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The Effect of Low Temperature Stress on Plant Physiological Development

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Abstract

Temperature is the most important factor affecting plant growth, development, and metabolic processes, which has significant theoretical value and practical significance for studying the physiological and biochemical characteristics of plants under temperature stress. The damage of low temperature to plants is caused by dehydration caused by extracellular ice formation, or by apoptosis caused by intracellular ice formation. This article mainly discusses the cold resistance of plants from several aspects, including lipid membrane peroxidation, osmotic regulation products, plant growth and development products, and antioxidant enzyme systems.

Keywords

Low Temperature; Coercion; Physiology; Antioxidant Enzyme.

1. Effects of Low Temperature Stress on Plant Cell Membrane System

The plasma membrane and inner membrane system together constitute the biofilm system of plants for material conversion and signal transmission, which plays a crucial role in plant growth. The plasma membrane is also the most sensitive part of plant cells to temperature stress, and it is also the main site of action in temperature stress on plant cells. Temperature stress can cause an increase in plant plasma membrane permeability, electrolyte leakage, protein denaturation, and a decrease or loss of enzyme activity, leading to metabolic disorders in plants. Biofilm permeability and membrane lipid peroxidation effects are commonly used to evaluate plant cold resistance. Under low temperature stress, plants may undergo some physiological and biochemical changes to adapt to the effects of temperature stress on the plant, with the most obvious change being the membrane lipid phase[1].

2. Effects of Low Temperature Stress on Plant Antioxidant Enzyme System

In general, the types of free radicals and reactive oxygen species formed within the plant cannot cause harm to the plant, as the antioxidant system within the plant can eliminate the types of reactive oxygen species and free radicals formed. However, so far, most of the enzymes studied are SOD, POD, CAT, etc., as their important function is to more efficiently remove harmful substances such as reactive oxygen species and free radicals from plants, in order to reduce damage to plants. In the plant body, the three enzymes of the antioxidant enzyme system are

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complementary and together form the plant's protective enzyme system, promoting the maintenance of oxygen free radicals at a relatively stable level, thereby avoiding the harm of oxygen free radicals to the plant. From this, it can be seen that the plant grows under adverse conditions, and the protective enzyme system can be used to evaluate the adaptability of the plant's ability to grow under adverse conditions. In the protective enzyme system, the main function of SOD is to remove the newly generated superoxide free radical 02- and form the disproportionating substance H2O2, in order to avoid the damage of these harmful substances to the formation of plant membranes. In the protective enzyme system, POD and CAT mainly decompose H2O2 and convert it into H2O and O2, which is mainly used to avoid damaging the cell membrane. During the normal growth process of plants, The reactive oxygen species and defense enzyme system within the plant itself remain stable, but due to abiotic stress at different temperatures, the balance within the plant is disrupted, leading to the accumulation of peroxides in the body[2]. As the temperature of abiotic stress decreases, the more peroxides accumulate and the greater the damage to cells. When the temperature drops, temperature can lead to lipid peroxidation of plant cell membranes. During this process, the lower the temperature, the more reactive oxygen species and strongly oxidizing free radicals produced in the plant body. This requires the antioxidant system in the plant to be quickly cleared. Failure to clear in a timely manner can damage cell results, leading to disruption of the antioxidant system and even leading to plant death[3].

3. The Effect of Low Temperature Stress on the Content of Plant Osmotic Regulators

Plants must use their own protective systems to regulate osmotic regulatory substances in metabolism in response to these invasions. The substances involved in osmotic regulation include both inorganic molecules from the outside of the cell that enter the cell, as well as compounds accumulated by the cells themselves in the plant. Within a certain limit, these chemicals accumulated by the cells can maintain normal cell metabolism and normal metabolic function at a certain temperature. Numerous scientific research and practice have shown that under temperature stress conditions, a large amount of water is lost in the plant cells, In such an environment, cells will be induced to form osmotic regulatory substances, which can increase the content of plant cell fluid, weaken osmotic potential, and enable the plant to absorb water from the outside to ensure normal metabolic growth. Under stress conditions, cells spontaneously produce an osmotic pressure regulation product, which increases cell water content and weakens osmotic potential, allowing plants to absorb water from the environment[4].

