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Dicyandiamide: Modern Tool for Nitrogen Management

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Abstract

Nitrogen is a most essential element for plant growth and development and major component of enzyme, nucleic acid, amino acid and chlorophyll. Nitrogen fertilizer is an essential input for crop production, its cost can be significant challenge for farmers that influenced by various factors such as production and transportation cost. Nitrogen management can optimize crop yield, profitability and reduce the nitrogen losses to environment. Nitrification inhibitors increase the nitrogen use efficiency and reduce the losses.Dicyandiamide is one of the nitrification inhibitor that inhibit the conversion of ammonium to nitrate, which is the first step in the nitrogen cycle in soil. By inhibiting nitrification, dicyandiamide can reduce the amount of nitrate in the soil, which can reduce the potential for nitrate leaching, denitrification, and volatilization.

Introduction

Plants require nitrogen in large amounts, and its availability can limit crop yields. Nitrogen is typically obtained by plants through soil mineralization of organic matter or through the application of fertilizers. However, excessive use of nitrogen fertilizers can result in environmental pollution, including nitrate leaching, greenhouse gas emissions, and eutrophication of water bodies. Therefore, optimizing nitrogen use efficiency in agriculture is a major component of sustainable crop production. Most of Indian soil are deficient in nitrogen generally 0.03-0.07%. Nitrogen status of Indian soil is low due to low organic matter. There is need to apply the balanced nitrogen fertilizer in Indian soil. The rise in food demand, coupled with the subsidization of nitrogen fertilizer and the adoption of intensive agricultural practices, has led to the imprudent use of nitrogen fertilizer and intensified environmental pollution issues. Over the time, consumption of N- fertilizer increased. Now

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the N,P and K fertilizer consumption is 6.7:2.4:1, where recommended ratio was 4:2:1.It shown that the consumption and production increased year by year. In India, the nitrogen consumption starts from 0.1million tons (MT) in 1960-1961 to13.4 MT in 2017-18. Nitrogen is lost mainly by leaching, volatilization, denitrification, surface runoff and fixation. Annual global nitrogen losses are estimated to be around 95, 37, 25 million tons due to leaching, volatilization and denitrification, respectively (Pathak 2013). These huge losses are responsible for ecosystem degradation, economic losses, low fertilizer use efficiency and crop productivity. The numerical value shows that nitrogen is more used than recommended and nitrogen use efficiency is low and losses are high.So, nitrification inhibitor are important chemicals which showed positive impact on increase the nitrogen use efficiency.

Use of dicyandiamide (DCD) as nitrification inhibitors

In this context, the use of nitrification inhibitors, such as dicynadiamide, can play an important role in reducing nitrogen losses and improving nitrogen use efficiency in crop production systems. Nitrification inhibitors are compounds that inhibit the conversion of ammonium to nitrate, which is the first step in the nitrogen cycle in soil. By inhibiting nitrification, nitrification inhibitors can reduce the amount of nitrate in the soil, which can reduce the potential for nitrate leaching, denitrification and volatilization.DCD have the ability to reduce the nitrification process for 50 days.

Adoption of Dicyandiamide as nitrification inhibitor that has shown promising results in reducing nitrogen losses and improving nitrogen use efficiency in agriculture. Its dual mode of action, inhibiting both urease and ammonia-oxidizing bacteria, makes it an effective inhibitor of nitrification. In addition, Dicyandiamide is considered to have low environmental impact, although its potential negative effects on soil microbial activity and biodiversity need to be further investigated. According to Ernfors et al. (2014), DCD was observed to have the strongest inhibitory impact on soil nitrification in clay soil followed by loamy soil whereas, its effect was found weakest in sandy soil.

Dicyandiamide (DCD) has been shown to increase nitrogen use efficiency (NUE) in various agricultural systems. Several studies have investigated the effects of DCD on NUE in different crops and regions. The use of DCD can inhibit the emission of N_2O in wheat and cotton fields located in the south-eastern region. A study conducted in New Zealand found

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that DCD application increased NUE in pasture systems by 18-22%. Similarly, a study in China showed that DCD application increased NUE in rice fields by 20-25%.

