

Hydrogel Applications in Agriculture: Enhancing Water Retention for Crop Growth

Archana Upadhyay¹ and Abhinav Yadav²

¹*Department of Vegetable Science, College of Agriculture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur-208 002, U.P., INDIA*

²*Department of Agronomy, College of Agriculture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur-208 002, U.P., INDIA*

Email: abhinavuptc@gmail.com

Hydrogels, water-absorbing polymers, offer a promising solution to water scarcity challenges in agriculture. Hydrogels possess water-absorbing capabilities, acting as reservoirs that gradually release water to plant roots, ensuring sustained moisture availability during dry periods. Their application optimizes water use efficiency, supporting essential plant functions and enhancing overall crop productivity. Versatile in application methods, hydrogels aid soil structure improvement, reduce nutrient leaching, and align with sustainable agriculture principles.

Introduction

Hydrogels, a class of water-absorbing polymers, have emerged as a promising technology in agriculture due to their ability to improve water retention in soils and enhance overall crop growth. In the face of increasing water scarcity and erratic rainfall patterns, hydrogel applications offer a potential solution to optimize water usage and mitigate the adverse effects of drought stress on crops. These hydrophilic polymers possess the unique capability to absorb and retain large quantities of water, forming hydrogels with immense water-holding capacities. When incorporated into soils, hydrogels act as reservoirs, effectively storing water and gradually releasing it to plant roots, thus ensuring sustained moisture availability for crops, especially during dry spells. The application of hydrogels in agriculture addresses the challenge of water scarcity by maximizing water-use efficiency and minimizing water loss through evaporation. By providing a continuous and consistent water supply to plants, hydrogels support optimal physiological functions, including nutrient uptake, photosynthesis, and growth processes, thereby enhancing overall crop productivity. Moreover, hydrogel technology offers versatility in its application methods. Farmers can apply hydrogels directly to the soil or incorporate them into seed coatings or irrigation systems, allowing for flexible and efficient utilization across various agricultural practices and crop types. The benefits of hydrogel use extend beyond water retention. They contribute to soil structure improvement, preventing soil erosion, and reducing nutrient leaching, thus enhancing soil fertility and sustainability. Additionally, the ability of hydrogels to reduce the frequency of irrigation and improve crop performance aligns with the principles of sustainable agriculture, conserving water resources and promoting environmental sustainability. Despite these advantages, challenges such as cost-effectiveness, potential environmental impacts, and optimal dosage for different soil types need consideration in the widespread adoption of hydrogel technology in agriculture. Nonetheless, the potential of hydrogel applications in enhancing water retention and supporting improved crop growth signifies a significant step towards addressing water scarcity challenges and promoting sustainable agricultural practices.

What is hydrogel?

Hydrogels are cross-linked polymers with a hydrophilic group which have the capacity to absorb large quantities of water without dissolving in water. Water absorption capacity arises from the hydrophilic functional groups attached to the polymer backbone while their resistance to dissolution arises from cross-links between network chains.

How to use hydrogel in field?

Using hydrogels in the field involves specific steps to ensure effective water retention and enhanced crop growth. Here's a general guideline on how to use hydrogel in agricultural fields.

Soil preparation: Prepare the soil by tilling or ploughing to ensure uniform mixing and distribution of the hydrogel. Remove any debris or large particles from the soil surface.

Hydrogel application rates: Rate of application of agricultural hydrogel depends upon the texture of soil – for clay soil: 2.5 kg/ha (at the soil depth of 6–8 inches). For sandy soil: up to 5.0 kg/ha (at the soil depth of 4 inches).

Application methods

- **For field crops:** Prepare an admixture of hydrogel and fine dry soil in 1:10 ratio and apply along with the seeds/fertilizers or in the opened furrows before sowing. For best results, hydrogel should be close to seeds.
- **In nursery bed for transplants:** Apply 2 g/m² (or according to recommended rate) of nursery bed mix of hydrogel uniformly in the top 2 inches of the nursery bed. In pot culture, mix 3–5 g/kg of soil before planting.
- **While transplanting:** Thoroughly mix 2 g (or according to recommended rate) of hydrogel per litre of water to prepare a free-flowing solution; allow it to settle for half an hour. Dip the roots of the plant in the solution and then transplant in the field.