3.1. Effect of Low Temperature Stress on Soluble Sugar Content in Plants

Scientific research has confirmed that soluble sugars can increase the osmotic concentration of plant cell sap. Under low temperature stress, the use of soluble sugars can reduce freezing point temperature, increase cell growth vitality, and significantly increase the cold tolerance of plants. Therefore, it can be found that there is a significant relationship between the concentration of soluble sugars and the cold resistance of plants. Under low temperature induction conditions, in order to adapt to abiotic stress at different temperatures, maintain the balance of intracellular osmotic concentration and the content of cell osmotic regulators, plants can become one of the key parameters for identifying cold tolerance. The higher the accumulation of soluble sugar content, the stronger the cold tolerance of the species, which can prove that the soluble sugar content is positively correlated and stable with the size of cold tolerance. By increasing the content of soluble sugar in the body, it is a way for plants to protect themselves in response to adversity. Research has shown that the lower the freezing point of a plant, the stronger its cold tolerance, and the higher the content of soluble polysaccharides in the leaves

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corresponding to its temperature. And the increase in soluble sugar content in different types also shows a certain correlation with their own cold tolerance ability[5].

3.2. Effect of Low Temperature Stress on Plant Soluble Protein Content

The soluble protein content in the plant is closely related to temperature changes, therefore it is believed that the production of stress proteins induced by different temperatures is closely related to the plant's cold resistance. There are currently two different views on the causal relationship between the changes in soluble protein content caused by different temperatures: one argument is that the changes in soluble protein content in plants caused by temperature stress are basically on the rise; Another viewpoint is that different temperatures do not lead to an increase or decrease in soluble protein content, and there is no direct correlation between the cold tolerance of plants and the increase in soluble protein content. So far, most scholars still believe that there is a positive correlation between soluble protein content and cold tolerance, and believe that under low temperature stress, the content of soluble protein in plants increases. Soluble proteins have good hydrophilicity and can effectively increase the water retention of proteins, thereby increasing the plant's cold resistance. Physiological studies at a certain temperature have shown that protein levels increase with the decrease of temperature. Among them, species with high cold resistance have higher protein concentrations than those with weak cold resistance, which is positively correlated with the cold resistance performance of various species[6].

3.3. Effect of Low Temperature Stress on Plant Free Proline Content

The stability of cell structure and function of proline (Pr), an important osmotic pressure regulating product in plants, is mainly achieved by regulating permeability. Under normal conditions, the concentration of proline in the plant is maintained at a low level. If the concentration of this chemical rises rapidly under adverse conditions, the accumulation of this chemical concentration is due to stimulating the biosynthesis of proline in the plant and inhibiting proline decomposition. In the investigation of perennial herbaceous plants such as Populus alba, winter wheat, and Daphne odoratum that overwinter, it can be found that under this environment, the free proline content in the plants accumulates in large quantities. After treatment at different temperatures, it has been found in many studies that the concentration of free proline increases significantly, accumulating and increasing[8]. When the environment at different temperatures is disrupted, it can be decomposed by itself. The research results indicate that wheat with relatively high cold resistance has a higher proline content. This result indicates that under short-term low temperature stress, wheat proline content can become an effective screening indicator for cold resistance quality[7]. The free proline concentrations of three soybean varieties germinated at the same temperature were calculated[9]. The results showed that with the increase of germination time at low temperature, the proline concentration gradually increased, while the proline concentration of cold tolerant varieties gradually accumulated, with less accumulated content than the other two[10].

4. Conclusion

Due to temperature stress being a natural disaster often encountered in planting, abnormal physiological and biochemical reactions can also occur in the body under temperature stress, which not only affects normal growth but also leads to plant death in more severe cases. Therefore, in the process of plants experiencing abiotic stress at different temperatures, we can understand the effects of different temperatures on plant physiology and biochemistry, as well as the physiological and biochemical responses of plants to abiotic stress. This provides theoretical significance for providing cold prevention research and measures for plants.

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