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Hydrogel Technology: A Step towards Futuristic Farming

Aditya Anil Kadam* and Akanksha Anand Joshi

Rajarshi Shahu Autonomous College, Latur, Maharashtra
*Corresponding author. E-mail: thesolarstepuniverse@gmail.com

A new technology is rising which could be beneficial for farmers in arid and semi-arid regions. Hydrogels were reported for the first time by Wichterle and Lím in 1960. Water must constitute at least 10% of the total volume or total weight of a substance to be a hydrogel. It is understood by very other names like Polyter, water crystals, hydrosource, water drops, root watering crystals, super-absorbent polymers, water retention granules, hydrating crystals, water beads, water pebbles, hydrobeads etc. but chemically it is a non-fluid polymer network that is expanded throughout its whole volume by a fluid such as water.

Month of June is considered as the beginning of the sowing season in India. Sowing at the onset of rains (which is 15 June to 15 July in India) ensures sufficient vegetative growth before flowering in crops. Varieties of many crops are sown in the first fortnight of June with irrigation or pre- monsoon rains for higher yields.

India has been experiencing significant widespread drought conditions since 2015. Today millions of farmers hit by drought and crop failure have to struggle to stay alive. According to the cumulative state-wise rainfall information issued by India Meteorological Department (Ministry of Earth Sciences, Government Of India) for period 01.06.2021 to 14.06.2021, rainfall in 18% districts was deficient and 7% districts of India are facing large rainfall deficiency. It has become the need of the hour to probe newer and newer innovations to overcome the crisis of water deficit before Indian agricultural sector. The predominant irrigation method practiced in India is surface draining i.e. applying water directly to the crops from the surface. It appears to be a problematic and flawed system as the crops can utilize only 50% of the provided water while the remaining is lost in conveyance, as runoff and by evaporation. Modern methods like drip irrigation and use of sprinklers can effectively reduce the wastage of irrigation water but they have high initial costs, inadequate government subsidy and cooperation, lack of technical input and after sales service, faulty equipment, damage due to pests and high costs of spares prevents farmers from opting them. Hydrogel is understood by very other names like… Polyter, Water Crystals, Hydrosource, Water drops, root watering crystals, super-absorbent polymers, water retention granules, hydrating crystals, water beads, water pebbles, hydrobeads etc. but chemically it is a non-fluid polymer network that is expanded throughout its whole volume by a fluid such as water. Many molecules are small – think "H_20" i.e. water for instance – but some are quite large, just like the DNA that contains a transcript of most of our genes. Very often, the larger molecules are literally a repetition of the many smaller molecules, each of them referred to as "monomers" that hook up to form one long chain, the "polymer".

Chemical Composition

Hydrogel polymer could be a boon for the agricultural lands under drought or limited rainfall. These superabsorbent polymers are specifically designed to retain and release water within the hope of helping plants address irregular rain or irrigation. The polymer will release the water, slowly bunch up and return to its original, dry, smaller and harder form. Hydrogels were reported for the

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It is actually a three-dimensional (3D) network of hydrophilic polymers that possess the ability to swell in water and hold a large amount of water. It achieves this along with maintaining the structure due to chemical or physical cross-linking of individual polymer chains. Hydrogels also possess a degree of flexibility which is very similar to natural tissue due to their significant water content. The hydrophilicity of the hydrogel network is due to the presence of hydrophilic groups such as $-NH_2$, -COOH, -OH, $-CONH_2$, - CONH -, and $-SO_3H$.

Types Of Hydrogel

There are three main types of Hydrogels have been found to be opportune for agricultural use:

1. Cross-linked Polyacrylates
2. Cross-linked Polyacrylamides & Acrylamide-acrylate copolymers
3. Starch-graft copolymers

The Super Absorbent Polymers(SAP) industry utilises Potassium Polyacrylate as the potential principle which is marketed as hydrogel for agricultural use. Its benefits include longer retention and high efficiency in soil with nil toxicity issues.

