Physiological response of different varieties of Sea Island Cotton Seedlings to salt stress

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Abstract: Salt is one of the important stresses that hinder crop growth and development. The effects of salt stress on cotton growth, yield and quality were summarized; The self-regulation and response mechanisms of cotton to adapt to salt stress and reduce injury were analyzed, including osmotic regulation, membrane lipid regulation, ion distribution and molecular mechanism; The main measures to alleviate salt stress in cotton, such as salt tolerant variety breeding, cultivation management technology and molecular breeding, were summarized; Finally, the research direction of salt tolerance of cotton is put forward: the combination of molecular mechanism and physiological mechanism; Combination of conventional cultivation measures and physical and chemical means; Development and application of remote sensing monitoring system.

1. Introduction

Power Salinization is one of the main problems to be solved in the process of sustainable agricultural development. According to the data, the soil area affected by salinization in China is about 9.91 × 107 Hm2, accounting for 10% of the current cultivated land area. Generally, saline alkali land is improved mainly through engineering, chemical, physical and biological improvement measures and comprehensive treatment. Under the current situation of rapid economic development and rapid increase of technology in China, it is more effective to use biological measures to improve saline soil. However, the premise of using biological improvement measures to control saline alkali soil needs to do sufficient basic work. Therefore, evaluating the germplasm resources of salt tolerant vegetation, exploring the salt tolerance of vegetation and the growth of plants under salt stress have always been the hot directions at home and abroad. Xinjiang is the main cotton production area in China. The cotton output has ranked first in China for more than 20 years. The area of saline soil in this area accounts for 31.1% of the existing cultivated land. The excessive accumulation of salt in soil can reduce the yield of various crops, especially Na +. Under NaCl stress, Na + is the primary toxic factor in cotton plant. As a pioneer crop planted in saline alkali land, cotton's salt tolerance is limited by salt concentration, and there are differences in salt tolerance among varieties. Appropriate salt stress can promote the normal growth of cotton plants. Supplementing a certain amount of Na salt can also promote the growth and increase the yield of cotton in the environment of K + deficiency. Under salt stress, cotton growth and development is slow, leaves turn yellow and dry, metabolism is damaged, and high salt concentration even causes the death of cotton plants. Salt stress affects the growth, yield and quality of cotton, and the degree of its influence depends on the salt environment and the adaptability of cotton to it. Salt stress, as one of the primary factors of low crop yield, inhibits the growth of vegetation to some extent. At present, scholars have been committed to enhancing the salt resistance of vegetation under salt stress through effective means, so as to make crops high yield. The area of global saline alkali land is still increasing. With the in-depth study of cotton salt tolerance, high concentration of salt in saline alkali land is still the main factor restricting cotton yield. Based on this, this study studies the physiological response mechanism of different salt tolerant cotton varieties under salt stress, so as to reveal the regulation mechanism of cotton seedling growth under salt stress, screen and evaluate varieties suitable for cultivation in saline alkali land, provide salt tolerant materials for cotton

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breeding, molecular markers and transgenic research, and increase the yield of cotton in existing saline alkali land, It is of positive significance to promote the development of saline alkali land, plant cotton, improve and utilize saline alkali land[1].

2. Effects of salt stress on cotton growth, yield and quality

2.1 Effects of salt stress on cotton growth and development

Generally, salt stress hinders the growth of roots and aboveground parts of cotton, resulting in the inhibition of lateral root growth, the shrinkage of leaf surface and the reduction of area, the slender stem, and the decline of fresh material quality above and below the ground. Among them, aboveground parts are particularly sensitive. High salt stress will have a serious impact on Photosynthesis and respiration, and hinder the absorption and utilization of nitrogen and phosphorus fertilizer. With the increase of salt concentration, the number of flowers and bolls decreased and the boll falling rate increased, resulting in the decrease of Boll formation. Different salt concentrations had effects on different stages and different organs of cotton growth and development. When 0.2% < salt concentration < 0.4%, it can promote seed germination; When 0.5% < salt concentration < 0.7%, physiological function and material metabolism were affected, and seedling growth was limited; When the salt concentration was more than 0.7%, the growth and development of cotton was significantly inhibited, resulting in the decline of yield and quality. Salt stress forced a large amount of Na^+ to accumulate, and the lack of inorganic ions limited water transport, resulting in nutritional imbalance of cotton. In 0.4% salt soil environment, salt tolerant varieties had stronger salt stress tolerance than salt sensitive varieties, and the inhibition effect was more obvious with the delay of sowing time. During the growth process, salt stress affected chlorophyll synthesis, photosynthesis was inhibited, chlorophyll content and photosynthetic rate in leaves decreased, Na^+, abscisic acid (ABA) content increased, K^+, zeatin nucleoside (Zr) content decreased, which promoted leaf senescence. The relative value of leaf green decreased slightly in the strain with good salt tolerance. Lower NaCl concentration promoted the growth of cotton callus, while higher NaCl concentration significantly inhibited the growth of cotton callus.

