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HYDROGELS: PLAYING A CRITICAL ROLE IN THE BASIC NEEDS OF PLANTS

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The term hydrogel refers to a three-dimensional crosslinked polymeric network made of synthetic or natural polymers that can hold water within its porous structure. The presence of hydrophilic groups in the polymer chains, such as amino, carboxyl, and hydroxyl groups, contributes significantly to the water holding capacity of hydrogels. At physiological temperature and pH, these polymeric materials do not dissolve in water but swell significantly in an aqueous medium. Hydrogels can be made from almost any water-soluble polymer, with a wide range of chemical compositions and bulk physical properties. Because of their ease of manufacture and self-application in clinical and fundamental applications, hydrogels have been widely used as drug carriers. Hydrogels have a variety of biomedical applications.

What is Hydrogel ?

Hydrogels are three-dimensional swollen networked structures, a class of hydrophilic homopolymers or copolymers covalently or ionically group material formed by loosely crosslinked networks capable of absorbing large amounts of water or biological fluids without dissolving in water. In 1954, Wichterle and Lim of Czechoslovakia created the first original polymeric hydrogel network.

A polymer can be divided into 3 groups:

- Acrylamide sodium acrylate co– polymers–cross–linked polyacrylamides.
- Vinyl alcohol–acrylic acid co– polymers (polyvinyl alcohols)
- Starch–polyacrylonitrile graft polymers (starch co–polymers)

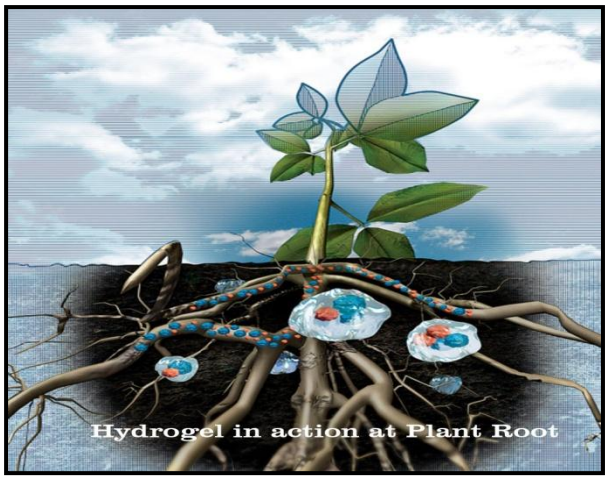

Fig.1(a): Action of Hydrogel in Rhizosphere

Fig.1(b): Hydrogels

Mechanism of Hydrogel Formation

Polymers are carbohydrate materials that, due to their availability, presence of modifiable functional groups, biocompatibility, and other properties, have been widely used to make physical and chemical hydrogels. By selecting the type of monomer or polymer and the type of hydrogel formation reactions, hydrogels can be tailored to a specific application. Chemical crosslinking and physical crosslinking are the two methods used to create hydrogels.

Types of Hydrogels

1. Pusa Hydrogels: It is a semi-synthetic superabsorbent polymer which fulfils the basic requirements of plants and widely used in agriculture. It is mixed with the soil on which the seeds are sown. It sicks to the roots of the trees and when the soil moisture falls as the temperature rises. The pusa hydrogel absorbs water and expands to 300 times its original size

2. Super Absorbent Polymers (Water Absorbent Polymers): The super absorbent polymers (SAP) are a non-toxic, natural, starch-based biodegradable material. It absorbs water more than a hundred times of its weight within a short time. The SAP has high water absorbance power and release 95% of absorbed water in soil. The SAP is a sugar like hygroscopic substance which becomes swell by absorbing water and form a gel like stuff. SAP is also called as Slush powder.

3. Water Retention Polymers and Potassium Polyacrylate: Water retention polymers are particularly useful in rainy and dry season, for better absorbency and retention power. This hydrogel is use to preserve their crop from seasonal variability. It can maintain the high growth of crops in a changing climate. Potassium Polyacrylate is a unique type of hydrogel which is applicable in seasonal crops., In transplanting and cut flowering, for bare toot dipping, agriculture, gardening, horticulture, landscape.

Salient Features of Hydrogels

- It increasing the agriculture productivity by improving of water use efficiency.
- Crop irrigation and fertigation requirements are reduced.
- It helps the plants withstand in moisture stress
- Seed additives to support seed coatings or seed germination
- Dipping of seedling roots before establishment
- Enhances the physical properties of soils and soil less media.
- Suitable for semi-arid and arid climatic regions.
- Water absorbs at minimum 350 times its dry weight and gradually released.
- At high temperatures, it exhibits the maximum absorbency (40- 50o c)
- Coated protecting agents' herbicides and pesticides for slow release.

Table 1: Hydrogel Characteristics and Potential Applications.

Sr. No	Parameters	Characteristic and Potential Applications
1.	Appearance	Amorphous granules
2.	Chemical constitution	Cross linked anionic polyacrylate, Cellulose based Grafted
3.	pH	7.0-7.5
4.	Particle size	20-100 mesh (micro granules)
5.	Sensitivity of UV light	Not sensitive
6.	Stability at 50°C	Stable
7.	Stability	~ 2 Years
8.	Temperature	40-50 °C
9.	Recommended dose	1-2 kg acre-1
10.	Depth	6-8 inches of soil (For clay soil 4 inches from soil surface)
11.	Toxicity in Soil	None

Additional Features

- Absorbs water 400 times of its dry weight and slowly releases it.

- In semi-arid and arid soils, it exhibits high absorbency temperature ranged from 40-500C.
- Increases the percentage of seed germination and seedling emergence rate.
- Reduces the need for irrigation and fertigation requirements, as well as amount of urea to be applied,

Application of Hydrogel in Tissue Culture Engineering

Hydrogels composed of highly hydrated polymer networks are similar to ECMs, which have received considerable attention for tissue engineering and regenerative medicine applications. To date, various hydrogels derived from natural or synthetic polymers have been used to repair damaged osteocortical joints or articular cartilage tissue. Alginate is a naturally occurring polysaccharide polymer derived from brown seaweed and various bacteria. One of alginate's distinguishing characteristics is its ability to physically crosslink by divalent cations such as Ca^{2+} at room temperature, making it useful in a variety of biotechnological methods such as moulding, spraying, and 3D printing.

Conclusion

Agricultural sustainability is essential for improving food and water security, especially in the face of climate change. It is obvious from the above context that hydrogels are very useful in Indian environment, as yield are improved tolerating the vagaries in monsoon with fewer schedules of irrigation. Hydrogels in modern agriculture farming have recently gotten a lot of attention from both researchers as well as among farmers. The hydrogels are used in areas where rainfall and irrigation are scarce. Hydrogel practices in the water stressed areas for improve agricultural productivity with preserving the environment sustainability. This will benefit the farmer by lowering his cultivation costs while also improves nutrient use efficiency and water use efficiency. Hydrogel has the potential to be an effective soil conditioner in arid and semi-arid regions. Hydrogels are good soil conditioners that can help to improve water use efficiency, plant yield and health. It would enhance soil texture, mitigates the effect of soil salinity on plants, release of stored water in dried soil and provide the required porosity for optimum flow of air and water.

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