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Interaction Between Tea Tree Root Probiotics and Tea Yellowing Disease

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Abstract Tea yellow disease is one of the common diseases in the growth of tea plants, which seriously affects the yield and quality of tea. In recent years, more and more studies have shown that probiotics play an important role in plant health and disease resistance. The purpose of this study was to investigate the interaction between tea root probiotics and tea yellowing, and to evaluate the application potential of probiotics in the prevention and treatment of tea yellowing. Research indicates that probiotics can establish symbiotic relationship with the root of tea tree, enhance the resistance of tea tree, and reduce the occurrence and development of tea yellow disease. Probiotics activate the immune system by regulating the expression of tea tree genes and improve the resistance of tea tree to pathogens. In addition, the active substances produced by probiotics also have antibacterial and plant growth regulation functions, and have an inhibitory effect on the pathogenic bacteria of tea yellow disease. The results of this study provide a sustainable and environmentally friendly biological control strategy for the control of tea yellow disease, and demonstrate the application prospect of probiotics in the control of tea yellow disease.
Keywords Tea roots; Probiotics; Tea; Yellowing disease

Tea, as one of the most popular drinks in the world, not only has a long history and cultural heritage, but also has huge economic value worldwide. The tea industry not only provides millions of jobs, but also makes a huge contribution to the export trade of many countries. The scale of the tea garden is huge, and the production and sale of tea is not only an agricultural activity, but also a large and complex industrial chain. The prosperity of the tea industry directly affects the interests of the upstream and downstream of the relevant industrial chain, so its sustainable development is particularly critical.

However, behind the prosperity of the tea industry, the diseases faced by tea trees are increasingly prominent, among which tea yellowing is a common and challenging disease. Tea yellowing disease is mainly manifested as the yellowing, wilting and yield decline of tea leaves, which poses a serious threat to the yield and quality of tea. The occurrence of this disease leads to the decline of tea quality, affects the market competitiveness of tea, and also brings huge economic losses to tea farmers. The prevention and control of tea yellowing disease is urgent, and finding effective prevention and control means has become an urgent task for the sustainable development of tea industry.

Probiotics are a class of microorganisms that are beneficial to the growth and health of host plants (Bahati et al., 2022). In agricultural production, probiotics are widely used to promote crop growth, increase yield and improve plant health. Probiotics can positively affect plants through a variety of mechanisms, such as activating the plant immune system, promoting nutrient uptake, and inhibiting the growth of pathogenic microorganisms. The application potential of probiotics in tea cultivation has not been fully explored, so it is of great theoretical and practical value to study the interaction between probiotics in tea roots and tea yellowing disease (Ren and Luo, 2005).

The purpose of this study was to explore the interaction between tea root probiotics and tea yellows, in order to provide new ideas and methods for the prevention and treatment of tea yellows, and to provide theoretical

and practical value for the sustainable development of tea industry. By revealing the pathogenesis of tea yellowing and its relationship with plant immune system, the etiology of tea yellowing disease can be deeply understood and theoretical basis for further prevention and control can be provided. To evaluate the potential of tea root probiotics in the control of tea yellowing disease is helpful to develop new strategies and methods to improve the yield and quality of tea. In addition, the application of probiotics can also promote soil health and crop disease resistance, contribute to the sustainable development of the tea industry and improve the economic benefits of tea farmers (Guan et al., 2020). It is hoped that the discussion in this study can provide references for improving the yield and quality of tea and promoting the development of the tea industry in a healthier and more sustainable direction.

1 Interaction between Probiotics and Tea Tree Roots

1.1 Classification and characteristics of probiotics

Probiotics are a class of microorganisms that are beneficial to the health of the host, and their main feature is that they can colonize the intestinal tract or other tissue parts of the host and form a symbiotic relationship with the host (Bahati et al., 2022). Probiotics can also colonize and play an important role in the root of the tea plant. Probiotics can be divided into different strains according to their classification, including lactic acid bacteria, bifidobacteria, yeast and so on.

Lactic acid bacteria are a group of Gram-positive bacteria that produce lactic acid as a metabolite. They are commonly found in fermented foods, such as yogurt and lactic acid-fermented vegetables. Lactic acid bacteria have an antibacterial effect, can inhibit the growth of some harmful microorganisms by producing antibacterial substances, and is very important for maintaining the balance of intestinal flora.

