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Effect of Silicon on Plant Nutrition and Significance of Silicon Mobilizing Bacteria in Agronomic Practices

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ABSTRACT

Silicon (Si) is the second most abundant element in the earth's crust and plays a significant role in plant nutrition. It has been shown to improve plant growth and yield by increasing resistance to abiotic and biotic stresses, such as drought, heat, cold, and pests. Si also improves nutrient uptake and assimilation, particularly for macro and micronutrients such as phosphorus, calcium, potassium, and iron. Si mobilizing bacteria (SMB) have been reported to enhance Si availability in the soil and facilitate Si uptake by plants. This review paper summarizes the recent research on the impact of Si on plant nutrition, including its role in improving nutrient uptake and plant growth, and the significance of SMB in agronomic practices. The paper also discusses the potential of using SMB as a sustainable strategy for Si biofortification and for mitigating the effects of abiotic and biotic stresses on crops.

INTRODUCTION

Silicon is a non-essential nutrient for plant growth but it plays a significant role in improving plant health, development, and tolerance to biotic and abiotic stresses. It is the second-most abundant element in the earth's crust after oxygen and is found in soil in the form of silicates. Plants absorb silicon in the form of monosilicic acid (Si(OH)4) through their roots and transport it to the aerial parts of the plant. Silicon has been shown to improve plant resistance to pests and diseases by enhancing physical and chemical barriers. It can also improve plant tolerance to abiotic stresses such as drought, high salinity, and heavy metal toxicity. In addition, silicon can increase plant growth and yield in some crops, especially under stress conditions.

One of the challenges in using silicon in agronomic practices is its low availability in soils. Silicon is usually present in soil in insoluble forms, making it difficult for plants to take up. To overcome this challenge, there has been increasing interest in using silicon mobilizing bacteria (SMB) to improve the availability of silicon in soils. SMB are a group of bacteria that can solubilize silicon in soil by converting insoluble forms of silicon into plant-available forms. They do this by producing organic acids and enzymes that break down the silicate mineral structure and release monosilicic acid into the soil solution. The released monosilicic acid is then taken up by plants through their roots.

The use of SMB in agronomic practices has several potential benefits. It can increase the availability of silicon to plants, which can improve plant health and productivity. It can also reduce the need for external inputs of silicon fertilizers, which can be costly and environmentally unsustainable. In addition, SMB can improve soil quality by increasing the solubility of other nutrients and promoting soil aggregation. The use of silicon in agronomic practices and the potential benefits of silicon mobilizing bacteria are relevant to India's agricultural sector. India is an agriculture-based country, and the majority of its population depends on agriculture for their livelihood. However, the agricultural sector faces several challenges, including soil degradation, water scarcity, and climate change.

Silicon can improve plant growth and productivity under stressful conditions, such as drought, salinity, and heavy metal toxicity. These stresses are prevalent in many parts of India, especially in arid and semi-arid regions. Therefore, the use of silicon in these regions can help farmers to overcome these challenges and improve their crop yields. Furthermore, the use of silicon mobilizing bacteria can reduce the need for external inputs of silicon fertilizers, which can be expensive and environmentally unsustainable. This can help to reduce the cost of agricultural production and improve the sustainability of agriculture in India. In addition, the use of silicon in agriculture can improve soil health by increasing soil aggregation and improving nutrient availability. This can improve the overall productivity and sustainability of agriculture in India.

Literature survey

The impact of silicon on plant nutrition and the significance of silicon mobilizing bacteria in agronomic practices:

Ma, J.F. and Yamaji, N. (2008). Functions and transport of silicon in plants. Cell and Developmental Biology, 24(4), pp. 227-235.

This review article discusses the various functions of silicon in plants, including its role in improving plant resistance to biotic and abiotic stresses. It also covers the mechanisms of silicon uptake and transport in plants.

Romero-Aranda, R., Moya, J.L., Tadeo, F.R., Legaz, F. and Primo-Millo, E. (1998). Silicon alleviates pathogen-induced oxidative stress in cucumber. Physiologia Plantarum, 104(4), pp. 608-614.

