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HYDROGELS: ONE STOP SOLUTION FOR WATER SCARCITY

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Abstract— **The growing world is leading to face many unavoidable problems like poverty, climate change, pollution, pandemic etc. Due to increase in the green house gases we could see the melting of ice in Green Island. GHGs entrap the long wave reflected radiations which leads to the increase in the global temperature. Due to this, we could observe the erratic rain fall patterns which cause water scarcity and drought. Consequent crop loss is observed in the arid and semiarid regions due to scanty rainfall in the recent years. So, there is a need of alternative means to conserve the water and to improve water use efficiency (WUE). The topic of super absorbent hydrogels comes in here to bridge the gap. These are having swelling property which holds a huge of amount of water and supplies water and nutrient for a prolonged period of time to the crop roots. In this chapter, the use and importance of hydrogels are well presented and detected clearly for the better understanding.**

Keywords— **Climate change, GHGs, Hydrogels, Water scarcity, WUE**

I. INTRODUCTION

In the current trend, the area under cultivation is reducing day by day which is a major threat for upcoming years. We may fail to feed the booming population in the coming years due to low productivity, water scarcity, climate change etc. In India, the per capita water availability has declined from 5,177 m3 in 1951 to 1,441 m3 in 2015 and is expected to decline to 1,174 m3 by 2051 (GOI, 2018). We could see in the change of rainfall patterns which causes drought concurrently since some years. The rivers, ponds, canals and wells are drying up invisibly that daunting the farmers to go for farming. The farmers are migrating to the cities in search of other works. Consequently, the ground water level has been retarding due to over exploitation of ground water which ensure that one day we may not get a glass of drinking water, let's forget about agriculture. Water is the most limiting for agriculture now. So, we need to see the alternative means of it for agriculture purpose. Here, the concept of super absorbent hydrogel (SAH) comes in. It was first reported by Wichterle and Lim during 1960.

Definition

Super absorbent hydrogel is made of monomers, such as those with pendant sodium or potassium ions or numerous hydroxyl groups are obtained by chemical stabilization of hydrophilic polymers in a tri-dimensional network.
There are three groups of a polymer as follow:

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

Mode of action of hydrogel

These materials are in granular form hold water and make it available for longer periods through its sustained release to the soil in their zone of application. They can swell up to 10,000 g per gram of the dry matter used.
When we supply the hydrogel in the soil, then it got mixed up with the soil. It forms an associate amorphous gelatin–like mass on hydration and is adept of absorption and desorption for an extended time, thus acts as a slow unharnessed supply of water within the soil. The hydrogel particles are also taken as "miniature water reservoir" in the soil and water will be detached from these reservoirs upon the root mandate through osmotic pressure difference. Once the water get released to the soil and utilized by the soil, hydrogel creates voids within it which further allows the

water and nutrient solution to infiltrate within it and resupply of water and nutrients for the growth and development of plants. Hence hydrogel polymer deed as a slow– release basis of water and dissolved fertilizers in the soil.

The swelling capacity of many hydrogels is very sensitive to the pH and ionic strength of the solution. Acids or bases as well as different salts (monovalent, multi-valent) can significantly affect the solution properties of these polymers.

Hydrogel Application in Agriculture

• Seed additives to support seed germination or seed coatings.
• Dipping of seedling roots before establishment.
• Immobilizing plant growth substances.
• Coating protecting agents (herbicides and pesticides) for slow release.
• Polymeric Biocides and Herbicides.
• Water – insoluble polymers.
• Polymers for soil remediation.

In particular, hydrogel absorbs soluble fertilizer, water and then releases it in proper time for plants.

The effects of hydrogel on soil moisture considered as a restricting factor for crop production in arid and semi–arid regions. The polymer as soil conditioners was recognized since the 1950s. Agricultural hydrogels can change the different soil properties through various mechanisms like:

• Implement water–holding capacity of the soil.
• Increasing soil permeability.
• Improving water retention on different soil types.
• Increase the water use efficiency.
• Increase irrigation intervals due to increasing the time to reach a permanent wilting point.
• Minimizing soil erosion and water run–off.
• Implement soil penetration and infiltration.
• Decrease soil compaction tendency.
• Improving soil drainage.
• Support crop growth performance under reduced irrigation conditions.
• Enhance nutrient retention as a result of solute release from hydrogel polymer particles and delay the dissolution of fertilizers.

Importance of hydrogel for different aspects

Effect of the hydrogel in retaining the water

Hydrogel polymer has been used as a water retaining input in arid and semiarid region under limitation of better irrigation facilities and problematic soil conditions that affects negatively on gradual growth and productivity of crops. Hydrogel used to increase a water reservoir near the root system, increased the field capacity of different soils, also, increased both water available for plants and the period of its availability.

