**Hydrogel in Agriculture: What it is and why it is important**

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**ABSTRACT**

A hydrogel is a water retention granule that increases its original size to several intervals when it comes into contact with water. In water-stressed situations, it is used to conserve soil moisture within the active rooting zone by reducing evaporation and deep percolation and runoff losses. It is able to absorb and retain a large amount of moisture under abundant rainfall and irrigation events, and release it back into the soil to reduce crop water demand in drought conditions. In agriculture, a hydrogel polymer plays a multifaceted role in soil-water retention, as a nutrient and pesticide carrier, as a seed coating, as a soil erosion reducer and as a food additive. It has the unique ability to improve various physicochemical and hydrophysical properties of soil, reduce irrigation frequency, improve water and nutrient use efficiency, and increase yield and quality of fields, plantations, ornamental and vegetable crops. Because hydrogels are biodegradable and non-toxic to soil, crops, and the environment, they are a promising and feasible technology to augment crop productivity in moisture stressed conditions.

**Keywords:** *Hydrogel, Agriculture, Water retention and Soil.*

**INTRODUCTION**

Hydrogel is a type of organic material that can absorb a lot of moisture in a short amount of time when it comes into contact with water. It’s also known as root watering crystal, water retention granules or “raindrop.” It’s made up of 3D networks of different kinds of hydrophilic molecules that are linked together by covalents or physical interactions, and it’s designed to be really absorbable and can be biodegradable. It helps keep the soil hydrated by providing more water when there’s a lack of moisture for a long time. It also helps the soil dry out evenly over a long period of time by desorbing the stored moisture.

Polymer-based hydrogel technology has recently been extensively utilised in the agricultural industry as a soil conditioner due to its numerous functions in superior water absorption and water retention. Hydrogel polymers sustain a very high rate of water swelling and moisture release under water deficiency conditions, thereby improving water and nutrient efficiency by controlling evaporation, deep water infiltration, and nutrient loss in arid or semiarid environments by enhancing plant growth and crop yield.

**Hydrogel materials need to have the following characteristics:**

* High water absorption ability
* Desorption and absorption rate based on plant requirement
* Lowest solubility and remaining monomer
* High durability/stability during swelling/storage
* Biodegradability/biocompatibility of the material
* High performance across a wide range of temperatures
* Water becomes neutral after swelling
* Colourless, odourless, and non-toxic
* Upsurface physical, chemical & biological properties
* Photostability
* Long-term rewetting ability
* Low cost material
* Eco-friendly

**HYDROGELS CLASSIFICATION**

Hydrogel for farming can be divided into three main categories: natural, semiartificial, and artificial. Natural hydrogel is made from natural ingredients, while semiartificial and artificial hydrogels are made from petroleum. The three main types of hydrogels you can find on the market are: starch-polyacrylate graft polymers, vinyl alcohol-acrylic acids copolymers, and acrylic acid copolymers.

**The Use of Hydrogel in Agriculture:**

**1.Soil-amendments**

Hydrogel is used as a soil additive in agriculture to help reduce water loss, conserve nutrients in the soil, and mitigate the negative consequences of drought and moisture stress in crops.

The main benefits of using hydrogel in soils are:

(a) it absorbs 100-times more water than the soil can absorb on its own

(b) it acts as a long-lasting gel

(c) it protects the soil against runoff flow

(d) it improves soil fertilizer performance

(e) improves soil microbial activity

**2. Reducing the Stress of Drought**

When there is a drought, the water content of the soil is reduced, which can lead to the production of oxygen radicals and the production of lipids. These lipids can have some negative effects on the morphology of the plants, such as a decrease in plant height, a decrease in leaf area and even leaf damage.

Hydrogels can be a saving tool for plants, helping them to grow and produce a crop even in bad weather. According to Bearce & McCollum, using hydrogel can reduce the need for irrigation and extend the life of the plants. Many researchers have reported on the benefits of using hydrogel for horticulture. In addition, hydrogel may increase the soil’s water-holding ability and water storage capacity in porous soils, thus reducing the risk of wilting of plants.

**3. ENHANCEMENT OF FERTILIZER AVAILABILITY**

In addition, hydrogels can be produced as fertilizers with the addition of potassium (NPK) and nitrogen (N2) ions. The chemicals that are left in the hydrogel network do not immediately wash off, but are released slowly into the soil, where they are then absorbed by plants.

