

Molecular biology strategies for the efficiency improvement of plant photosynthesis and their applications in agriculture

Boqian Lin

Yangjiang Yangdong Zhengyang school, Yangjiang Guangdong, 529500

ABSTRACT

Photosynthesis is a process in which plants use light energy to transform inorganic substances into organic substances, which is crucial for the growth and development of plants. However, increasing the efficiency of photosynthesis has always been an important topic in agricultural scientific research. Recently, with the rapid development of molecular biology techniques, strategies to improve the efficiency of photosynthesis at the molecular level. We review the molecular biological strategies to increase the efficiency of plant photosynthesis, including gene editing, transgenic technology, and expression regulation of genes involved in photosynthesis, and discuss the promise of these strategies in agriculture. Through further research and rational application of these strategies, it is expected to bring revolutionary breakthroughs to agricultural production.

KEYWORDS

photosynthesis efficiency, molecular biology strategy; gene editing; transgenic technology; agricultural application

1 Introduction

Photosynthesis is one of the most important chemical reactions on Earth, through which plants are able to use sunlight, water, and carbon dioxide to synthesize organic matter while releasing oxygen. Photosynthesis not only provides plants with essential energy and nutrients, but also provides the basis for energy flow and material circulation throughout the biosphere. However, the efficiency of photosynthesis is affected by many factors, such as light intensity, temperature, water content, carbon dioxide concentration, etc. Therefore, improving the efficiency of plant photosynthesis has always been an important topic in agricultural scientific research. In recent years, with the rapid development of molecular biology technology, strategies to improve the efficiency of photosynthesis from the molecular level. Scientists have made some remarkable achievements through gene editing, transgenic technology, and regulating the expression of genes involved in photosynthesis. These results not only provide us with a new understanding of the mechanisms of photosynthesis, but also provide revolutionary possibilities for agricultural production. This paper will review the molecular biology strategies for improve the efficiency of plant photosynthesis, in order to provide reference for research in related fields.

2 Molecular biology strategy for photosynthesis efficiency improvement in plants

2.1 Gene-editing technology

Gene editing is a technique that enables the direct and precise modification of the genome of an

organism. Gene-editing technology has great potential to improve the efficiency of plant photosynthesis. Through gene editing, site-directed mutating photosynthesis-related genes can change the structure and function of their encoded proteins, thus increasing the efficiency of photosynthesis.

For example, the researchers used the CRISPR/ Cas 9 gene editing system to edit the photosynthesis-related genes in rice, which successfully improved the photosynthetic rate and yield of rice. In addition, it has been shown that changing the structure and function of plant chloroplasts through gene-editing technology can also improve the efficiency of photosynthesis. The results show that gene editing technology provides a new way to improve the efficiency of plant photosynthesis.

2.2 Transgenic technology

Transgenic technology is a technique for introducing foreign genes into an organism and making them expressed. In terms of plant photosynthesis efficiency improvement, transgenic technology also has broad application prospects. Through transgenic technology, photosynthesis can be introduced into plants to increase their expression or change their expression pattern, thus improving the efficiency of photosynthesis.

For example, the researchers introduced the carbonic anhydrase gene in cyanobacteria into tobacco, and found that the photosynthetic rate and biomass of transgenic tobacco were significantly higher. Moreover, it has been shown that the introduction of exogenous genes into plants can optimize the activity of photosynthesis-related enzymes and further improve the efficiency of photosynthesis. These results show that the transgenic technology provides new ideas for improving the efficiency of plant photosynthesis.

2.3 The expression and regulation of genes related to photosynthesis

Regulation of the expression of photosynthesis-related genes is another important strategy to improve the efficiency of photosynthesis in plants. By regulating the expression amount or expression pattern of genes involved in photosynthesis, the activity and number of key enzymes during photosynthesis can be optimized, thus improving the efficiency of photosynthesis.

For example, the researchers found that by regulating the expression of Rubisco enzyme-related genes in rice, the activity and content of Rubisco enzymes can be increased, and then increase the photosynthetic rate and yield of rice. In addition, it has been shown that, by regulating the expression patterns of genes related to photosynthesis, plants can optimize the efficiency of light and carbon dioxide utilization, and further improve the efficiency of photosynthesis. These findings suggest that the expression regulation of photosynthesis-related genes is an effective way to improve the efficiency of photosynthesis in plants.

3 A molecular biology strategy for improving plant photosynthesis efficiency in agriculture

3.1 Increase crop yield

Increasing crop yield is the primary goal of agricultural production. The crop productivity can be significantly increased by increasing plant photosynthesis efficiency by applying molecular biology strategies. For example, optimization of photosynthesis-related genes by gene editing or transgenic technology can synthesize more organic matter under the same light and carbon dioxide

conditions, thus increasing crop yield. In addition, by regulating the regulation of the expression of the genes involved in photosynthesis, the crop growth and development process can also be optimized to further improve the crop yield and quality.