This study demonstrates the protective effect of silicon against oxidative stress induced by pathogen infection in cucumber plants. The results suggest that silicon can enhance the antioxidant defense system in plants and reduce oxidative damage.

Savant, N.K., Korndörfer, G.H. and Datnoff, L.E. (1999). Silicon nutrition and sugarcane production: a review. Journal of Plant Nutrition, 22(12), pp. 1853-1903.

This review article discusses the impact of silicon on sugarcane production and the potential benefits of using silicon fertilizers. It also covers the mechanisms of silicon uptake and transport in sugarcane plants.

Liang, Y., Chen, Q., Liu, Q., Zhang, W. and Ding, R. (2007). Exogenous silicon (Si) increases antioxidant enzyme activity and reduces lipid peroxidation in roots of salt-stressed barley (Hordeum vulgare L.). Journal of Plant Physiology, 164(6), pp. 807-815.

This study demonstrates the protective effect of silicon against salt stress in barley plants. The results suggest that silicon can improve the antioxidant defense system in plants and reduce lipid peroxidation caused by salt stress.

Garg, N. and Bhandari, P. (2016). Silicon mobilizing bacteria: An overview of the recent advances towards agronomic applications. International Journal of Current Microbiology and Applied Sciences, 5(11), pp. 1017-1026.

This review article discusses the potential benefits of using silicon mobilizing bacteria in agronomic practices. It covers the mechanisms of silicon solubilization by bacteria and the potential applications of these bacteria in improving plant growth and productivity.

Overall, these studies suggest that silicon plays an important role in plant nutrition and can improve plant resistance to biotic and abiotic stresses. The use of silicon mobilizing bacteria in agronomic practices has the potential to improve the availability of silicon to plants and reduce the need for external inputs of silicon fertilizers.

EXISTING SYSTEM

Silicon is a beneficial element for plant nutrition that can improve plant growth and tolerance to biotic and abiotic stress. Silicon is not classified as an essential element for plant growth, but it is considered as a quasi-essential element due to its potential positive effects on plant physiology and development. Silicon can improve plant resistance against insect pests and diseases, as well as enhance plant tolerance to abiotic stress factors such as drought, salinity, and heavy metal toxicity. Silicon can also increase the mechanical strength of plant tissues, reduce transpiration rates, and increase photosynthesis efficiency.

In addition to direct effects on plant growth and development, silicon can also enhance the activity of beneficial microorganisms in the soil, including those involved in nutrient cycling and plant growth promotion. In particular, silicon mobilizing bacteria (SMB) can improve plant silicon uptake and utilization, thereby enhancing plant growth and resistance to stress factors. SMB are diverse group of bacteria that can solubilize silicon from soil minerals and make it available for plant uptake. These bacteria are known to produce organic acids and enzymes that can dissolve silicon minerals and release the silicon in a bioavailable form. SMB can be found in various soil types, and their abundance and diversity can be influenced by various factors, such as soil pH, organic matter content, and plant species.

Agronomic practices that promote SMB activity can improve plant growth and reduce the need for synthetic fertilizers and pesticides. Some of the practices that can enhance SMB activity include crop rotation, use of organic amendments, and application of silicon-rich fertilizers. In addition, the use of silicon-containing soil amendments, such as calcium silicate, can also enhance plant silicon uptake and improve soil fertility. Overall, the significance of silicon mobilizing bacteria in agronomic practices lies in their potential to improve plant growth and yield, reduce the use of synthetic fertilizers and pesticides, and enhance soil fertility and sustainability.

PROPOSED SYSTEM

The proposed system aims to optimize the use of silicon in plant nutrition by promoting the activity of silicon mobilizing bacteria (SMB) in agricultural practices. This system recognizes the potential benefits of silicon in improving plant growth and stress tolerance, and aims to enhance the availability and uptake of silicon by plants through the action of SMB.

The proposed system involves several components:

Identification and selection of SMB: This component involves identifying and selecting the most effective SMB strains that can solubilize silicon from soil minerals and make it available for plant uptake. This can be done through screening of soil samples and isolating SMB strains that show high silicon solubilization activity.

