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PROSPECTS OF WATER HOLDING POLYMERS IN AGRICULTURE

Email
savi.bhu31@gmail.com

Savita Jangde

Department of Plant Physiology, Institute of Agricultural Sciences,
Varanasi-221005, India

India's population is growing at a worrisome rate and is anticipated to present significant issues in the near future. The demand for water is anticipated to increase by 50% due to population expansion. The use of water-holding polymers in agriculture has given answers to the issues facing modern agriculture and increased the soil's ability to store water. Water-holding polymers may have an impact on the rate of soil evaporation and water infiltration. In particular, the polymers lessen the need for irrigation and have a tendency to compact soil, which prevents erosion and water runoff. The purpose of this article was to provide information on the potential uses of water-holding polymers in agriculture.

The condition of water resources in India is a cause for concern. India is facing increasing challenges with regards to water scarcity, water quality, and access to clean water. Groundwater, which provides drinking water for over 60% of the rural population and nearly 25% of urban population, is being over-exploited in many regions. Water is a critical resource for agriculture, as it is necessary for plant growth and the production of food. In many regions, irrigation is used to supplement insufficient rainfall or to provide water during dry periods. However, the increased demand for water in agriculture has put pressure on water resources, leading to over-extraction of groundwater, depletion of rivers, and water scarcity. This has resulted in water stress and reduced crop yields in some areas. To address these challenges, farmers are using various water management practices such as precision irrigation, rainwater harvesting, and conservation tillage to conserve water and improve efficiency. It is estimated by 2025 water scarcity will be a major issue in India requiring immediate redressal. The Central Water Commission reports that although the need for water is steadily increasing, the supply of clean water is expected to decrease much more rapidly in the future. In the case of India, agricultural irrigation methods appear to be the main consumer of 80% of the potable water available. With the continued intensification of agrobased sectors, this trend is growing. Modern irrigation techniques can still only support 40% of the planted crops due to the subcontinent's vast geographic size, variable soil, and farming methods. The effectiveness and wise use of available water for crops is substantially reduced in the remaining areas because they are far more vulnerable to bad practises.

Water-holding polymers (WHP), are a type of polymer that can absorb and retain large amounts of water. These materials are used in various applications, agriculture and food processing. They are typically made of a network of polymer chains that are cross-linked to form a three-dimensional structure that can hold onto water molecules. The water-retaining properties of WHP make them useful in a variety of settings where moisture management is important. The soil's ability to store water was increased as a result of water-holding polymers swiftly forming gels with irrigation water. Plants get access to the water that is kept in this way for a long period of time. In addition to the water they receive during building, fertilizers, nutrients, and mineral salts are also present in the soil along with the polymers. This method effectively supplies irrigated water to plant roots at critical times.

Natural polymers, semi-synthetic polymers, and synthetic polymers are the three main forms of water-holding polymers employed today. Starch-based natural polymers come from grains like corn and wheat and are based on starch. Natural polymers are frequently used in the food sector as a thickening. First, cellulose is converted into semi-synthetic polymers, which are then combined with petrochemicals. The cation or anion of these polymers varies. Agriculture is the principal application for synthetic polymers. The most common sources of synthetic hydrophilic polymers are polyvinyl alcohol and polyacrylamides. The chemical composition of polymers operating as a type of soil microsponge is cross-linked acrylamide, acrylic acid, potassium salt, and ammonium salt in potassium-based water absorbers. The materials are rendered insoluble in water by the cross-linking molecules that create a three-dimensional network in the polymer structure. These substances absorb water and nutrients that are water soluble when they come into contact with water, swelling quickly and forming a gel structure.

Super Absorbent Polymers

A new class of macromolecular synthetic water absorbing polymer material, super absorbent polymers are also referred to as hydrogel, absorbent polymers, absorbent gels, super soakers, and super slurpers. By osmosis, it has the ability to absorb up to 100,000% of its own weight in water in a short amount of time and forms granules in soil to improve soil qualities. SAPs are typically hygroscopic materials that resemble white sugar and swell in water to produce a clear gel consisting of distinct individual particles. They can hold moisture even under pressure without burning up or rupturing or blasting.The majority of super absorbent polymers used in agriculture are made via solution or suspension polymerization from acrylic acids and a cross-linking agent like potassium. The polymer created in this way is known as a polyacrylate, and the amount and type of cross-linker utilized considerably influences its swelling capacity and gel modulus. Polyacrylates have been shown to be biodegradable with a degradation rate of 10%–15% annually. They are non-toxic, non-irritating, and non-corrosive by nature. They have a high water absorption capacity and may freely release 95% of the same when plant roots apply suction. Two significant examples of SAPs made by agriculture

1. **Pusa hydrogel**: To satisfy the needs of water productivity in agriculture, the Indian Agricultural Research Institute, New Delhi, has created an absorbent polymer named "Pusa Hydrogel."Natural polymer backbone-based water absorber based on cross-linked potassium polyacrylate polymer, exhibits maximum absorbency at temperatures (40- 50^{o}C) characteristic of semiarid and arid soils. Absorbs water 400 times its dry weight and gradually releases the same. Stable in soil for a minimum period of one year. Less affected by salts and low rates of soil application.

2. **Casava starch-based SAP**: A semi-synthetic SAP is developed by Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala.Uses cassava starch backbone (other starches can also be used, but absorbency may vary) Contains no detectable level of the monomer, acrylamide. Absorbency ranges from 400-425 g/g of the dry sample.

Benefits : SAPs have several applications in agriculture, including:

1. Improving soil moisture retention: SAPs can be added to soil to increase its ability to retain moisture, reducing the need for frequent watering and improving plant growth.
2. Drought management: SAPs can be used to mitigate the effects of drought by retaining water in the soil and making it available to plants when needed.
3. Seed coating: SAPs can be used as a coating for seeds to improve germination rates and seedling growth.
4. Irrigation: SAPs can be used in combination with irrigation systems to increase the efficiency of water usage, reducing waste and conserving resources.

5. Fertilizer enhancement: SAPs can be added to fertilizer to increase its effectiveness by retaining moisture and nutrients near the roots of plants.
6. Soil remediation: SAPs can be used to clean up contaminated soil by absorbing and retaining pollutants.
7. Landscaping: SAPs can be used in landscaping to improve soil moisture retention, reducing the need for frequent watering and promoting plant growth.

SAPs have some disadvantages, including:

1. Environmental impact: SAPs are not biodegradable, so they can persist in the environment for a long time, potentially causing harm to wildlife and ecosystems.
2. Production process: The production process of SAPs often involves the use of harsh chemicals and requires large amounts of energy, which can have negative environmental impacts.
3. Cost: SAPs can be relatively expensive compared to traditional absorbent materials, making them less accessible to some consumers.
4. Disposal: Disposing of SAP-containing products, such as disposable diapers, can be challenging as they do not break down in the environment and can take up space in landfills.
5. Health concerns: There is limited research on the long-term health effects of SAPs, but some studies have suggested that exposure to SAPs may be linked to skin irritation and other health problems.

Conclusion

In dry and semiarid areas, water is increasingly the limiting constraint for sustainable crop production. Water holding polymers can be used as a soil conditioner to enhance the hydro-physical, physicochemical, and biological environments of the soil, increase soil water retention and release capacity, boost irrigation, water and nutrient use efficiency, raise crop yield and quality, and maintain environmental quality. In terms of increasing yield and reducing soil moisture stress, this technology may become a radical and practically useful one in water-stressed locations. This article envisages that, the widespread implementation of SAPs could benefit farmers and other stakeholders by optimizing water resource management for greater agricultural productivity.

References

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