stresses

Variety / Handle	A	B	C	D
CK	43.67±2.52a	42.00±2.65b	48.00±3.61a	46.00±3.46a
NaCL0.3mol/L	48.67±5.69a	49.67±2.08a	45.67±2.08a	42.67±0.58ab
NaCL0.6mol/L	43.00±2.00a	41.00±1.73b	42.33±3.21b	38.67±4.16bc
NaCL0.9mol/L	44.00±1.00a	44.33±2.31a	43.33±4.53ab	43.33±4.53ab
NaCL1.2mol/L	44.67±2.08a	43.57±1.50a	44.00±2.65ab	42.33±1.53ab
$NaHCO_3$0.3mol/L	32.67±2.08b	32.00±3.00bc	30.00±3.61c	31.67±1.53de
$NaHCO_3$0.6mol/L	28.67±4.16b	34.67±0.58c	30.67±1.53c	36.00±2.65cd
$NaHCO_3$0.9mol/L	33.00±4.36b	30.67±1.53d	31.33±4.04c	30.67±3.51e
$NaHCO_3$1.2mol/L	30.33±3.21b	29.67±3.21d	33.67±1.53c	30.33±3.21e

3.4 Effects of Salt Stress on Root and Bud Length Under Different Stress

According to the measurement of root length values in Table 5, under NaCl 1.2mol/L stress, except for C, A, B and D varieties had significant differences from the control group, while under other concentration stress, varieties had no significant differences from the control group. With the increase of NaCl solution concentration, the root growth of all varieties showed a trend of first increasing and then decreasing, which indicated that the root growth would be promoted under low concentration salt stress. Under the stress of 0.3mol/L and 0.6mol/L of NaHCO3, except D, there were significant differences between A ,B and C and the control group, and there were significant differences between all varieties at 0.9mol/L and 1.2mol/L concentrations. Except D, the root length of all varieties under NaHCO3 stress was lower than that of the control group, and the root length of D seedling increased with the increase of NaHCO3 concentration, indicating that D seedling root length was better than other varieties under NaHCO3 stress, and the adaptability to NaHCO3 was better than other varieties.

Table 5. Determination of root length of different tomato varieties under different stresses

Variety / Handle	A	B	C	D
CK	559.00±32.36a	630.60±22.05a	543.30±20.84a	533.67±26.31c
NaCL0.3mol/L	562.00±38.51a	652.00±19.67a	561.60±15.95a	533.67±26.31c
NaCL0.6mol/L	537.30±29.19a	651.60±26.65a	529.60±11.59a	538.00±6.56c
NaCL0.9mol/L	540.30±25.93a	624.67±6.11a	543.30±22.19a	524.67±33.25c
NaCL1.2mol/L	462.00±35.68b	574.00±32.23b	520.67±5.86a	484.33±15.95d
Na-$HCO_3$0.3mol/L	437.00±12.29bc	466.30±11.72c	480.33±8.02b	521.33±20.65c

Na-HCO3 0.6mol/L	440.30±12.9bc	465.00±4.58c	446.30±26.69c	550.33±16.5c
Na-HCO3 0.9mol/L	446.00±21.7bc	426.60±14.74d	422.33±5.86c	596.33±7.64b
Na-HCO3 1.2mol/L	409.33±7.37c	340.60±12.01e	376.00±24.43d	646.67±9.07a

As can be seen from Table 6 bud length, under NaCl 0.6mol/L stress, A and B have significant differences from the control group; under NaCl 0.9mol/L stress, all varieties have significant differences from the control group; under NaCl 1.2mol/L stress, There were significant differences between C and D and control group. Under NaCl solution treatment, seedling bud length of four different tomato varieties increased first and then decreased with the increase of NaCl concentration. In the comparison of various varieties, the bud growth rate of B under low concentration NaCl stress was better than that of other varieties, and the growth rate of A under high concentration NaCl stress was better than that of other varieties. Under $NaHCO_3$ stress, there was a significant difference between B and control group under 0.3mol/L concentration stress; under 0.6mol/L concentration stress, there was a significant difference between A, B and C and 0 concentrations; under 0.9mol/L and 1.2mol/L concentration, There were significant differences between all varieties and control group. The seedling bud length of four different tomato varieties was lower than that of control group, and showed a decreasing trend with the increase of $NaHCO_3$ solution concentration. These results indicated that $NaHCO_3$ stress could inhibit seedling bud length, and the higher the concentration, the deeper the effect.

