Hydrogel And Its Application In Agriculture Field- A Review

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Abstract- *In India 60% of the net cultivated area is under dry land condition. Also, more than 30% of the area faces the problem of insufficient rainfall. So, there is a strong need for plant growth media with increased water and nutrient holding capacity. The use of water holding amendments like hydrogel polymers material for enhancing water and nutrient use efficiency will become more important over time, especially in arid and semiarid regions with limiting water availability, the hydrogel able to retain water and plant nutrients and release it to the plants when surrounding soil near the root zone of plants start to dry up. Hydrogels are polymer super absorbents that are high in molecular weight with cross linking behaviour. The hydrogel increase efficient water consumption, decreasing irrigation costs and increasing irrigation intervals, also, implement soil's water holding capacity and soil porosity, providing plants with eventual moisture and nutrients as well as enhancing plant viability and ventilation and root development which provides a conducive atmosphere for better growth of plants and finally increases crop yield.*

Keywords- hydrogel, soil conditioner, arid region, crop yield.

I. INTRODUCTION

Hydrogels are water insoluble polymers having cross-linked structures with a hydrophilic group which have the capacity to absorb water[1,2]. Hydrogel has various characters like the high swelling and the slow water retention encourage their use as safer release systems for fertilizers and as a soil conditioner in agricultural applications. Hydrogel polymer is particularly valuable in agricultural sector since they can retain water and reduce land erosion. Hydrogel may prove as a practically convenient and economically feasible option to achieve the goal of agricultural productivity under conditions of water scarcity. It can be easily applied directly in the soil at the time of sowing of field crops and in the growth medium for nursery plantation. There are various papers, reviews, and books focused on the synthesis, properties, and applications of hydrogel polymer. The objectives of this paper are to explain the role and applications of hydrogel polymer in agricultural sector to increase water holding capacity of soil.

Methods For Preparation of Hydrogel

The various preparation techniques adopted are physical cross-linking, chemical cross-linking, grafting polymerisation, and radiation cross-linking[6].

Water Absorption Mechanism of hydrogel

The hydrophilic groups (viz. acrylamide, acrylic acid, acrylate, carboxylic acid, etc.) of the polymer chain are responsible for water absorption in hydrogels. The acid groups are attached to the main chain of the polymer. When these polymers are put in water, the latter enters into the hydrogel system by osmosis and hydrogen atoms react and come out as positive ions. This leaves negative ions along the length of the polymer chain. Hence the hydrogel now has several negative charges down its length . These negative charges repel each other. This forces the polymer chain to unwind and open up. They also attract water molecules and bind them with hydrogen bonding.

Hydrogel can absorb more than 400 times its weight of water by this mode. When its surroundings begin to dry out, the hydrogel gradually dispenses up to 95% of its stored water. When exposed to water again, it will rehydrate and repeat the process of storing water. This process can last up to 2–5 years, by which time biodegradable hydrogel decomposes[5].

Key characteristics of agricultural hydrogels

Agricultural hydrogels are natural polymers containing a cellulose backbone . They can also perform well at high temperatures (40–500C) and hence are suitable for semi-arid and arid regions. They can absorb a minimum of 400 times of their dry weight of pure water[2] and gradually release it according to the needs of the crop plant. Because of their neutral pH, they do not affect nutrient availability, soil chemical composition, action of other agro chemicals, viz. fertilizers, herbicides, fungicides, insecticides, etc. Hydrogels are found to improve the physical properties of soils (viz. porosity, bulk density, water holding capacity, soil permeability, infiltration rate, etc.).

Increase in porosity results in improvement in seed germination and rate of seedling emergence, root growth and density, and reduced soil erosion due to reduction in soil compaction. It also increases biological/microbial activities in the soil, which increase oxygen/air availability in root zone of the plant24. Hydrogels help plants withstand extended moisture stress by delaying the onset of permanent wilting point and reducing irrigation requirements of crops due to reduced water loss through evaporation. The water held in root zone of the crop and leaching of nutrients in the soil are also reduced.

Application Method

1) 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[5].
2) 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[5].
3) 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[5].

Hydrogels are environment friendly

1. Hydrogels cannot return to their starting monomers on decomposition[3].
2. Moderately biodegraded in the soil by the ionic and microbial media to convert finally to ammonia and carbon dioxide[3].
3. Worldwide research has shown little or no consistent adverse effect on soil microbial populations[3].

Hydrogel application in agriculture

Hydrogel polymers play a vital role in agricultural uses as structural materials for creating a climate beneficial to plant growth in arid and semi–arid regions; it could use as retaining ingredients in different forms as follow:

1) Seed additives to support seed germination or seed coatings.
2) Dipping of seedling roots before establishment.
3) Immobilizing plant growth substances.
4) Coating protecting agents (herbicides and pesticides) for slow release.
5) Implement water–holding capacity of the soil.
6) Increasing soil permeability.
7) Improving water retention on different soil types.
8) Increase the water use efficiency.
9) Increase irrigation intervals due to increasing the time to reach a permanent wilting point.
10) Minimizing soil erosion and water run–off.
11) Implement soil penetration and infiltration.
12) Decrease soil compaction tendency.
13) Improving soil drainage.
14) Support crop growth performance under reduced irrigation conditions.
15) Enhance nutrient retention as a result of solute release from hydrogel polymer particles and delay the dissolution of fertilizers[4].

II. FUTURE SCOPE

Recently the use of hydrogel polymer has shown a great potential and growth in the agricultural sector such as arid and semiarid regions where there is attracting considerable interest for usage of hydrogel polymer to increase soil water holding and improve production of crop. On other side most of these hydrogel have multi–functional applications especially in the field of slow release nutrients using natural materials is the future scope.

III. CONCLUSION

Conclusion The application of hydrogel in arid and semi–arid regions improve soil properties, increases the water holding capacity of the soil, enhance of the soil water retention, improving irrigation efficiency, increasing the growth of various crops, and enhancement water productivity of the crop. It also provides a conducive atmosphere for the better growth of roots in well–drained soils and ultimately increases yield. According to chemical and physical structures of hydrogels, it can be used as an absorbent in environment preservation in the agricultural sector as water retention, soil conditioners, and nutrient carriers..

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