Bifidobacteria is a group of Gram-positive bacteria commonly found in the intestines of humans and animals. They have strong acid resistance and bile salt tolerance, can resist the influence of stomach acid and bile, and successfully colonize the intestine and play a probiotic role (Guan et al., 2020). Bifidobacteria aid in digestion and absorption of nutrients, promote the normal function of the immune system, and play an important role in intestinal health.

Yeast is a class of single-celled fungi commonly found in the natural environment and in food. Yeasts have the ability to ferment and convert carbohydrates into alcohol and carbon dioxide. Certain yeasts have antioxidant and antibacterial effects, which can promote nutrient absorption and immune function of the host. Each strain has different metabolic characteristics and physiological functions and therefore plays a different role in the interaction with the root of the tea plant.

1.2 Effects of probiotics on the growth and health of tea plants

Studies have shown that probiotics can promote the growth and development of tea tree roots (Huang et al., 2020). The organic acids and enzymes they produce can reduce soil pH, improve soil structure, increase the surface area absorbed by roots, and increase the growth of root hairs. These beneficial substances can also promote the division and elongation of root cells, and improve the absorption capacity of roots for nutrients. Probiotics, through metabolic activity, convert some organic and inorganic substances into forms that can be absorbed and utilized by the tea plant. They produce enzymes that break down organic matter in organic fertilizers and soil, releasing more nutrients for the tea plant to absorb. Probiotics can also improve the utilization efficiency of nutrients such as nitrogen, phosphorus and potassium, and reduce the loss and waste of nutrients.

Probiotics activate the immune system of the tea plant and enhance the plant's resistance to pathogens. They regulate plant growth and development processes by producing some hormonal substances, such as auxin and gibberellin, and enhance plant recognition and defense against pathogens (Wang et al., 2020). In addition, probiotics can also activate the synthesis of some antioxidant enzymes, reducing the damage of tea plants by

oxidative stress. Through mechanisms such as competition and production of antimicrobial substances, the growth of some harmful microorganisms in the soil can be inhibited. These harmful microorganisms may cause tea plant diseases, such as tea yellowing. The presence of probiotics can reduce the number of pathogenic microorganisms and the incidence of disease, and protect the health of tea plants.

1.3 Symbiotic relationship between probiotics and tea root

Probiotics form a symbiotic relationship with tea tree roots, a relationship that benefits both (Huang et al., 2020). Tea tree roots provide a suitable living environment for probiotics, including suitable temperature, humidity and nutrients. Some substances secreted by the root of the tea plant, such as root mucus and rhizosphere acids, attract probiotics to colonize and provide nutrients needed for growth. Probiotics, on the other hand, form a protective barrier by colonizing the roots of the tea plant, preventing the invasion of some harmful microorganisms. In addition, probiotics can also communicate signals with the root of the tea tree, regulate the activity of the plant immune system, and improve the disease resistance of the tea tree.

There is a close interaction between probiotics and tea roots. Probiotics have a positive impact on the growth and health status of tea plants through their specific metabolic and physiological functions. Tea tree root provides a suitable living environment for probiotics, and forms a symbiotic relationship with them to promote each other's growth and development. These interactions are of great significance for the control of tea yellowing and the improvement of tea yield.

2 Etiology and Pathological Mechanism of Tea Yellowing

2.1 Etiology and pathogenesis of tea yellowing

Tea yellowing is an important disease in tea plants, and its pathogenesis is closely related to complex pathological mechanisms (Figure 1). The occurrence of tea yellowing is closely related to environmental factors, and climatic conditions are one of the important factors. Environmental conditions such as high temperature, high humidity and high light easily lead to the occurrence of tea yellowing (Wang, 2017). In addition, the change of soil conditions, excess or insufficient water will also play a certain role in the incidence of tea yellowing.

Figure 1 Tea yellowing disease (Image Source: http://zhibao.yuanlin.com)

The incidence of tea yellowing disease is related to pathogen infection. The pathogens of tea yellowing mainly include viruses and fungi. Virus infection is one of the main causes of tea yellowing disease, common viruses include CYLV (Camellia yellow leaf virus), CYMLV (Camellia yellow mottle leaf virus) and so on.

These viruses are spread by means of vector insects or root contact, causing damage and yellowing of tea tissue.

