

Revolutionizing Agriculture: The Impact of Hydrogel Application

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In regions with limited water availability, such as arid and semi-arid areas where farming relies on rainfall, the lack of water can make agriculture unsustainable. To address this challenge, a new solution is to use super absorbent polymers (SAP), which can absorb water and retain it in the soil for crops to use. This helps to conserve moisture in the soil and reduces losses from evaporation, percolation, and runoff. Hydrogel is a type of SAP that absorbs water through hydrogen bonding with water molecules. These granules can expand significantly in size when in contact with water, making them useful as water retention agents in agriculture.



Granules form and Swelling form

What is Hydrogel?

Hydrogel, also known as SAP (Super Absorbent Polymers), absorbent gels, or super soakers, is a type of synthetic water-absorbing polymer material. These cross-linked polymers with a hydrophilic nature can absorb large amounts of water without dissolving in it. The hydrophilic functional groups attached to the polymer backbone are responsible for the water absorption capacity of the soil, while the cross-links between network chains help in their resistance to dissolution.

Types of Hydrogel

There are mainly three types of Hydrogel for agricultural uses:

- Starch-graft copolymers
- Cross-linked polyacrylates
- Cross-linked polyacrylamides & Acrylamide-acrylate copolymers.

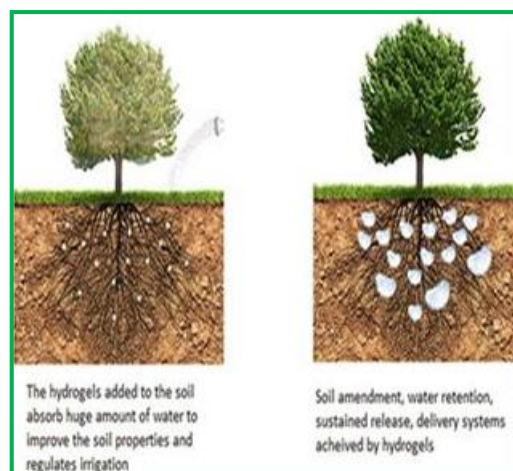
Potassium Polyacrylate is the primary component used in Hydrogel technology, which is commonly marketed as a hydrogel for agriculture. It is widely used because of its exceptional ability to retain water for longer periods without any toxicity issues.

Hydrogels are formed by polymerizing acrylic acid with a cross-linker. Cross-linked polymers can retain water 400 to 500 times their weight and release 95% of that water to the growing plants.

Hydrogels are used in Agriculture

Hydrogel is widely used in agriculture to improve farming mechanization, crop growth, and plant development. Its usage in agricultural plantations is increasing steadily to achieve higher harvest yields, improve plant quality, and save space and costs. Polymers are also used in agriculture as soil conditioners, planting and transplanting gels, seed coatings for controlled germination, soil aerators, and sterilization. The hydrogel releases water and

nutrients to plants when the surrounding soil dries up, and plant growth depends mainly on fertilizer and water to sustain life during drought conditions. Polymers are useful for improving root development, plant growth, and reducing nutrient losses by leaching. They also aid soil penetration and seedling development. The polymer hydrogel slow-release acts as a nutrient carrier in the soil, improving fertilizer efficiency by reducing nutrient losses by leaching, lowering costs, and decreasing pollution. Hydrogels are crucial in agriculture as they retain water, prevent soil erosion, and help plants thrive even in adverse weather conditions.



Functional Characteristics of a Hydrogel

The features of an ideal hydrogel material should include the following:

- 1) High water absorption capability.
- 2) Desired rate of absorption and desorption capacity according to plant requirements.
- 3) Lowest soluble content and residual monomer.
- 4) High durability and stability during swelling and storage.
- 5) High biodegradability and biocompatibility.
- 6) High performance over a wide temperature range.
- 7) After swelling, water becomes neutral in pH.
- 8) Colorlessness, odorlessness, and non-toxicity.
- 9) Improvement of soil's physical, chemical, and biological properties.
- 10) Photostability, rewetting capability for a longer time, low-cost material, and eco-friendliness.

Application of hydrogel granules

Hydrogel can absorb water up to 500-600 times its weight and can be applied in liquid or granule form, depending on the water's salt content.

Dry Application: For the hydrogel to function properly, it needs to be stored in a dry place. To use it, mix 5kg per hectare of hydrogel with dry, fine sand that has a size of less than 0.25 mm at a ratio of 1:10. If you're using it for vegetable crops, mix the hydrogel-sand mixture with the top 5 cm of soil. To use it economically, apply hydrogel in the same line where you're sowing the seed.

