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Uses of Agriculture Polymers in Dryland Farming: Sustainable Solution for Water Scarcity

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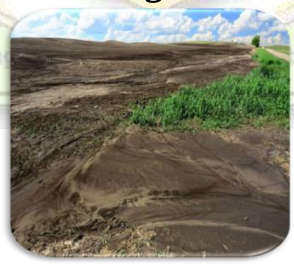
Agriculture polymers are special materials that help soil and plants grow better. They can hold water like a sponge and release it slowly, so plants have moisture for longer periods. Many of these polymers can break down naturally in the environment, making them safe to use. Farmers add them to soil to improve its structure, keep nutrients in specific place, and reduce the need for frequent watering. They act as soil conditioners and water reservoirs. Hydrogel, also known as super absorbent polymer, is an amorphous polymer that is cross-linked, hydrophilic, biodegradable, and capable of retaining water at least 400 times its original weight. It also makes at least 95% of the stored water available for crop absorption. A polymer that is combined with soil works as a slow-release source of water in the soil because it hydrates to form an amorphous gelatinous mass and can absorb and desorb water over an extended period of time. The hydrogel particles in the soil can be thought of as "miniature water reservoirs" from which water is drawn out when roots require it due to an osmotic pressure differential. Because they contain hydrophilic moieties, hydrogels are hydrophilic polymers with a three-dimensional network structure that can absorb a lot of water.

Major Objectives

1. Water Conservation and Retention
2. Enhancement of Nutrient Use Efficiency (NUE)
3. Improvement of Soil Physical Properties
4. Seedling Establishment and Survival
5. Environmental and Economic Sustainability

Major Challenges in Dryland Farming


Water Scarcity


Soil Erosion


Low Productivity

Types of Agriculture Polymers (Based on function)

1. Biodegradable Polymers

Biodegradable Polymers are nature-friendly plastics made from plants like starch and cellulose that break down naturally, reducing pollution, unlike regular plastics that last forever.

Microorganisms consume them, breaking them down into simple, harmless substances.

Starch-based: Examples include Polylactic acid (PLA), often used in bioplastics.
Cellulose-based: Examples include Carboxymethyl cellulose (CMC) used for SOIL BINDING.

2. Superabsorbent Polymers (SAPs)

Superabsorbent polymers (SAPs), also known as hydrogels, are materials that act like tiny, powerful sponges in soil. They can soak up hundreds of times their own weight in water and then slowly release it to plant roots, acting as miniature reservoirs. This process improves soil quality, conserves water, helps plants survive droughts, and reduces the need for frequent irrigation.

Common Types: Acrylic acid-based polymers (e.g. Polyacrylamide)
Starch-q-polyacrylamide (Hybrid semi-synthetic)

3. Mulch films polymers

Protective soil covers

Farmers use protective covers, called mulch films, over the soil to change the ground temperature and keep moisture in soil. Historically, these films were made of non-degradable plastic. However, modern agriculture is shifting towards environmentally friendly options. Modern agricultural films focus on degradability. This type of mulch films naturally break down and turn into compost within the soil.

Biodegradable: Polylactic Acid or Polylactide PLA-based films that compost into the soil.
Photodegradable: Polyethylene-based films designed to break down under UV light exposure.

Salient features:

1. Shows maximal absorbency at temperatures between 40 and 500C, which is typical of both dry and semi-arid soils.
2. 400 times its dry weight in water is absorbed and then gradually released.
3. Stable in soil for a year at the very least.
4. Less impacted by sodium.
5. Low soil application rates: 1-2 kg/ha for horticultural nursery crops and 2.5–5 kg/ha for field crops.
6. Minimizes fertilizer and herbicide leaching.
7. Enhances the physical characteristics of soils and soil less materials.
8. Enhances root growth and density.
9. Boosts seed germination and seedling emergence rate.
10. Assists plants in withstanding extended moisture stress.
11. Lessens the need for fertigation and irrigation of crops.
12. Encourages early and abundant fruiting, blooming and tillering.
13. Delays the permanent wilting point's development.
14. Profound root development that improves the efficiency of water and nutrient utilization
15. A notable improvement over control in terms of seed germination and seedling growth efficiency.

Agricultural hydrogels can change the physical properties of soils by:

1. Increasing their water-holding capacity
2. Lowering runoff and erosion
3. Cutting back on irrigation frequency
4. Improving water usage efficiency
5. Increasing soil permeability and infiltration
6. Lessen the soil's propensity to compress
7. Enhance plant growth.

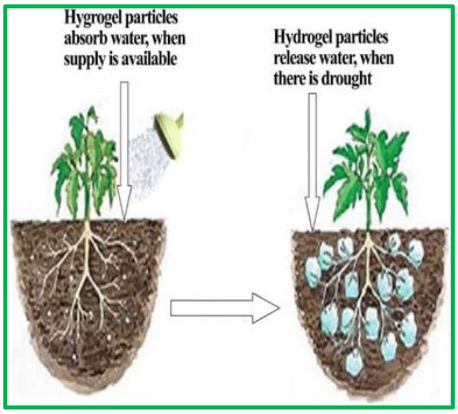
Different mechanism of agriculture polymers:

SAPs Mechanism

Superabsorbent polymers (SAPs) are special materials that act like very powerful sponges in the soil. When it rains or when plants are watered, these polymers absorb a large amount of water—sometimes up to 400 times their own size—and hold it inside. As the soil begins to dry out, they don't release the water all at once. Instead, they slowly let the water out, giving the plant roots a steady supply of moisture. This slow release happens because of natural pressure differences in the soil.