Konzen *et al.,* for example, compared the effects of a hydrogel with a variety of traditional herbaceous nitrogen (NPK) fertilizers (superphosphate) and potassium (chloro) fertilizers (NPK, NPK, and NPK chloride) and found that the growth of Mimosa SCA Brella seedlings was increased due to increased water retention and uptake of nutrients

**METHODS OF HYDROGEL APPLICATION:.**

Hydrogels are used as soil conditioners to stabilize surface soils, prevent crust formation, improve poor structure soils at greater depths by aggregating them, increase water-holding capabilities, and improve plant growth and development in agriculture. The rate of hydrogel application in agriculture depends on the soil texture. For clay soil, hydrogels are applied to the soil at an initial depth of 6-8 soil depths. For sandy soil, the depth of hydrogels is up to 4 soil depths.

There are two main ways to apply hydrogels to soils:

* **Dry method:** a dry polymer (PAAm, PVA) is mixed with sandy soil at a depth of 15-25 cm prior to cultivation.
* **Wet method:** a polymer solution is sprayed on topsoil that has already been wetted and dried.

**Benefits of wet method:**

* Decrease water consumption
* Reduce soil erosion
* Increase soil hydraulic conductivity
* Improve soil structure and water penetration
* Increase soil retention capacity
* Immediate sowing

**The new characteristics of the hydrogel as soil conditions are as follows:**

* Resistant to salt in soil
* Improve soil physical, chemical and biological properties
* Encourage seed germination and seedling growth
* Promote root growth and plant density
* Higher water absorption in excess and gradual release in drought stress
* Alleviate plant from moisture stress and tolerate long-term moisture stress
* Delay onset of permanent wilting point in intense evaporation under arid environment
* Render water consumption more efficiently
* Improve water use efficiency by minimising evaporation and loss of water
* Reduce irrigation frequency, fertilizer requirement, crop and irrigation cost
* Maximum soil stability and durability
* No environmental hazards
* High performance at high temperature (40 – 50°C)
* Suitable for hot and dry climate

**Hydrogel in agriculture-ADVANTAGES**

1.Hydrogel acts as a “miniature water reservoir” near the roots of plants.

2.Hydrogels absorb and release water up to 1500 times its own weight in water shortage conditions.

3.It performs the cyclical process of absorption/desorption.

4.It provides optimal plant-available water for seed germination/seedling establishment.

5.It increases crop growth and yield.

6.In cold areas, hydrogels do not freeze moisture absorbed in structure and make it easy for plants to access.

7.It helps seedlings grow faster and prevent death by freezing.

8.It reduces the cost of irrigation, labour and production.

9.Reduces the need for irrigation of crops.

10.Makes drought conditions less severe. Decreases water and nutrient runoff.

11.Improves water & nutrient use efficiency in plants.

12.Restores soil microorganisms & enzymes.

13.Helps the plant withstand long-term moisture stress. It prevents permanent wilting.

**The DISADVANTAGES of using hydrogel in agriculture are as follows:**

1.Water hardness plays a role in the ability of hydrogel to absorb water. As water hardness increases, the concentration of calcium and magnesium ions in the water increases, mainly from fertilisers and irrigation water sources. When calcium and magnesium ions react with the polymeric chain, nonsoluble salts are formed that block the negative ion site. This blockage increases with increased salinity and additional wetting and drying cycles.

2.Most soils can absorb enough water to support plant growth. However, if there is a shortage of rainfall, the water in the soil will be exhausted and hydrogel won’t be able to solve the problem. In the same way, a good distribution of rainfall throughout the cropping period will not make hydrogel effective.

3.However, numerous studies have demonstrated that the hydrogel had no or minimal negative and positive effects on soil amendment in terms of moisture retention and yield improvement in a number of crops. In water-deprived conditions, rather than providing water to plants, the hydrogel may, in some cases, instead, irreversibly absorb water from the biological system, resulting in plant stands withering.

**Nano-Based Hydrogel in Agriculture**

In addition, SAPs are used in conjunction with pesticides to control release rates to encourage the efficient use of pesticides and water.

Nano fertilizers are loaded with or capsulated with readily soluble hydrogel nano-particles that slow down the rate at which nutrients are released into the soil. Biodegradable nanofertilized hydrogels are easily dispersed into roots via symplastic or apoplastic pathways, and translocated through xylem tissue, to the above ground parts of the plant, including stems and leaves.

However, the use of nano-fertilizers for stimulating plant growth should be limited to low concentrations, as high concentrations can have serious toxic effects on plant, animal and human health, food-web contamination, and, in extreme cases, environmental damage.

**CONCLUSION**

Hydrogel plays an important role in dry farming. Since the majority of the area of India is located in the arid and semi-arid regions, more efficient water usage is necessary in the field of agriculture. Implementing appropriate management practices in agriculture to maintain soil moisture and increase water retention capacity is considered as one of the ways to save water. Super absorbent polymers (SAP) hydrogel can swell to absorb a large volume of water or aqueous solution. This property has led to many practical applications of these new materials in particular in agriculture to improve water retention of soils and water supply of plants.

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