The incidence of tea yellowing is also related to the resistance and immune mechanism of tea plant itself (Jin et al., 2021). The resistance of tea cultivars to tea yellowing disease is different, and some cultivars have strong resistance to virus infection. At the same time, the immune mechanism of tea plant plays an important role in resisting pathogen invasion, including activation of antioxidant system and synthesis of antibacterial substances.

2.2 Influence of tea yellowing on tea growth and quality

Tea yellowing has a significant effect on the growth and quality of tea. Tea yellowing can lead to growth restriction of tea plants. Virus infection and tissue yellowing will destroy the photosynthesis of tea trees and reduce the photosynthetic efficiency of leaves, thus affecting the growth and development of plants. After tea tree is attacked by tea yellowing disease, the number and size of leaves are reduced, and the growth rate is slowed down, resulting in poor overall growth state of tea tree. Tea yellowing disease will reduce the quality of tea, and there are obvious differences in color, aroma and taste between yellow tea and healthy tea. Tea yellowing causes the leaves to lose their green pigment, making the tea lighter in color and losing its vibrant green color. At the same time, the metabolic activity of the diseased tissue is reduced, resulting in the aroma and taste of the tea being affected (Jin et al., 2021). Tea yellowing may also cause the accumulation of harmful substances in tea and affect the flavor and quality of tea.

Tea yellowing also affects the yield stability of tea plants. Tea yellowing causes poor growth of tea plants and reduces the yield of leaves, thus reducing the yield stability of tea. This is an important economic loss for the tea growing industry. The pathogenesis of tea yellowing involves many factors, including environmental factors, pathogen infection, resistance and immune mechanism of tea plant itself. Tea yellowing has a significant impact on the growth and quality of tea, including tea tree growth restriction, tea quality reduction and yield stability decline. In-depth research on tea yellowing disease is helpful to formulate effective prevention and control strategies to ensure the sustainable development of tea industry.

3 Interaction between Tea Root Probiotics and Tea Yellowing

3.1 Study on the prevention and control effect of probiotics on tea yellowing disease

Tea root probiotics play an important role in the prevention and treatment of tea yellowing disease. The study on the effect of probiotics on tea yellowing can provide an effective disease management strategy for tea industry. Liu et al. (2021) screened a series of probiotic strains with disease resistance characteristics, and isolated several probiotic strains with antagonistic ability against pathogens from the rhizosphere of tea tree through screening and identification under laboratory conditions. These strains can inhibit the growth and spread of pathogenic bacteria of tea yellowing disease, so as to reduce the degree of disease of tea trees.

Yu et al. (2020) conducted a field test of probiotics, selecting areas with severe tea yellows in tea gardens, and applying the selected probiotics to the roots of tea trees. The effect of probiotics on tea yellowing was evaluated by comparing experimental group and control group. The results showed that the degree of yellowing of tea leaves was significantly reduced, the growth state of tea plants was significantly improved, and the tea yield and quality were also improved.

3.2 Effects of probiotics on rhizosphere microbial community structure of tea tree

The application of probiotics can not only directly affect the control effect of tea yellowing disease, but also may be achieved by regulating the rhizosphere microbial community structure of tea tree (Figure 2). Tea rhizosphere microbial community is a complex ecosystem in which microbial interactions have an important impact on plant health and disease development (Liu et al., 2021).

Huang et al. (2020) conducted a comparative analysis of rhizosphere microbial communities of tea trees treated with probiotics and those treated with control bacteria through high-throughput sequencing technology. The results showed that the application of probiotics significantly affected the composition and diversity of rhizosphere microorganisms. The introduction of some beneficial strains increased the abundance of beneficial microorganisms and inhibited the growth of some potential pathogens. This regulation helps to maintain the balance of rhizosphere microbial community, improve plant resistance and reduce the invasion of pathogenic bacteria.

