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Balancing of Plant Growth and Stress Response

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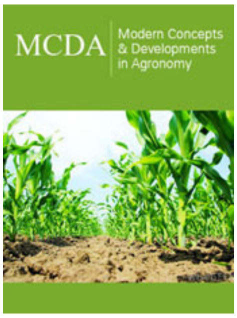

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Abstract

Resisting stress and actively inhibiting growth are two complementary strategies for plants to respond to adverse environments. Although stress response is beneficial for plant survival, actively inhibiting growth is often not advisable for crop productivity. Compared to the knowledge of how plants defend against cell damage caused by stress, our understanding of stress-regulated plant growth is relatively limited. The mutual regulation between stress response and growth regulation pathways occurs at multiple levels. Understanding the balance between stress resistance and growth is crucial in designing high levels of resistance and yield crops.

Keywords: Plant growth; Stress; Response; Resistance; Productivity; Trade-off

Introduction

Plants have the characteristic of fixed growth. It cannot effectively evade external unfavorable factors like animals. Therefore, its growth and development will be affected by various stress conditions. Timely and effective response to these stress conditions is a prerequisite for plant survival [1]. How adverse environments affect plant growth is not only a fundamental scientific issue, but also crucial for agriculture and food security, since abiotic stress greatly reduces the growth rate of plants. When plants are in a state of stress, environmental conditions are not applicable to the growth process, including cell division and expansion. However, plants under stress also actively slow down their growth to adapt to stress conditions. This “active” growth inhibition is achieved through stress triggered cellular signaling [2].

Stress resistance measurement is often defined as the growth or survival rate of plants under stress relative to control conditions. However, the ability to resist stress may differ in terms of growth and survival [3]. Some plants have the ability to increase the growth of their own organs in response to specific stress responses. For example, increasing root growth during mild drought or increasing stem growth under complete submergence conditions [4,5]. The growth induced by specific organ stress is usually achieved at the expense of the growth of other parts of the plant. The accumulation of whole plant biomass in this situation reflects the overall impact of stress.

Researchers have been trying to mitigate the negative impact of stress on crop yield through genetic engineering, but the results have been minimal. Although many genes related to plant abiotic stress signal and response have been identified, it is still challenging to transform them into crops with enhanced stress resistance [6]. The trade-off between plant growth and stress resistance can be explained in this way: plants under stress must transfer energy and resources from growth to stress responses. However, increasing evidence suggests that plants actively inhibit growth under stress conditions, which is an adaptive strategy to maximize survival. Plant species that adapt to harsh environments often grow slowly, even when transferred to an ideal environment with unlimited resources, which means that control of growth rate is formed through long-term evolution. Most plants are sensitive to mild stress, which helps them prepare for more severe stress in the future. In the early stages of stress response, the stress signal network actively inhibits cell synthesis metabolism and plant growth, even if the cellular energy state has not been affected. This situation becomes obvious in transgenic plants that overexpress the main transcription factor of abiotic stress response, leading to increased stress resistance in survival, but growth is seriously affected [7]. On the other hand, it has been found that pathways that promote growth can actively inhibit stress response programs [8]. Therefore, understanding the mutual regulatory mechanism between stress response and growth may be the key to breaking or resetting growth under stress conditions, thus enabling engineering transformation of crops.

Conclusion

When plants are subjected to abiotic stress, their physiological and molecular levels change. Although the specific sensing mechanism depends on the type of stress, the modules that signal transduction processes rely on are similar. The regulatory network of stress response and growth regulation interacts at multiple levels. Future research will elucidate key connections and propose strategies to improve resilience with minimal yield reduction. This strategy should not increase crop productivity by making plants sensitive to stress, but by desensitizing stress responses. A warning is that this crop may fail to harvest under extremely severe stress. Anyway, as the relationship between growth and stress response pathways becomes more thorough, the ability to achieve stress resistance and high productivity may be enhanced.

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