Table 1 Effects of different salt concentrations on cotton growth and development

Salt concentration	influence
0.2% < salt concentration < 0.4%	Promote seed germination
0.5% < salt concentration < 0.7%	Seedling growth restriction
Salt concentration > 0.7%	Yield and quality decline

2.2 Effects of salt stress on cotton yield and quality

Cotton dry matter production is significantly affected by soil salinity. Under high salinity conditions, cotton growth process lags behind, reproductive growth and nutritional growth are uncoordinated, resulting in an increase in abscission rate and a decrease in economic yield. Soil salinity significantly affected the absorption, accumulation and distribution of N, P and K nutrients by cotton. The absorption in cotton and boll shell was negatively correlated with salinity. Cotton seedling rate, plant height, number of fruit branches, single boll weight, maximum leaf area per plant, pre frost flower rate, uniformity index and breaking ratio intensity all decreased with the increase of irrigation water salinity, and had a negative impact on fiber quality through micronaire value. The salt tolerance of cotton was positively correlated with boll weight and fiber length; There was a significant negative correlation with kernel protein content and micronaire value. After salt stress, the protein content decreased. Salt in an appropriate range of concentrations can be used as nutrients to improve seed yield, but a large amount of Na^+ intake will lead to premature leaf senescence or premature senescence, and the seed yield will decrease sharply. The cotton fiber properties of different genotypes are also affected in a variety of ways.

3. Response mechanism of cotton to salt stress

3.1 Osmotic adjustment

Under salt stress, the external osmotic potential is low, and water deficit occurs in plant cells, that is, osmotic stress. In order to ensure the normal supply of water, cells will accumulate some soluble substances to avoid damage. Osmotic stress caused by salt stress is easy to cause cell dehydration. Cotton plants absorb a large number of inorganic salts and accumulate salt ions into vacuoles to improve the concentration of vacuole solution, so as to reduce the cell water potential to adapt to the low water potential caused by salt stress, so as to make the plants absorb water under high osmotic conditions, maintain swelling pressure and improve the dehydration resistance. However, the accumulation of excessive salt ions will produce toxic effects.

3.2 Membrane lipid regulation

Under salt stress, the excessive accumulation of Na + in plant cells leads to the production of reactive oxygen species, breaks the dynamic balance of scavenging system, starts membrane lipid peroxidation and degreasing, resulting in the loss of membrane protein and membrane lipid and the destruction of membrane structure. At this time, superoxide dismutase (SOD), catalase (CAT), peroxidase (POD) The activities of glutathione reductase (GR) and ascorbic acid (ASA) changed to some extent to maintain the stability of membrane structure and function. Through a large number of studies on the antioxidant defense system in plants under salt stress, it is found that SOD, pod, ASA and other enzymes that scavenge reactive oxygen species cooperate with antioxidants to resist the oxidative damage induced by salt stress. A single antioxidant enzyme is not enough to defend against this oxidative stress. Under salt stress, the activity of membrane lipid peroxidation scavenging system in the leaves of salt tolerant cotton varieties increased significantly, while the indexes of salt tolerant cotton varieties remained unchanged or decreased.

3.3 Ion distribution

In salt tolerance physiology, carbohydrate is the main osmotic regulator and participates in the balance of vacuolar water potential. Organic acids are also a kind of important organic substances, which can be used as a osmotic regulator and can also be used to maintain the ion balance in plants. By neutralizing excess cations such as Na +, K +, Ca2 +, Mg2 +, the toxicity of cations is reduced to a certain extent. Due to the different sensitivity of cytoplasmic enzymes of halophytes and non halophytes to Na +, the regional distribution of Na + and Cl ions is the adaptation result of saline environment. The concentration of Na + in vacuole is greater than that in cytoplasm. Under salt stress, Na + and Cl plasma accumulate in vacuole. Under salt stress, the contents of Ca2 +, Na +, CL in cotton plants increased with the increase of soil salinity, and the Na + content in rhizome xylem and leaves increased rapidly with the increase of external salt concentration, especially in leaves. In salt tolerant varieties, Na + is the main cation in the body, and about 90% of it accumulates in the shoot. NaCl stress significantly reduced the contents of Ca2 +, K +, Mg2 +, P3 + and Mn4 + in leaves and roots of cotton seedlings. The K + content in leaves of varieties with strong salt tolerance was significantly higher than that of varieties with weak salt tolerance, and the Na + content was significantly lower than that of varieties with weak salt tolerance.