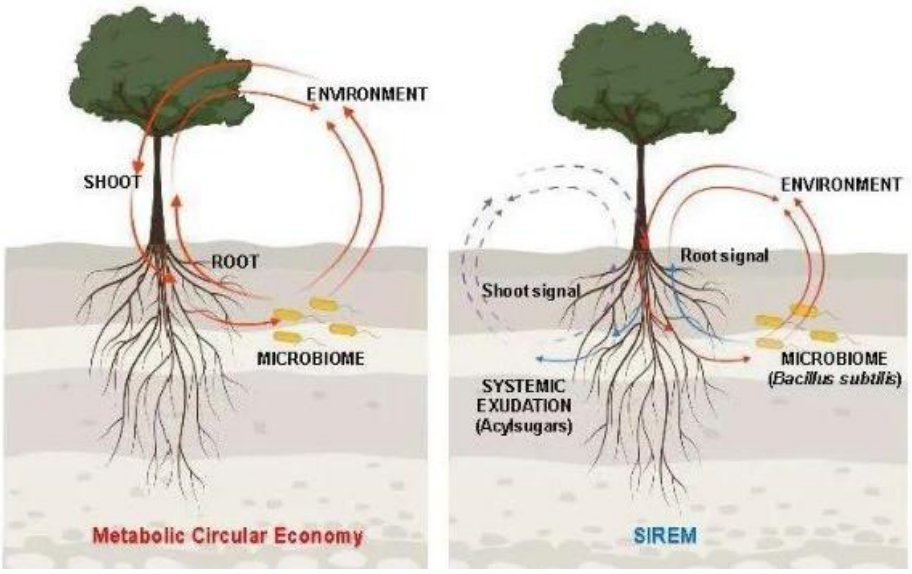

Figure 2 Tea tree roots interact with microbes (Image Source: https://zhuanlan.zhihu.com/p/527306152)

3.3 Regulation of metabolic pathways related to tea yellowing by probiotics

In addition to the direct control effect of tea yellowing disease and the influence of tea rhizosphere microbial community, probiotics may also achieve the regulation of tea yellowing disease by regulating metabolic pathways.

Chen et al. (2018) performed a metabolomic analysis to compare tea samples from the probiotic treatment group and the control group. The results showed that the application of probiotics led to significant changes in metabolites inside the tea. The content of some metabolites related to antioxidant, disease resistance and plant growth was significantly regulated. This suggests that probiotics may enhance the plant's resistance and inhibit the development of tea yellowing by activating the plant's defensive metabolic pathways.

Further metabolic pathway analysis revealed the key metabolic pathways involved in probiotics. By identifying and quantifying the expression changes of key enzymes, it can be found that probiotics may affect the development of tea yellowing by regulating metabolic pathways such as photosynthesis, secondary metabolism and nutrient transport in tea. The regulation of these metabolic pathways may provide more energy and resources for tea plants and enhance their resistance to pathogens.

In conclusion, there are many interactions between tea root probiotics and tea yellowing. Probiotics can not only directly inhibit the growth and spread of pathogenic bacteria and reduce the degree of tea yellowing disease, but also control the disease by regulating the rhizosphere microbial community structure of tea tree and the regulation of metabolic pathways related to tea yellowing disease. These research results provide important theoretical basis and technical support for the tea industry, help to improve the quality and yield of tea, and promote the sustainable development of tea industry.

4 Molecular Mechanism Analysis

4.1 Regulation of expression of tea root probiotics and tea yellowing related genes

The interaction between tea root probiotics and tea yellowing involves complex molecular mechanisms. Through transcriptomic analysis, significantly different gene expression patterns were found between the tea tree root probiotic treatment group and the control group (Chen et al., 2018). Some genes related to immune response, antioxidant response and plant growth regulation were significantly up-regulated in the probiotic treatment group. This suggests that the application of probiotics may enhance the disease resistance and growth status of tea plants by regulating the expression of these genes.

Further functional enrichment analysis showed that the up-regulated genes in the tea root probiotics treatment group were mainly involved in disease-resistance-related pathways, such as signal transduction pathways in plant immune system and pathogen recognition mechanisms. These findings suggest that tea root probiotics may inhibit the development of tea yellowing by activating the plant's immune response.

4.2 Influence of active substances produced by probiotics on tea yellowing disease

The results of chemical analysis showed that the culture medium produced by tea root probiotics contained a variety of secondary metabolites, such as antibiotics, plant growth regulation substances and secondary metabolites. Some of these substances have been shown to have antibacterial activity and plant growth regulation ability (Chen et al., 2018). Through further bioactivity evaluation, it was found that probiotic culture solution had inhibitory effect on the growth and physiological activity of pathogenic bacteria of tea yellowing.