Hydrogel incorporation: Mix the hydrogel thoroughly into the soil. Ensure uniform dispersion of hydrogel particles throughout the root zone. Consider using mechanical equipment for even distribution.

Adhering to recommended application rates, proper mixing, and irrigation management is essential to harness the full potential of hydrogels in enhancing water retention and supporting crop growth in agricultural fields.

Benefits of hydrogel

Hydrogels offer numerous benefits in agriculture, primarily focused on enhancing water retention in soils and fostering improved crop growth. Here are several advantages of using hydrogels in agricultural practices.

Improved water retention: Hydrogels are renowned for their exceptional water-absorbing capacity. They can retain significant amounts of water within their structure, acting as reservoirs in the soil. This capability ensures sustained moisture availability for plant roots, particularly during dry spells or in regions facing water scarcity, thereby reducing water stress on crops.

Enhanced water use efficiency: By effectively storing and gradually releasing water to plant roots, hydrogels optimize water use efficiency. They minimize water loss due to evaporation, runoff, or percolation, allowing plants to access water as needed, reducing overall irrigation requirements.

Drought mitigation: Hydrogels aid in mitigating the adverse effects of drought stress on crops. Their water-holding capacity ensures a continuous water supply to plants, supporting vital

physiological functions such as nutrient uptake, photosynthesis, and growth, even in dry conditions.

Increased crop yield and quality: Improved water availability through hydrogel application translates into increased crop yield and improved quality. Proper moisture levels support optimal plant growth, leading to higher yields and better-quality produce.

Reduced irrigation frequency: The use of hydrogels reduces the frequency of irrigation needed for crops. With the ability to store and slowly release water, hydrogels extend the intervals between watering, promoting sustainable irrigation practices.

Versatile application methods: Hydrogels offer versatility in application methods. They can be applied directly to the soil, incorporated into seed coatings, or mixed with fertilizers, providing flexibility in their usage across various crops and agricultural practices.

Soil structure improvement: Hydrogel incorporation improves soil structure by enhancing soil aggregation and reducing soil compaction. This leads to improved aeration, root penetration, and nutrient uptake by plants, fostering healthy soil conditions for optimal crop growth.

Reduction in soil erosion: By aiding in soil structure improvement, hydrogels contribute to reducing soil erosion. Enhanced soil stability minimizes the risk of erosion caused by water runoff, preserving fertile topsoil and preventing environmental degradation.

Nutrient retention and availability: Hydrogels not only retain water but also improve nutrient retention in soils. They can hold nutrients, preventing leaching and enhancing their availability to plants, thereby supporting better nutrient uptake and utilization by crops.

Environmental sustainability: Hydrogel usage promotes environmental sustainability by conserving water resources and minimizing the environmental impact of agriculture. By reducing water usage and avoiding excessive irrigation, it contributes to water conservation efforts and supports eco-friendly farming practices.

Suitability for arid and semi-arid regions: Hydrogels are particularly beneficial in arid and semi-arid regions where water availability is limited. Their ability to retain moisture in the soil helps overcome water scarcity challenges, making them a valuable tool in such environments.

Cost-efficiency in the long run: While initial costs might be a consideration, the long-term benefits of using hydrogels, such as reduced water consumption, increased crop yields, and improved soil health, can outweigh the initial investment, offering cost-efficiency over time.

Adaptability to climate change: Hydrogels contribute to agricultural resilience in the face of climate change. By ensuring better water management and supporting crops during water stress events, they aid in adapting agricultural practices to changing climatic conditions.

The benefits of hydrogel applications in agriculture span from efficient water retention and improved water use efficiency to increased crop productivity, soil health enhancement, and environmental sustainability. Their role in addressing water scarcity issues, supporting crop growth, and fostering sustainable agricultural practices underscores their significance in modern farming techniques.

Conclusion

Hydrogel applications in agriculture offer a promising solution for enhancing water retention and promoting improved crop growth. With their remarkable ability to retain and gradually release water, hydrogels aid in mitigating water scarcity, optimizing water use efficiency, and supporting sustainable irrigation practices.