Table 6. Determination of bud length of different tomato varieties under different stresses

Variety / Handle	A	B	C	D
CK	275.33±35.7b	330.33±21.5ab	307.00±25.71a	286.67±31.02ab
NaCL0.3mol/L	278.00±17.69b	357.33±23.07a	312.00±17.06ab	293.67±22.94a
NaCL0.6mol/L	366.33±35.57a	221.33±23.01c	248.00±30.51abcd	300.00±12.77a
NaCL0.9mol/L	386.67±35.23a	203.67±22.19d	232.33±8.02cde	223.00±5.00d
NaCL1.2mol/L	302.00±23.81b	217.33±27.5b	203.30±10.97e	197.33±23.63d
NaHCO3 0.3mol/L	262.67±20.79b	274.67±26.84cd	280.67±18.15abc	276.00±39.28abc
NaHCO3 0.6mol/L	214.33±15.14c	244.00±8.54cd	253.67±25.01bcde	244.33±23.07bcd
NaHCO3 0.9mol/L	204.33±6.81c	219.67±8.96cd	211.00±22.27de	233.33±32.19cd

$NaHCO_3$ 1.2mol/L	208.33±17.01c	218.00±12.53cd	208.00±24.64e	222.00±19.97d

4 Discussion

The salt tolerance of plants is regulated by many physiological and biochemical factors. Therefore, the assessment of tomato salt tolerance can not only rely on a single index, but should be a comprehensive consideration of a number of indicators related to salt tolerance, and study the relationship between them to determine the level of its salt tolerance. In this paper, NaCl solution and $NaHCO_3$ solution were selected, both containing Na^+. Song X Q et al. [10] studied the response of processed tomato seedlings to salt stress. The study showed that plants actively absorbed inorganic ions in soil, but excessive Na^+ would cause serious salt damage and seriously affect plant growth.

The influencing factors are discussed as follows: Firstly, osmotic stress leads to water deficit in plants, which affects seed germination and inhibits radicle growth; The second is the damage of cell membrane. When seeds germinate, the permeability of cell membrane increases due to the action of salt, which leads to the outflow of solutes, thus increasing the permeability of electrolytes. The third aspect is the toxic effect of ions on tomato seed cells. Under high concentration of salt stress, excessive Na^+ can cause swelling and variation of seed cells, resulting in imbalance of intracellular ion balance, which adversely affects the normal physiological function of cells.

The countermeasures to improve the salt tolerance of seeds are as follows: 1) Improve the salt environment: the salt content in the soil can be effectively reduced and the germination of seeds can be promoted by using such methods as elevating the ground surface, pressing alkali with fresh water and scouring with fresh water. Slight salinization and pressure alkalization treatment before sowing can effectively reduce the salt content in the soil, so that some basic nutrients in the soil will not be lost. However, due to the constraints of climate, hydrology and other factors, coupled with large investment, it is difficult to achieve long-term governance. At the same time, proper preparation can also increase the germination of seeds, and the soil with high salt content should be shallow tillage. Soil improvement can also increase the salt tolerance of seeds, but it is not suitable for nationwide promotion. At the same time, the salt tolerance of seeds can be effectively improved by selecting a suitable sowing date and sowing under appropriate temperature conditions after the rainy season. 2) Seed pretreatment: Before sowing, different pretreatment can be carried out on the seeds, such as temperature change, hormones, etc. These methods were helpful to improve the salt-resistant germination ability of seeds. However, different species employ different strategies. In addition, salt initiators such as nitrate can be added to accelerate the division of plant cells, enhance the activity of various enzymes in plants, and enhance the germination ability of plants. 3) Salt-tolerant germplasm screening: Use existing germplasm resources to explore salt-tolerant genotypes. There are a number of methods for the identification of salt tolerance, which can be classified as identification based on growth status or yield, identification based on the degree of injury or tolerance to a high salt environment, and identification based on physiological mechanisms. Due to the spatial heterogeneity of soil physical and chemical properties and the seasonal variation of precipitation, field experiments are difficult to carry out. Therefore, in the current study, it is necessary to establish a set of techniques capable of salt tolerance identification in an indoor controlled environment.