3.4 Molecular mechanism

Under salt stress, the ATPase / H + pump of plasma membrane and vacuole membrane is driven by reverse transport proton, and the Na + in cytoplasm is pumped into vacuole through Na + / H + reverse transporter to alleviate the harm caused by salt stress. The salt tolerance of cotton varies with genotypes. The difference of salt tolerance among genotypes is related to the content of malondialdehyde, proline, soluble sugar, carotenoid, protective enzyme activity and the accumulation of salt ions in leaves. Cotton is a salt tolerant plant, V-PPase (pyrophosphatase) plays the role of ion compartmentalization under salt stress, and plant stress has an important relationship with DNA methylation. Under salt stress, DNA methylation variation occurs more frequently in roots, almost dominated by reduced methylation. The signal pathway of significant enrichment of salt tolerant strains is the antigen processing process, while that of salt sensitive strains is the alkaloid synthesis pathway In addition, LEA protein gene, aquaporin gene, K^+ channel protein and its gene, salt shock protein and its gene also play an important role in the salt tolerance response mechanism of cotton.

4. Main measures to alleviate salt stress

Identification, screening and cultivation of salt tolerant varieties

The first is identification and screening. The evaluation and screening of salt tolerant germplasm resources is also the basis and prerequisite of salt tolerant breeding. At present, the known detection methods of salt tolerance include salt pool identification method, germination rate and emergence rate estimation method, biological character comparison method, ion ratio method, whole plant identification method, pollen germination rate determination method, multi marker combination identification method and so on. Salt pond identification method is a traditional method to identify salt tolerance. Seedling stage is an important stage for identifying cotton salt tolerance. Relative indexes such as seed relative germination rate, relative cotton seedling dry matter mass, relative plant height, K^+ / Na^+ and Ca^{2+} / Na^+ can be used to assist in identifying cotton salt tolerance during germination. The salt tolerance of the whole plant was identified by hydroponic culture. The total leaf area and the reduction percentage of leaf fresh weight could reflect the salt tolerance of the whole plant. The percentage of cotton pollen germination is also a reliable index to reflect its salt tolerance. With the continuous progress of biotechnology, the emergence of molecular markers has brought new ideas and methods to the study of salt tolerance.

5. Outlook

For a long time, how to improve the salt resistance of cotton and increase the yield under salt stress has been the focus of attention. At present, the research on the salt resistance mechanism of cotton is limited. A more in-depth and systematic understanding of the salt resistance mechanism of cotton and exploring the response mechanism and salt resistance mechanism of cotton to salt and alkali stress are the premise to guide the transformation of cotton by biotechnology and other measures to improve the salt and alkali resistance. Nowadays, the development of interdisciplinary network has put forward new thoughts and opportunities for cotton salt tolerance.

5.1 Combination of molecular mechanism and physiological mechanism

Salt tolerance of cotton is a complex quantitative trait, which is controlled by multiple genes. With the continuous deepening and development of transgenic technology, some transgenic cotton has achieved good economic and social benefits, but there are still problems to be solved in the research of salt tolerant transgenic cotton, such as the low conversion rate of salt tolerant genes, the limitations of gene expression on the improvement of salt tolerance, and how to perceive environmental stress signals, And how to control it. Salt tolerant varieties can be screened and cultivated through the combined application of physiological mechanism, molecular mechanism and breeding. Salt tolerance varies with genotypes, and brown cotton and green cotton have the strongest salt tolerance. Therefore, varieties with strong practicability can be selected in combination with production.

5.2 Combination of conventional cultivation measures and physical and chemical means

Traditional cultivation measures such as salt resistance exercise, use of growth regulators and transformation of saline alkali soil are effective means to improve the salt resistance of cotton. The results show that magnetic treatment can affect the changes of ion transfer and distribution in plant cells after salt stress, and then change the related metabolic enzymes and physiological activities, so as to try to improve the germination rate of cotton seeds in saline environment.

5.3 Development and application of remote sensing monitoring system

Using the thinking of software engineering, the cotton leaf water and salt condition monitoring model and soil dielectric constant model based on ground remote sensing are coupled, and a remote sensing monitoring system with the function of monitoring cotton and soil water and salt condition in coastal saline soil cotton field is developed. Through the spectral inversion of soil salinity in cotton field, the sensitive band of salinization spectrum is selected, and the model of monitoring soil salinization in cotton field by salinity indexes SI1, Bi, SI2, NDSI and Si3 is established, which provides the possibility for remote sensing dynamic monitoring of soil salinization.

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