Further studies have shown that these active substances may affect tea yellowing by directly inhibiting the growth of pathogenic bacteria, reducing their virulence, or by activating the plant's defense response. These active substances may be closely related to the symbiotic mechanism of tea root probiotics, and provide a potential mechanism for the prevention and treatment of tea yelosis.

4.3 Interaction of tea root probiotics with immune system

The interaction between tea root probiotics and tea yelosis also involves the immune system of the tea plant (Figure 3). Zhu et al. (2020) analyzed the expression regulation of immune-related genes in tea tree roots treated with probiotics and control plants to understand the effect of probiotics on the immune response of tea trees. The results showed that the expression of many genes related to immune response showed a significant up-regulation trend in the tea tree root probiotic treatment group. These genes include key components encoding defense proteins, signaling factors and hormone synthases. This suggests that tea root probiotics may enhance the immune response of tea plants by regulating the expression of immune-related genes (Wang et al., 2020).

Further functional enrichment analysis also revealed that the genes upregulated in the tea tree root probiotic treatment group were associated with key pathways in the plant immune system, such as activation signaling pathways and hormone regulation mechanisms. These findings suggest that tea root probiotics may promote disease resistance of the plant through interaction with the immune system of the tea plant, thereby reducing the occurrence and development of tea yellowing disease.

The interaction between tea root probiotics and tea yelosis involves several molecular mechanisms. By regulating the expression of related genes in tea tree, probiotics may enhance the disease resistance and growth status of tea tree. In addition, the active substances produced by probiotics have an inhibitory effect on the pathogenic bacteria of tea yellowing disease and may affect the disease by activating the plant's defense response. At the same time, the interaction of tea plant root probiotics with the immune system helps to enhance the immune response and disease resistance of tea plant. These results provide an important

theoretical basis for the prevention and control of tea yellowing disease, and provide a scientific basis for the application of probiotics in tea cultivation.

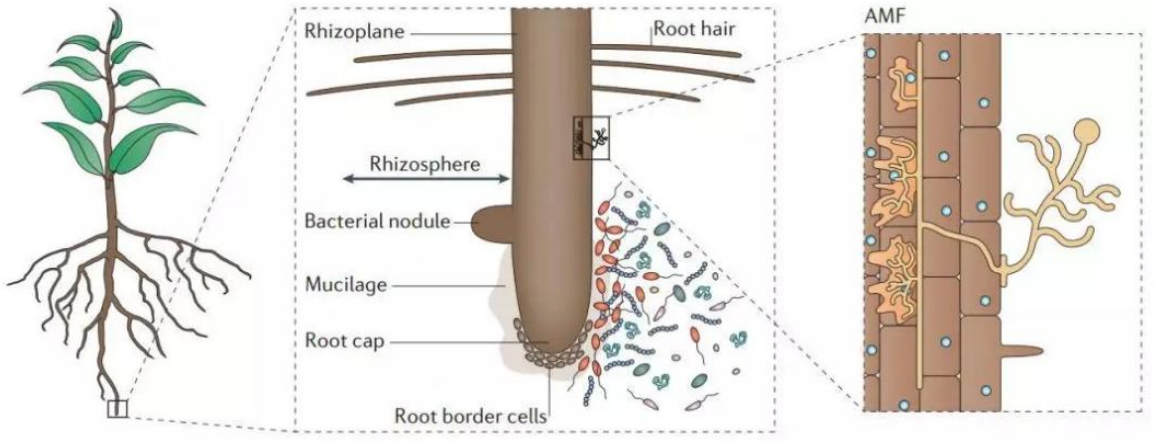

Figure 3 Tea tree roots (Image Source: https://www.sohu.com/a/363191056_100281977)

5 Prospect of Probiotics Applied in the Prevention and Control of Tea Yellowing Disease

5.1 Advantages and potential of probiotics in the prevention and control of tea yellowing disease

As a biological control strategy, probiotics have many advantages and potential in the control of tea yellowing disease (Luan, 2016, Agriculture of Jilin, 18: 97). Probiotics can enhance the disease resistance of tea plants by establishing a symbiotic relationship with the roots of tea plants. By regulating the expression of tea tree genes and activating the immune system, probiotics can enhance the resistance of tea tree to pathogens and reduce the occurrence and development of tea yellowing disease.