5 Conclusion

According to the test results, there were significant differences in the growth of the same tomato varieties under different concentrations of the same solution. Under the stress conditions of the same solution, there were significant differences in the germination of tomato seeds and the growth of seedlings, indicating that there were significant differences in the tolerance of tomato seeds to concentrations. There are obvious differences in the tolerance of tomato varieties to different salt solutions. According to the germination potential and germination rate, the adaptability of A and D to high concentration salt solution was better than that of B and C. According to the analysis of root bud length, the seedling bud length of four different tomato varieties increased first and then decreased with the increase of NaCl stress and $NaHCO_3$ stress, and the bud length of D variety was higher than that of the other three varieties at the end of the experiment.

References

1. Fu S, Lei T, Jin W, et al. (2023) Effects of salt stress on growth and physiological indexes of tomato seedlings. J. Journal of Hubei Normal University (Natural Science Edition), 43(03): 9-15. DOI:10.3969/j.issn.2096-3149.2023.03.002.
2. Xie Y Y, Wang Q, Wang C, et al. (2019) Mechanical research on plant stress under salt stress. J. Chinese Journal of Laser Biology, 31(05): 398-403. DOI:10.3969/j.issn.1007-7146.2022.05.003.
3. Wu X R, Li J, Wu Y, et al. (2022) Effects of salt stress on growth and physiological characteristics of Sunflower seedlings with different salt sensitivity. J. Acta Agriculturae Sinica of North China, 50(04): 18-25. DOI:10.12190/j.issn.2096-1197.2022.04.03.
4. Chen Z P, Shi X M, Wang R, et al. (2022) Osmotic regulation and antioxidant capacity of different grape rootstocks under salt stress. J. Acta Botanica Sinica of Northwest China, 42(11): 1880-1891. DOI:10.7606/j.issn.1000-4025.2022.11.1880.
5. Sun Y Y, Zhu P S, Diao M, et al. (2021) Effects of different concentrations of GSNO on the growth of tomato seedlings under salt inoculation. J. Xinjiang Agricultural Sciences, 58(04): 625-633. DOI:10.6048/j.issn.1000-4330.2021.04.005.
6. Mohammadreza N,Dadashi D C,Ebrahim S. (2023) Culation with salt inoculation Pseudomonas baetica R27N3 under salt stress condition improved antioxidant defense and increased expression of salt resistance elements. J. Industrial Crops & Products, 206: 117648. https://doi.org/10.1016/j.indcrop.2023.117648.
7. Mohsin M H,Jahangir M A,Mahmud A A, et al. (2023) Sowing date-induced salinity stress impacts the performance of mustard genotypes grown in the coastal saline areas of Bangladesh. J. Arabian Journal of Geosciences, 16(3): 202. DOI:10.1007/s12517-023-11298-0.

8. Xu J L, Wang X Z, Fan J B. (2019) Physiological and photosynthetic changes of wild soybean induced by salt stress. J. Chinese Journal of Plant Science, 40(06): 829-838. DOI:10.11913/PSJ.2095-0837.2022.60829.
9. Li J, Wang L H, Wang Y, et al. (2022) Effects of salt stress on seed germination and seedling growth of herbage type Chicory. J. Seed, 41(11): 119-124. DOI:10.16590/j.cnki.1001-4705.2022.11.119.
10. Song X Q, Liu Y, et al. (2021) Responses of processed tomato seedlings to salt stress. J. Acta Agriculologica Sinica of North China, 49(02):104-10.DOI:10.12190/j.issn.2096-1197.2021.02.16.