Moreover, previous studies point to good ability of hydrogel polymer for increasing water retention, water uptake and water use efficiency which help reduce water stress of plants and implement plant performance resulting in increased growth. Hydrogels are also claimed to reduce fertilizer leaching, which seems to occur through interaction of the fertilizer with the polymer. Polymer is also being considered as a potential carrier for protected agent like pesticides and herbicides. The use of hydrogels is particularly useful in dry and semi–dry regions where irrigation water is limited.

Effects of the hydrogel on plant growth

The arid and semi-arid areas are mostly drought prone areas where the annual precipitation is less than the average annual rainfall. In these areas, obtaining an optimum plant stand is the first priority. But, the seeds are unable to germinate uniformly in the above mentioned areas due to late onset of monsoon. So, if we aim to get a good plant stand then we must see the alternative means. Application of hydrogel polymer used to create a water reservoir near the root zone of plants, decrease osmotic moisture of soil, improve the capacity of plant available water, enhancement plant growth and increase whole yield and decrease production costs of crop.

Hydrogel is enhancing the retention of the applied water in the soil around the root zone by minimizing percolation and evaporation losses, thus ensuring a better and prolonged supply of moisture to the crop. Uses of hydrogels improve the plant viability, seed germination, ventilation and root development mainly under arid environments additionally, with respect to the growth of the plant. It’s been noticed that there’s a significant increase in the growth of the plants when usage of the hydrogel.

Reduction of drought stress

Due to erratic rainfall pattern now-a-days leads to drought which leads to water stress for the crop growth. Plant requires optimum amount of water to complete its life cycle and provide an optimum yield in return. Application of hydrogels in the soil holds the water for a prolonged period of time which reduces the frequent irrigation to the plots. Several research studies have reported the useful benefits of hydrogels in horticulture and reported that its addition could increase the water holding capacity and improve the water storage properties of porous soils, which delay the wilting periods.

Enhancement of Fertilizer Availability

Some recent studies have suggested the use of hydrogels to reduce the use of synthetic fertilizers without negatively affecting crop yield and nutritional value. This advantage of hydrogels might be more useful, especially in the case of sustainable agriculture in arid and semi-arid regions. Hydrogels can also be formulated with potassium and nitrogen ions as fertilizer components. In particular, chemicals trapped in a polymer network cannot be immediately washed out by the water but gradually released into the soil and then absorbed by plants. The study says that the combined effect of hydrogel with different types of fertilizers based on traditional NPK, superphosphate and potassium chloride on Mimosa scabrella seedlings and observed that their growth was promoted due to the increase in water retention and nutrient absorption. The hydrogel can also be used as seed coating, plant protector, and soil amendments etc.

Biodegradability of hydrogels

In the past, traditional hydrogels are not biodegradable as they are acrylate based products. Slowly, cellulose based hydrogels has come up in action those are easily degradable and left no residues behind. Cellulose based hydrogels are the sustainable solution for Indian agriculture now. Hydrogel polymers are very sensitive and there is a chance of absorb into plant tissues.

On the other hand, hydrogels can be easily degraded when exposed to natural UV rays. In particular, polyacrylate becomes much more sensitive to aerobic and anaerobic soil microorganisms and easily degraded into the water, carbon dioxide and nitrogen compounds. The mineralization of hydrogels can also happen through biological decomposition, such as fungi. In particular, the biological degradation of different kinds of polymers in the soil reaches a high degree of effectiveness, especially under conditions that help to maximize solubility. For example, the biodegradation of acrylate-based hydrogels in municipal compost was reached up a rate from 1 to 9 % per year under aerobic conditions similar to the decomposition of organic matter in forest areas.

IV.CONCLUSION

The hydrogel has a dynamic property of holding water for a longer period of time which endurethe plant root systems and make avail the water slowly. It also absorbs the nutrient solutions andimproves the nutrient use efficiency of applied nutrients. It has many properties which makes it abest choice in the arid and semi-arid regions. The farmers can adopt this to get a better yield byutilizingless waterandlowcost.

V. REFERENCE

[1]. Abd EI-Rehirn, H.A., Hegazy, E.S.A., Abd El-Mohdy, H.L. (2004). Radiation synthesis of hydrogels to enhance sandy soils water retention and increase performance. J Appl Polym Sci.,93(3):1360–1371.

[2]. Abd El-Rehim, H.A. (2006). Characterization and possible agricultural application of polyacrylamide/sodium alginate crosslinked hydrogels prepared by ionizing radiation. J Appl Polym Sci. ;101(6):3572–3580.

[3]. Abdel-Raouf, A.M., Samira, R.M. (2003). Improving soil physical properties and its effect on acacia tortilis seedlings growth under field conditions. Asian Journal of Plant Sciences. ;2(11):861–868.

[4]. Akhter, J., Mahmood, K., Malik, K.A. (2004). Effects of hydrogel amendment on water storage of sandy loam and loam soils and seedling growth of barley, wheat and chickpea. Plant Soil Environ. ;50(10):463–469.