The active substances produced by probiotics also have the function of antibacterial and plant growth regulation, and have the inhibitory effect on pathogenic bacteria of tea yellowing disease. These active substances can directly inhibit the growth of the pathogen, reduce its virulence, or inhibit the development of the disease by activating the plant's defense response. Therefore, the application of probiotics can provide a sustainable and environmentally friendly control method, reducing the reliance on chemical pesticides.

In addition, probiotics have high adaptability and survival ability, and can form a stable symbiotic relationship in the tea rhizosphere. This means that the application of probiotics can provide long-term and stable control effect on tea yellows, and has good durability.

5.2 Application strategy and development trend of probiotics

The application strategies of probiotics are diverse and flexible in the control of tea yellowing disease (Zhang et al., 2020). A common application strategy is to apply probiotics to the roots of the tea tree to promote the interaction between the probiotics and the tea tree through rhizosphere co-generation. This can be done through soil application, root soaking or seed treatment. Probiotics can also be applied to the leaf surface spray or soak treatment of tea to improve the immune capacity and disease resistance of tea.

The future development trend of probiotics in the control of tea yellows mainly includes the following aspects, such as further research and screening of probiotics strains with high disease resistance, exploration of more functional active substances, and optimization of their yield and stability. To strengthen the research on the application strategy of probiotics, including the optimization of the best application time, dosage and method, in order to improve the control effect. The strategy of multi-strain combined application can also be explored to enhance the control effect through the synergistic action of different probiotics.

Strengthen the research on the interaction mechanism between probiotics and tea trees, and gain an in-depth understanding of how probiotics regulate the immune system and gene expression of tea trees, as well as its

inhibition mechanism on pathogenic bacteria of tea yellowing (Zhu et al., 2020). This will help to better understand the mode of action of probiotics and provide a scientific basis for further optimization of probiotic application strategies. With the continuous development of biotechnology and genetic engineering, the improvement and optimization of probiotics will also become an important research direction. Through genetic modification, metabolic engineering and other means, the bioactivity, disease resistance and adaptability of probiotics can be improved, and the application effect of probiotics in the control of tea yellowing can be further improved.

Probiotics have broad prospects in the control of tea yellows. By giving full play to the advantages and potential of probiotics, optimizing the application strategy, and deeply studying the interaction mechanism between probiotics and tea trees, it is expected to develop more efficient and environmentally friendly biological control methods, and contribute to the sustainable development of tea industry.

6 Summary and Prospect

6.1 Summary of the interaction between tea root probiotics and tea yellowing disease

This study systematically investigated the interaction between tea root probiotics and tea yellowing. Studies have found that probiotics can enhance the disease resistance of tea trees and reduce the occurrence and development of tea yellowing by establishing a symbiotic relationship with tea tree roots (Chen et al., 2007). Probiotics improve the resistance of tea plant to pathogens by regulating the expression of tea plant genes and activating the immune system.

The active substances produced by probiotics also have the effect of antibacterial and plant growth regulation, and have the effect of inhibiting the pathogenic bacteria of tea yellowing disease. The interaction between tea root probiotics and tea yellowing provides a sustainable and environmentally friendly biological control strategy for the control of tea yellowing.

6.2 Application prospect of probiotics in the prevention and treatment of tea yellowing disease

Probiotics have broad application prospects in the control of tea yellowing disease. With the in-depth study of probiotics, it is possible to further optimize the screening and improvement of probiotics, select more disease-resistant strains, and improve their biological activity and adaptability. At the same time, the strategy of multi-strain combined application can be explored to enhance the control effect through the synergistic effect of different probiotics (Zhu et al., 2020). This will provide a more efficient and sustainable method for the control of tea yellowing disease.

Studies on the mechanism of action of probiotics in rhizosphere symbiosis of tea tree should be strengthened to further understand how probiotics regulate the immune system and gene expression of tea tree, as well as the inhibition mechanism of pathogenic bacteria of tea yellowing (Figure 2). This will help to better understand the mode of action of probiotics and provide scientific basis for optimizing the application strategy of probiotics. With the continuous development of biotechnology and genetic engineering, advanced technical means can be used to improve and optimize probiotics to improve their disease resistance and adaptability. Through genetic modification, metabolic engineering and other methods, the prevention and control effect of probiotics can be further improved, and a more reliable and controllable means for the prevention and control of tea yellowing can be provided.