Some general guidelines for using DCD as a nitrification inhibitor:

1. Determine the appropriate rate of DCD for the specific crop and soil conditions. The recommended rate can vary depending on the nitrogen fertilizer source and application method, as well as the environmental conditions.
2. Apply DCD uniformly across the field, either as a separate application or in combination with nitrogen fertilizer. DCD can be applied as a dry granule or as a liquid solution.
3. Time the application of DCD appropriately. For best results, DCD should be applied prior to the onset of nitrification, typically within a few days of nitrogen fertilizer application.
4. Incorporate DCD into the soil to ensure it reaches the root zone. This can be done through tillage or irrigation, depending on the soil and irrigation practices.
5. Monitor soil and crop nitrogen status regularly to ensure proper nitrogen management and to adjust DCD application rates as necessary.

It is important to follow local regulations and guidelines for the safe and responsible use of DCD and to consult with a qualified agronomist or agricultural extension agent for specific recommendations on DCD application in your area.

Some different aspects of DCD as a nitrification inhibitor that can increase the use efficiency:

1. **Reduced Nitrogen Loss:** DCD slows down the conversion of ammonium to nitrate, which reduces the amount of nitrate available for leaching or denitrification. This means that more nitrogen stays in the soil for plant uptake, which can improve crop yields and reduce environmental impacts.
2. **Long-Lasting Effect:** DCD has a longer-lasting effect in the soil than some other nitrification inhibitors, which means that it can continue to protect nitrogen from loss for a longer period of time.
3. **Compatibility:** DCD is compatible with a wide range of fertilizers and can be applied in a variety of ways, including as a soil drench, a foliar spray or a granular application.

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4. **Low Cost:** DCD is generally less expensive than some other nitrification inhibitors, which makes it an attractive option for farmers who want to increase the use efficiency of their nitrogen fertilizers without incurring significant additional costs.

Overall, the use of DCD as a nitrification inhibitor can increase the use efficiency of nitrogen fertilizers by reducing nitrogen loss and improving crop yields, while also being cost-effective and easy to apply.

Dicyandiamide (DCD) is different from other nitrification inhibitors in several ways:

1. **Mode of action:** DCD inhibits the activity of ammonia-oxidizing bacteria (AOB) and nitrite-oxidizing bacteria (NOB) in the soil. AOB and NOB are responsible for the conversion of ammonium (NH_4^+) to nitrite (NO_2^-) and then to nitrate (NO_3^-), respectively. By inhibiting these bacteria, DCD slows down the nitrification process and reduces the production of nitrate.
2. **Persistence:** DCD has a relatively long persistence in the soil, with a half-life ranging from 20 to 40 days depending on soil type, temperature, and moisture content.
3. **Mode of Application:** DCD can be applied in various ways, including incorporation into the soil, surface application, or mixing with fertilizers. It is commonly used in conjunction with urea fertilizers.
4. **Compatibility:** DCD is compatible with a wide range of nitrogen fertilizers and does not interfere with their effectiveness.
5. **Safety:** DCD is considered safe for use in agriculture and has a low risk of negative impacts on human health and the environment when used according to recommended guidelines.
6. **Efficacy:** DCD has been shown to be effective in reducing nitrate leaching and improving nitrogen use efficiency in various crops and soil types.

Overall, DCD is a useful tool for reducing nitrogen losses from fertilizers and improving nitrogen use efficiency in agriculture. However, it should be used with caution and in accordance with local regulations to minimize its environmental impact.

Conclusion

Dicyandiamide (DCD) is an effective nitrification inhibitor that can help reduce nitrate leaching and improve nitrogen use efficiency in agriculture. Dicyandiamide (DCD) has the potential to play a significant role in the future of fertilizer management. DCD offers

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a valuable tool for managing nitrogen in agriculture, particularly in areas where nitrate leaching is a significant concern. It is possible that DCD could be incorporated into new and innovative fertilizer formulations that are designed to enhance nutrient uptake and reduce nutrient losses. For example, controlled-release fertilizers that slowly release nitrogen over time could be combined with DCD to prevent excessive nitrification and improve nitrogen use efficiency. However, the effectiveness of DCD can vary depending on crop type, soil type and climate, and it should be used as part of a comprehensive nitrogen management plan. When used correctly, DCD represents a valuable tool for managing nitrogen and reducing the environmental impacts of agricultural practice.

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