It has longer retention along with high efficiency in soil with nil toxicity issues. Polymerizing Acrylic acid with a cross linker prepares a hydrogel. Cross-linked polymers can hold water 400 times their own weight and release 95% of that to growing plants. Use of Hydrogel increases water use efficiency by preventing leaching and increasing frequency for irrigation. Summers in semi arid regions promote lack of soil moisture that can cause plant stress. Moisture released by hydrogel close to the root area helps reduce stress and increase growth and plant performance.

Hydrogels come in the form of small sugar like hygroscopic crystals that can be directly added to cultivation soils. They are predominantly used for improving irrigation efficiency. They are the smart delivery materials that can help combat plant pathogens even with lower pesticide dosage. They help to reduce the quantity of soluble NPK fertilizers per crop cycle thus greatly contributing to water and environmental conservancy practices.

Agriculture Specific Applications Of Hydrogel:

- Conserving Agricultural Land:

Adding hydrogel polymers can increase water retention capacity of soil by 50-70% along with proper amendment with various dosages of soil to hydrogel ratio. This also helps soil bulk density to reduce by 8-10%.

It is observed that hydrogel directly influences the permeability, density, structure, texture of the soil and evaporation as well as infiltration rates of water. It decreases irrigation frequency, compaction tendency and run-offs while promoting the aeration & microbial activity.

Premature leaf shedding, decreasing chlorophyll content, reduced seed yield, less fruit and flower yield per plant are the visible symptoms of water stress due to lack of moisture in the soil. Application of hydrogel can help moderate these impacts caused by deficit irrigation. Being a water retaining agent, it greatly increases the irrigation period of cultivation, enhancing irrigation efficiency particularly in arid & semi-arid belts.

- Reduction of drought stress:

Oxidative stress and increased perioxidations of lipids are the consequences of draught stress. Visible effects of this can be decreased leaf area, foliar matrix damage and stunned height. Application of hydrogel can reduce drought impact on plants by helping them cope and reduce the stress and form oxygen radicals. This also provides scope for better growth and yield even in unfavorable climatic conditions.

- Enhanced Fertilizer Efficiency:

Many irrigation technologies have flaws in the fields of application of fertilizers, herbicides and germicides. Studies say that application of hydrogel effectively reduces the usage of synthetic fertilizers without hindering the crop yield and its nutritional value. Besides this, potassium polyacrylate is non-toxic and safe. Thus it prevents pollution of agro ecosystems.

- Biodegradability

Studies confirm that hydrogel is remarkably sensitive to the action of UV rays, and starts to degrade into oligomers. The Polyacrylate becomes much more sensitive to aerobic and anaerobic microbiological degradation and can degrade at rates of 10-15% per year into water, carbon dioxide and nitrogen compounds. The hydrogel molecules are too voluminous for being absorbed into plant tissue and additionally have zero bioaccumulation potential.

Table 1: Suggested Dosage Of Hydrogel In Accordance With Type Of Soil

Type Of Soil	Suggested dosage of hydrogel
Arid & semi-arid Regions	4-6g/kg soil
To improve relative water content and leaf water use efficiency	0.5-2.0g/pot
For all level of water stress treatment and improved irrigation period	2.25-3g/kg soil
To delay permanent wilting point in sandy soils	0.2-0.4g/kg OR 0.8% of soil whichever is more
To reduce irrigation water by 50% in loamy soil	2-4g/ plant pit
To reduce drought stress	0.2-0.4% of soil
To decrease water stress	3% by weight
To prohibit drought stress totally	225-300kg/ha of cultivated area

Conclusion:

Potassium polyacrylate predicated hydrogel increases water retention capacity of soil by 50-70% which could be propitious for the conservation of the agricultural lands. Its application could avail truncate drought impact on plants by availing them to cope and truncate the stress. It could also efficiently abbreviate the utilization of synthetic fertilizers without obstructing the crop yield and its alimental value and avail farmers preserve mazuma. Additionally, hydrogel is eco-amicable. It is biodegradable into carbon dioxide, dihydrogen monoxide and nitrogen compounds. Hydrogel could be a boon for the farmers with agricultural lands in arid and semi-arid regions.

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