The interaction between tea root probiotics and tea yellowing provides a new idea and method for the control of tea yellowing. By further studying the mechanism of action and optimizing the application strategy of probiotics, the disease resistance of tea plant can be further improved and the occurrence and development of tea yellowing disease can be alleviated.

Reference

Bahati A., Tan C.M., and Li P.L., 2022, Classification and applications of probiotics, Shengwu Jiagong Guocheng (Chinese Journal of Bioprocess Engineering), 20(1): 88-94.

Chen L.Y., Zhang Y.M., Chen X.Y., Fang R.X., and Zhang L.L., 2018, Identification of endophytic bacteria selectively enriched in Camellia sinensis leaf, Weishengwu Xuebao (Acta Microbiologica Sinica), 58(10): 1776-1785.

https://doi.org/ 10.13343/j.cnki.wsxb.20170592

Chen Y.H., Liu F.Z., and Lian Y., 2007, The pathogens and the biological characteristics from yellowing and wilted eggplant in part of Beijing Area, Zhongguo Shucai (China Vegetables), (11): 16-19.

https://doi.org/10.3969/j.issn.1000-6346.2007.11.006

Guan J.Q., Li B.L., Jiao W.S., Li H.Z., Yue Y.X., Li N., Shi J.L., Zhao L., and Huo G.C., 2020, Recent advances in understanding the role of probiotics in promoting intestinal development, Shiping Kexue (Food Science), 41(21): 278-285.

https://doi.org/ 10.7506/spkx1002-6630-20191015-132

Huang F.F., Li Q., and Huang J.A., 2020, Research progress of tea rhizosphere microorganisms, Chaye Kexue (Journal Of Tea Science), 40(6): 715-723.

https://doi.org/ 10.13305/j.cnki.jts.2020.06.002.

Jin K., Huang J.A., Xiong L.G., Liu S.Q., Qin X.H., Peng J., Li Y.H., and Li J., 2021, Research of theanine-related genes expressed in etiolated tea plant (*Camellia sinensis*), Chaye Kexue (Journal of Tea Science), 41(1): 40-47.

Liu J.W., Li X.Z., and Yao M.J., 2021, Research progress on assembly of plant rhizosphere microbial community, Weishengwu Xuebao (Acta Microbiologica Sinica), 61(2): 231-246.

https://doi.org/ 10.13343/j.cnki.wsxb.20200154

Ren M.X., and Luo Y.P., 2005, Advances in research on VA mycorrhiza in tea plants, Chaye (Journal of Tea), 31(1): 28-31.

https://doi.org/10.3969/j.issn.0577-8921.2005.01.014.

Wang H., Wu A.J., Liu B.X., Liu R.J., Chen Y.L., 2020, Interactions between mycorrhizal fungal diversity and plant diversity: a review, Weishengwuxue Tongbao (Microbiology China), 47(11): 3918-3932.

https://doi.org/10.13344/j.microbiol.china.190956

Wang Z.H., 2017, Studies on identification of anew tea disease and its detection technology, Dissertation for Ph.D.,Huazhong Agricultural University, Supervisors: Xiao Y.N., pp.27-34.

Yu K., Wang X.L., Zhang X.B., and Wang E.T., 2020, Research progress on interactions between root and beneficial microbes, Zhiwu Shengli Xuebao (Plant Physiology Journal), 56(11): 2275-2287.

https://doi.org/ 10.13592/j.cnki.ppj.2020.0156

Zhang Y.T., Chen J.Y., Li P.G., and Jv S.M., 2020, Mechanism and application of arbuscular mycorrhiza on prevention and treatment of iron deficiency chlorosis in plants, Linye Keji Qingbao (Forestry Science And Technology Information Linye Keji Qingbao), 52(3): 1-5.

https://doi.org/10.3969/j.issn.1009-3303.2020.03.001

Zhu Z.Y., Li P.G., Li L.Y., Jv S.M., and Nan N., 2020, Research status of siderophore bacteria on biological control of plant iron-deficiency yellow disease, Linye Keji Qingbao (Forestry Science And Technology Information Linye Keji Qingbao), 52(3): 9-11.

https://doi.org/10.3969/j.issn.1009-3303.2020.03.003