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WATER HOLDING POLYMERS AND ITS RELEVANCE IN AGRICULTURE

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Abstract:

The increasing water requirement in agriculture is becoming a serious issue because of population increase, global warming, and irregular rain patterns. Freshwater is being utilized at its maximum, and hence groundwater levels are depleting. This will raise the pressure for food, particularly in arid and semi-arid regions where water is used economically to maintain crop production. For mitigation of this problem, effective water management is the key to sustainable crop production & food security. Water-holding polymers, or Super Absorbent Polymers (SAPs), are chemicals that can absorb several times their weight in water; they create a gel-like matrix that slowly releases moisture to plant roots as and when required. These hydrophilic chemicals have been found to be an emerging technology to increase water retention in soil, increase water use efficiency by lowering irrigation requirements and stimulate plant growth even in drought-like situations. Water holding polymers are now being used as a tool to mitigate water scarcity, enhance soil water dynamics & ensure food security in water-limited situations in an environmentally, socially and economically sustainable way. This article deals with the science behind water-holding polymers, types, mode of action & significance in agriculture.

Keywords: Water scarcity, Water holding polymers, Water retention, Soil water relationship, Water use efficiency.

Introduction:

Water resource is an important parameter for crop development and growth in agriculture. Due to extreme climate change, the water supply is becoming critically short. Due to a lack of water supply, crops are not allowed to use other available resources to their full potential. India possesses 17.78 percent of the world population but only 4 percent of the world's water resources, making it one of the most water-stressed nations for long-term sustainability of the agricultural sector, which is the backbone of sustainable living. Water resources play an important role in planting and growing crops. Due to extreme climate change, the water supply is becoming critically short. Due to a lack of water supply, crops are not allowed to use other available resources to their full potential. India possesses 17.78 percent of the world population but only 4 percent of the world's water resources, making it one of the most water-stressed nations for long-term sustainability of the agricultural sector, which is the backbone of sustainable living. Water-holding polymers are those materials that can absorb water and hold water in the soil without rupturing in water. SAPs' granules are incorporated in soil; they are often dry and

swell to a jelly-like material when they are released in the soil by a diffusive action, since the soil dries.

Types of Water Holding polymers:

Water Holding Polymers

Natural Polymers - Polysaccharide-Based SAP, such as cellulose, starch, chitin, chitosan, and natural gums (e.g., xanthan, guar, and alginates). Example Zeba: A starch-based, biodegradable hydrogel.

Synthetic Polymers – Polyacrylamide(PAM) – high water absorbency & stability, Polyacrylic acid(PAA) – soil conditioners , Polyvinyl alcohol (PVA) – medium water holding capacity. Eg: Aquasorb – SAP cross linked polyacrylamide.

Properties of Agricultural Hydrogel:

1. Capable of swelling
2. Retains and releases water – Hydrophilic tendency
3. Compatible with biological systems and biodegradable
4. Soft and fluffy texture
5. Extremely high absorbency
6. Viscoelastic behaviour – Mixture of liquid and solid behaviour

Water absorption mechanism of Water Holding Polymer:

1. Dry Polymers are incorporated into soil, absorb water and swell, forming a gel- like structure increases the water retention capacity.
2. They are tiny water reservoirs in the soil that store water within the root zone, reducing evapotranspiration, enhancing the porosity of the soil and providing more oxygen to roots.
3. During dry conditions, swollen hydrogels release limited amount of water & nutrients to the plant root; this is a slow releasing mechanism – long term water availability during dry periods.

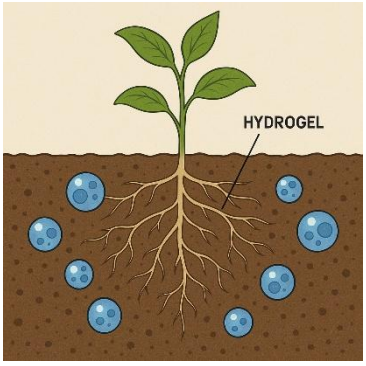


Fig.1 Hydrogel in action at plant roots

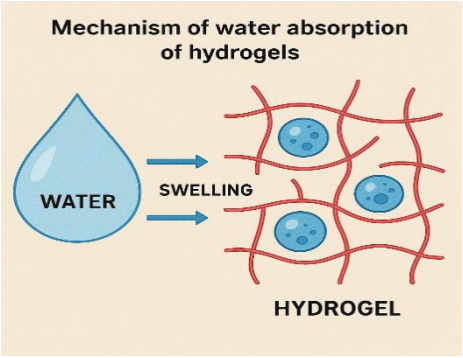


Fig. 2 Mechanism of water absorption of hydrogels

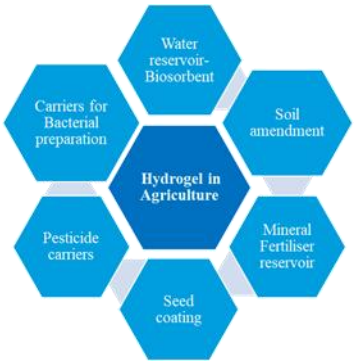
Examples of Water Holding polymers:

- Pusa Hydrogel - Potassium polyacrylate polymer starch-based cross-linked for water retention in agriculture.
- Cross – linked Polyacrylamide - synthetic polymer possesses large sorption ability, applied in agriculture & other uses.
- Starch – based polymers - Natural Polymers from natural sources like corn & wheat used in agriculture and as thickeners. Zeba is an example, which is a biodegradable hydrogel.
- Chitosan – Biodegradable natural polymer with high water holding capacity obtained from chitin in crustacean shells.
- Cellulose polymers – They are cellulose polymers used for water retention in agriculture & as a component in hydrogels