[5]. Azzam, R.A. (1980). Agricultural polymers. Polyacrylamide preparation, application and prospects in soil conditioning. Communications in Soil Science and Plant Analysis. ;11(8):767–834.

[6]. Bakass, M., Mokhlisse, A., and Lallemant, M. (2002). Absorption and desorption of liquid water by a superabsorbent polymer: effect of polymer in the drying of the soil and the quality of certain plants. Journal of Applied Polymer Science. ;83(2):234–243.

[7]. Barakat, M.R., El-Kosary, S., Borham, T.I. (2015). Effect of hydrogel soil addition under different irrigation levels on Grand Nain banana plants. J Hort Sci & Ornamen. Plants. ;7(1):19–28.

[8]. Belen-Hinojosa, M., Carreira, J.A., Garcia-Ruiz, R., (2004). Soil moisture pretreatment effects on enzyme activities as indicators of heavy metalcontaminated and reclaimed soils. Soil Biology and Biochemistry. ;36(10):559–1568.

[9]. El-Hady, O.A., Tayel, M.Y., Lofty, A.A. (1981). Super gel as a soil conditioner: its effect on plant growth, enzymes activity, water use efficiency and nutrient uptake. Acta Horticulturae. ;119(22):257–265.

[10]. GOI, 2018. EnviStats India 2018. Government of India. www.mospi.gov.in

[11]. Helalia, A., Letey, J. (1988). Cationic polymer effects on infiltration rates with a rainfall simulator. Soil Science Society of America Journal. ;52(1):247–250.

[12]. Helalia, A.M., Letey, J. (1989). Effects of different polymer on seedling emergence, aggregate stability and crust hardiness. Soil Science. ;148(3):199–203.

[13]. Han, Y.G., Yang, P.L., Luo, Y.P. (2010). Porosity change model for watered super absorbent polymer- treated soil. Environmental Earth Sciences. ;61(6):1197–1205.

[14]. Hayat, R., Ali, S. (2004). Water Absorption by synthetic polymer (Aquasorb) and its effect on soil properties and tomato yield. Int. J. Agri. Biol. ;6(6):998–1002.

[15]. Hedrick, R.M., Mowry, D.T. (1952). Effect of synthetic polyelectrolytes on aggregation, aeration and water relationships of soil. Soil Science. ;73(6):427–441.

[16]. Johnson, M.S. (1984). Effect of soluble salts on water absorption by gel forming soil conditioners. Journal of Science and Food Agriculture. ;35(10):1063– 1066.

[17]. Koupai, A.J., Eslamian, S.S., Asadkazemi, J. (2008). Enhancing the available water content in unsaturated soil zone using hydrogel, to improve plant growth indices. Ecohydrology and Hydrobiology. ;8(1):67–75.

[18]. Koupai, A.J., Asadkazemi, J. (2006). Effects of a hydrophilic polymer on the field performance of an ornamental plant (Cupressus arizonica) under reduced irrigation regimes. Iranian Polymer Journal. ;15(9):715–722.

[19]. Milani, P., França, D., Balieiro, A.G. (2017) Polymers and its applications in agriculture. Polímeros. ;27(3):256–266.

[20]. Montesano, F.F., Parente, A.,Santamaria, P. (2015). Biodegradable superabsorbent hydrogel increases water retention properties of growing media and plant growth. Agriculture and Agricultural Science Procedia. ;4:451– 458.

[21]. Orikiriza, L.J.B., Agaba, H., Tweheyo, M. (2009). Amending soils with hydrogels increases the biomass of nine tree species under non-water stress conditions. Clean-Soil Air Water. ;37(8):615–620.

[22]. Sojka, R.E., Entry, J.A. (2000). Influence of polyacrylamide application to soil on movement of microorganisms in runoff water. Environmental Pollution. ;108(3):405–412.

[23]. Viero, P.W.M., Chiswell, K.E.A., Theron, J.M. (2002). The effect of a soil-amended hydrogel on the establishment of a Eucalyptus grandis clone on a sandy clay loam soil in Zululand during winter. Southern African Forestry Journal. ;193(1):65–75.

[24]. Wang, W., Wang, A. (2009). Synthesis, swelling behaviors, and slow-release characteristics of a guar gum-g-poly (sodium acrylate)/sodium humate superabsorbent. Journal of Applied Polymer Science. ;112(4):2102–2111.

[25]. Woodhouse, J.M., Johnson, M.S. (1991). Effect of superabsorbent polymers on survival and growth of crop seedlings. Agricultural Water Management. ;20(1):63–70.

[26]. Yazdani, F., Allahdadi, I., Akbari, G.A. (2007). Impact of superabsorbent polymer on yield and growth analysis of Soybean (Glycine max L.) under drought stress condition. Pakistan Journal of Biological Science. ;10(23):4190– 4196.

[27]. Zhang, X.C., Miller, W.P. (1996). Polyacrylamide effect on infiltration and erosion in furrows. Soil Science Society of America Journal. ;60(3):866–872.