Wet Application: To use superabsorbent hydrophilic polymers (also called hydrogels), mix the granules in water and let them sit for 60-90 minutes. Hot water will make the process faster. Once the polymer has absorbed all the water, you can use it by applying roughly one part of hydrated polymer to four parts of soil. This method works best for small applications such as repotting house plants, planting shrubs, small trees, and bedding plants. Some commonly used hydrogels in agriculture are Pusa Hydrogel, Cumigel, Luquasorb, Agrosoak, Magic Hydrogel, Soil Moist, Waterlock, Stockosorb®, and Jalshakti.

Benefits of Hydrogel in Agriculture

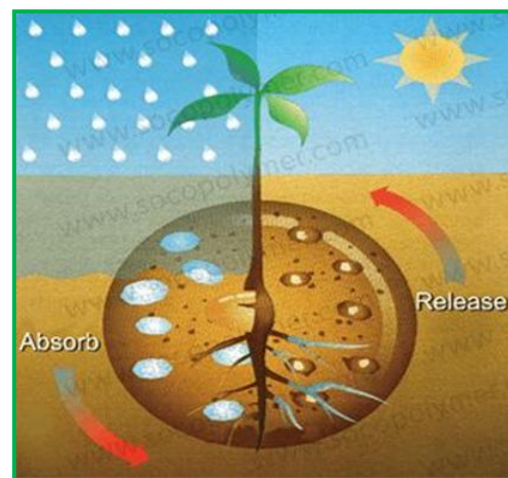
- 1) Hydrogels function close to the plant's root zone as "miniature water reservoirs." By using root capillary suction mechanisms, it can absorb 400–1500 times its weight in water, both naturally occurring and supplied and release it gradually when there is water scarcity.

- 2) It can carry out the continuous process of absorbing and releasing water, provide the ideal amount of moisture that plants need to quickly germinate and establish seedlings, and boost crop growth and yield.
- 3) It can lower the osmotic moisture content of the soil, save irrigation water, labour, and production costs; lessen the need for crop irrigation; lessen the effects of drought; stop water and nutrient runoff and leaching; increase plant water and nutrient use efficiency; and replenish soil microbes and enzymes.
- 4) Hydrogels are used in cold climates to prevent freezing-induced plant death by allowing absorbed moisture to remain in the structure and being readily accessible to the plants.
- 5) It can help the plant withstand prolonged moisture stress by delaying the onset of permanent wilting.
- 6) It can lessen excessive mineral use, such as in pesticides and fertilizers with micronutrients.
- 7) It can prevent soil compaction, improve soil aeration, and release soil mineral nutrients.
- 8) It can enhance stronger and healthier plant growth and marketable yield.

Effect of hydrogel on plant growth

The growth of any plant species heavily relies on successful seed germination and seedling establishment, which are considered to be the most critical phases. However, the availability of water is a significant challenge, especially in arid and semi-arid regions where soil moisture levels are low. Hydrogel polymers can enhance plant growth by improving the water holding capacity of the soil, which prolongs the time taken to reach the wilting point and increases plant survival under water stress. This also leads to a decrease in the fruit drop ratio and may result in an expanded total yield and fruit weight under different severity conditions.

Moreover, adding hydrogel to the soil increases the plant circumference due to the availability of more water in the root zone, which allows for longer irrigation intervals. Using hydrogel polymer can create a water reservoir near the root zone of plants, decrease osmotic moisture of soil, improve the capacity of plant available water, enhance plant growth, and increase the whole yield while decreasing production costs of the crop. The use of hydrogels improves plant viability, seed germination, ventilation, and root development, mainly under arid environments. Furthermore, it



Hydrogel Swelling on Plant

has been observed that using hydrogel leads to a significant increase in plant growth.

Conclusion

When hydrogel is applied in arid and semi-arid areas, the soil's qualities are improved, its capacity to hold water is increased, soil water retention is improved, irrigation efficiency is increased, crop growth is promoted, and the crop's water productivity is increased. In well-drained soils, also creates an environment that is favorable for improved root growth, which eventually boosts yield. Hydrogels' chemical and physical structures allow for their potential application as nutrient carriers, soil conditioners, and water retainers in the agricultural industry, among other environmental preservation applications.

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