Effect on Soil physical – chemical & biological properties	**Effect on crop growth**
Soil Bulk density	Enhances seed germination
Soil porosity	Root growth & development with enhanced oxygenation
Improving soil water- holding capacity	Improves plant growth & yield traits
Improves soil infiltration rate & permeability	Improves nutrient use efficiency
Soil erosion control	Crop protection

Application of Hydrogel :

- Dry Application - Hydrogel should be kept dry for it to work best. Mix the needed quantity of hydrogel (2.5 to 5kg/ha) for vegetable crops; mix the hydrogel-sand mixture with the top 5 cm of soil. Putting hydrogel into the furrow of the seed is a cost-effective way.
- Wet Application – Mix the granules with water and allow the mixture to settle for 60–90 minutes. Hot water can be employed to facilitate faster absorption. Once all the polymer has soaked, apply it near the root zone. It is best suited for minor applications such as repotting houseplants, shrub planting, and tree planting of small trees.



Role of Water Holding polymer / SAPs/ Hydrogels in Agriculture:

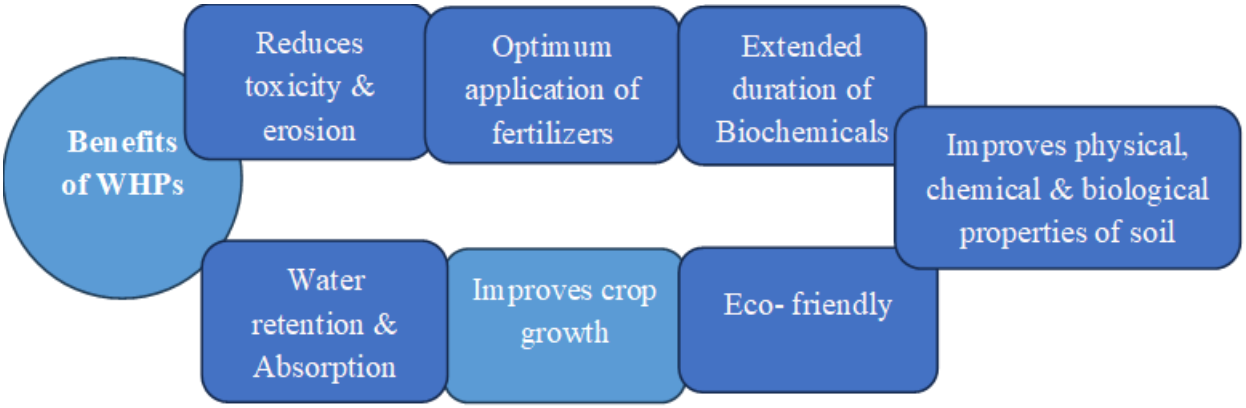
Relevance of Hydrogels:

- Water Use Efficiency
- Water Holding Capacity
- Less leaching of fertilizer & better nutrient delivery

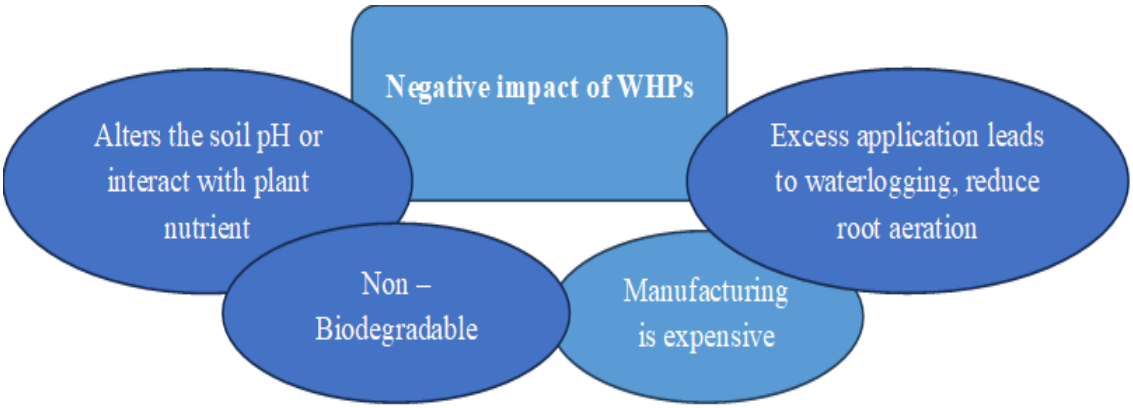
- Improve soil infiltration and penetration rates.
- Decrease irrigation frequency
- Lower the soil compaction tendency
- Reduce water erosion and soil run-off
- Increased crop yield

Impact of Hydrogels in Agriculture:

Benefits of Water Holding Polymers in Agriculture:



Shortcomings of Water Holding Polymers in Agriculture:



Possible Future research studies:

- Enhancing SAP formulations & Longevity – Novel SAPs with higher absorption & retention capabilities.
- Biodegradability & environmental impact – Natural breakdown in soil, minimizing environmental footprint.
- Combining SAPs with soil amendments.
- SAP application optimization in agriculture
- Meeting economic & pragmatic needs – minimizing cost & encouraging farmer adoption.

Conclusion:

Water shortage is increasingly becoming the constraining factor for sustainable agriculture production. Water holding polymers are new technologies that improve the soil structure & porosity of the soil, enhance water retention and slow-release

functionality, improve irrigation, enhance water and nutrient use efficiency, increase crop yield and quality, and preserve environmental quality. This technology can prove to be a useful one in practical terms in arid & dry areas. This technology is a lifeline in reviving the barren soils, minimizing the irrigation requirements and resolving the problem of water shortage in agriculture, thereby enhancing the crop productivity.

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