3.2 Enhance the stress resistance of crops

Crops will be affected by various stress factors, such as drought, salinity, high temperature, etc. These stress factors can lead to decreased crop photosynthesis efficiency, which can affect crop growth and yield. Increasing plant photosynthesis efficiency can enhance crop stress resistance by applying molecular biology strategies. For example, the optimization of photosynthesis-related genes by gene editing technology can enable crops to maintain high photosynthesis efficiency under stress conditions, and thus maintain normal growth and development. In addition, by regulating the expression regulation of genes involved in photosynthesis, crops can also adapt to the environment by adjusting the photosynthesis process under stress conditions, further improving the stress resistance of crops.

3.3 Promoting sustainable agricultural development

Sustainable agricultural development is an important direction of global agricultural development. Improving plant photosynthesis efficiency by applying molecular biology strategies can promote sustainable agriculture. On the one hand, improving the efficiency of photosynthesis can significantly reduce the consumption of crop resources such as light and carbon dioxide, thus reducing the pressure of agricultural production on the environment. On the other hand, by optimizing the photosynthesis process, the resource utilization efficiency of crops can be improved, and the waste and pollution in agricultural production can be reduced. These measures will help to realize the green and sustainable agricultural production and provide strong support for the sustainable development of agriculture.

4 case analysis

4.1 Gene editing cases of improved photosynthesis efficiency in rice

Rice is one of the most important food crops in the world, and its increased yield is of great significance for ensuring global food security. In recent years, researchers have successfully improved the photosynthesis efficiency by using gene-editing technology in rice. For example, researchers at the Institute of Genetics and Developmental Biology of the Chinese Academy of Sciences used the CRISPR / Cas 9 gene editing system to edit Rubisco enzyme-related genes in rice, which successfully increased the activity and content of Rubisco enzymes. Field experiments showed that the photosynthetic rate and yield of transgenic rice were significantly increased. This research result not only provides a new way to improve the rice yield, but also provides a reference for improving the photosynthesis efficiency of other crops.

4.2 Transgenic cases of tobacco photosynthesis efficiency

Tobacco is an important economic crop, and nicotine in its leaves has widely widely value. However, tobacco growth and production are influenced by multiple factors, of which photosynthesis efficiency is a key factor. In recent years, researchers have successfully improved the photosynthesis efficiency of tobacco by using transgenic technologies. For example, researchers at the University of California introduced the carbonic anhydrase gene in cyanobacteria into tobacco,

and found that the photosynthetic rate and biomass of transgenic tobacco were significantly higher. This research result not only provides a new way to increase tobacco yield, but also provides a reference for improving photosynthesis efficiency in other crops.

4.3 Expression and regulation cases of wheat photosynthesis efficiency improvement

Wheat is one of the most important food crops in the world, and its increased yield is of great significance for ensuring global food security. However, wheat can be affected by multiple stress factors during growth, leading to a decrease in photosynthesis efficiency. Recently, the researchers have successfully improved the efficiency of photosynthesis and stress resistance in wheat by regulating the expression and regulation of genes involved in photosynthesis in wheat. For example, researchers from the National Agricultural University increased the activity and content of Rubisco enzymes by regulating the expression of Rubisco enzyme-related genes in wheat, and then increased the photosynthetic rate and yield of wheat. Meanwhile, the study also found that by regulating the expression pattern of genes related to photosynthesis, wheat can adjust to the environment by adjusting the photosynthesis process under stress conditions, and further improve the stress resistance of wheat. This research result not only provides a new way to increase wheat yield, but also provides a reference for the improvement of photosynthesis efficiency and stress resistance of other crops.

5 Challenges and prospects

Despite significant advances in molecular biology strategies, some challenges remain. On the one hand, photosynthesis is a complex physiological process involving the concerted action of multiple genes and enzymes. Therefore, insights into the functions and regulatory mechanisms of key genes and enzymes in photosynthesis processes is needed when using molecular biology strategies to improve photosynthesis efficiency. On the other hand, the application of molecular biology strategies in agricultural production also needs to consider the safety and feasibility issues. For example, gene editing and transgenic technologies may raise problems such as genetic escape and ecological risk, and require rigorous safety assessment and regulatory measures.

In the future, with the continuous development and improvement of molecular biology technology, it is believed that more molecular biology strategies will be applied to improve the efficiency of plant photosynthesis. For example, through high-throughput sequencing and gene chips, the genetic variation and functional differences of photosynthesis genes and enzymes, metabolic routes and regulation networks can be constructed and optimized by synthetic biology and metabolic engineering, and the efficiency of photosynthesis can be improved through precision agriculture and intelligent agriculture. The application of these technical means will help to further improve the efficiency of plant photosynthesis, and to bring greater benefits and contributions to agricultural production.

6 Conclusion

Photosynthetic efficiency is one of the key factors affecting plant growth and yield. Improving the efficiency of plant photosynthesis by applying molecular biology strategies can significantly improve the yield and quality of crop plants, enhance their stress resistance, and promote the sustainable development of agriculture. Although there are still some challenges and difficulties, with the continuous development and improvement of molecular biology technologies, it is

believed that more molecular biology strategies will be applied to improve the efficiency of plant photosynthesis in the future, and will bring greater benefits and contributions to agricultural production.

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