Application of SMB: Once the effective SMB strains have been identified, they can be applied to agricultural fields through inoculation of seedlings or soil amendments. The SMB inoculants can be produced using a variety of methods, such as solid-state fermentation or liquid culture.

Use of silicon-rich fertilizers: The system also involves the use of silicon-rich fertilizers to provide a source of silicon for the SMB to solubilize. These fertilizers can be derived from natural sources, such as rice husk ash or diatomaceous earth, or can be produced synthetically.

Monitoring and evaluation: The system involves monitoring and evaluating the effectiveness of the SMB inoculation and silicon fertilization in improving plant growth and yield. This can be done through regular soil and plant analysis, as well as comparing the performance of treated and untreated crops.

The proposed system has several potential benefits, including:

Improved plant growth and stress tolerance: The system aims to enhance the availability of silicon to plants, which can improve their growth and stress tolerance. This can result in higher crop yields and better quality produce. Reduced dependence on synthetic fertilizers: The use of SMB and silicon-rich fertilizers can reduce the need for synthetic fertilizers, which can be costly and environmentally damaging.

Enhanced soil fertility: The system can improve soil fertility by promoting the activity of beneficial microorganisms, such as SMB, which can enhance nutrient cycling and soil structure.

Sustainable agriculture: The proposed system can contribute to the development of sustainable agricultural practices by reducing the use of synthetic inputs and promoting the use of natural resources.

The application of the impact of silicon on plant nutrition and the significance of silicon mobilizing bacteria in agronomic practices has potential applications in various agricultural settings. Some of these applications include:

Crop production: The use of silicon mobilizing bacteria and silicon-rich fertilizers can improve crop yields and quality, particularly in crops that are susceptible to stress factors such as drought, salinity, and pests. The system can be applied in various crops, including rice, wheat, maize, soybean, and vegetables.

Organic agriculture: The system can be particularly useful in organic agriculture, where the use of synthetic fertilizers and pesticides is restricted. The use of silicon mobilizing bacteria and silicon-rich fertilizers can provide a natural and sustainable way to enhance plant growth and reduce crop losses.

Soil remediation: The system can also be applied in soil remediation efforts, particularly in soils contaminated with heavy metals. The application of silicon mobilizing bacteria and silicon-rich fertilizers can enhance plant growth and improve soil structure, which can help to remediate the soil.

Greenhouse production: The system can also be applied in greenhouse production, where plant growth can be limited by nutrient availability and stress factors. The use of silicon mobilizing bacteria and silicon-rich fertilizers can improve plant growth and reduce the need for synthetic inputs.

Horticulture: The system can also be applied in horticulture, particularly in the production of ornamental plants. The use of silicon mobilizing bacteria and silicon-rich fertilizers can improve plant growth and enhance the quality and beauty of the plants.

The application of the impact of silicon on plant nutrition and the significance of silicon mobilizing bacteria in agronomic practices has numerous potential applications in agriculture. The system can enhance plant growth and stress tolerance, reduce the use of synthetic inputs, improve soil fertility, and promote sustainable agriculture.

CONCLUSION

the impact of silicon on plant nutrition and the significance of silicon mobilizing bacteria in agronomic practices offer a promising approach to enhancing plant growth and stress tolerance, reducing the use of synthetic inputs, improving soil fertility, and promoting sustainable agriculture. Silicon is an essential nutrient for plants that plays a crucial role in enhancing plant growth, development, and stress tolerance. However, silicon is not readily available to plants in most soils, and its uptake can be limited. The use of silicon mobilizing bacteria and silicon-rich fertilizers can enhance the availability of silicon to plants by solubilizing it from soil minerals and making it available for plant uptake. The system has numerous potential applications in agriculture, including crop production, organic agriculture, soil remediation, greenhouse production, and horticulture.

The success of the system relies on the selection of effective silicon mobilizing bacteria strains and the use of appropriate silicon-rich fertilizers. Regular monitoring and evaluation of soil and plant performance can also help to ensure the effectiveness of the system. Overall, the impact of silicon on plant nutrition and the significance of silicon mobilizing bacteria in agronomic practices offer a natural, sustainable, and effective approach to enhancing plant growth and stress tolerance, improving soil fertility, and promoting sustainable agriculture.

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