Mulch Films Mechanism

Films create a physical barrier on the soil surface. This barrier breaks the capillary action of water evaporating from the soil surface, effectively trapping moisture below the film where the roots are active.



Soil moisture conservation

Seed Coating Technology

Smart Germination: Polymer coatings are applied directly to seeds to regulate water uptake. This prevents seeds from germinating prematurely after light rains, ensuring they only sprout when there is sufficient moisture for sustained growth.

Nutrient Delivery: Coatings can be infused with fertilizers, providing an immediate nutrient boost to the seedling upon germination.

Soil Erosion Control: In arid and semi arid area strong wind and flash floods strip away valuable topsoil. Polymers offer a solution by acting as soil binders.

How it works: Anionic polyacrylamides (PAM) bind fine soil particles together, creating larger aggregates. This improves the soil's structural integrity, increases water infiltration rates, and drastically reduces sediment runoff.

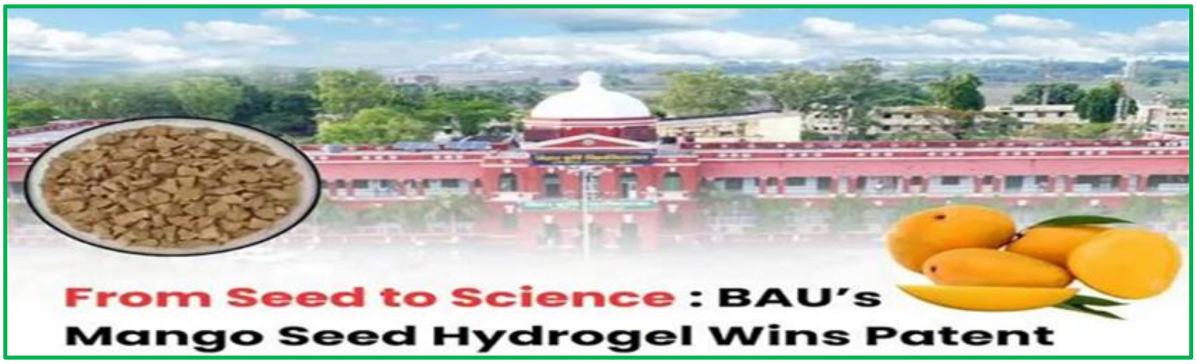
Pusa Hydrogel Revolution

The total growth and development of a plant depends heavily on water. This issue has become exponentially more problematic because of climate change. So, to keep these points in mind Scientists from Indian Agricultural Research Institute, New Delhi invented the PUSA HYDROGEL to alarming rate of water scarcity which is to be faced by the world . Scientists found out that PUSA-HYDROGEL is applicable to all crops primarily wheat, paddy, sugarcane, groundnut, potato, strawberry, tomato, onion, carrot mustard, cauliflower, cotton, chrysanthemum, turmeric etc. The average rate of usage is 2.5-3.0kg/ha of PUSA HYDROGEL. It is applied to the field at the time of sowing or before irrigation. It is found out that there was an increase in about 18-22% of yield on various crops done under the field conditions of IARI, New Delhi for at the period of 2 years and also found out that the irrigation requirements were limited.

Case Study

A study carried out at S.K.N. College of Agriculture in Jobner, Rajasthan,showed that adding Pusa hydrogel to loamy sand soil helps pearl millet grow better under dry conditions. Farmers tested different amounts of hydrogel—2.5, 5.0, and 7.5 kg per hectare—and found that 5.0 kg/ha worked best, increasing grain yield by about 14% compared to 2.5 kg/ha and 33%

compared to no hydrogel. The hydrogel also improved important growth features such as earhead length and girth, grain weight per earhead, and 1000-grain weight. Overall, the study showed that Pusa hydrogel helps the soil hold more moisture, leading to healthier plants and higher yields.



On August 21, 2025, Bihar Agricultural University (BAU), Sabour, was granted the patent after filing process for its unique method of producing hydrogel from mango seed kernels humble waste product—mango seeds—into a world-class agricultural innovation. The powder is treated with heat and safe chemicals, and blended with natural polymers to improve its water-holding capacity. The main goal behind this invention is not only to support agriculture but also to strengthen India's "waste-to-wealth" mission by transforming discarded mango seeds into a product of global value.

Agricultural hydrogel products available in India (Kalhapure *et al*., 2016)

Trade name	Manufacturing company
Pusa Hydrogel	IARI, New Delhi
Waterlock 93N	Acuro Organics Ltd, New Delhi
Agro-forestry water absorbent polymer	Technocare Products, Ahmedabad
Super absorbent polymer	Gel frost packs, Kalyani enterprises, Chennai
Hydrogel	Chetex Speciality Ltd, Mumbai
Rain drops	M5 Exotic Lifestyle Concepts, Chennai

Conclusions

In India, where there will be water shortages, PUSA-HYDROGEL is the way of the future for agriculture. Farmers and the government must incorporate PUSA-HYDROGEL into field operations to improve soil quality and water use efficiency in order to make the most effective use of the country's limited water resources. Additionally, it is essential for maintaining the natural ecology, raising the groundwater table, and conserving resources for future generations.

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