Pusa Hydrogel: A Novel Technology to Tackle Water Crisis

Pratyasha Jonak Boruah[1]*, Dr. Rekhashree Kalita[2], Moumita Routh[1] and Porismita Goswami[1]

[1] M.Sc. Scholar, [2] Associate Professor,
Department of Agronomy, BNCA, Assam Agricultural University

Corresponding Author
Pratyasha Jonak Boruah
Email: pratyashaboruah09@gmail.com

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ABSTRACT

Water is life. Freshwater (only 3% of total world water) is indispensable for the survival of all biotic components on earth's landmass. Out of this 2.5% is frozen in glaciers and polar ice caps. Also, half of the ground water is stored at depths more than 1000m which is considered uneconomical to use in agriculture. Being an essential element for plant growth, the availability of fresh water is crucial for food security. Even in humid climates, precipitation is insufficient to meet crop water requirements. Thus there is a need to efficiently use the water to meet crop water demands. One approach to solve this problem is the application of Pusa hydrogel which absorbs water and slowly releases it for the crop to uptake.

INTRODUCTION

Hydrogel is ubiquitous around us. It is present in the extracellular matrix of most soft tissues in our body, bacterial biofilms, and marine plant tissue. Structurally it is a 3D, crosslinked network with abundant hydrophilic groups in its backbone chains or side chains, which get swollen in water. Its inter-chain cross-linking structure prevents it from losing the integrity of the material. Various substances like natural products like agar, chitosan, alginate, gelatin, and carrageenan as well as synthetic polymers

such as poly acrylic acid (PAA), PEO etc. are used as hosts for the production of hydrogel and these materials along with the mechanism of synthesis and external environment determine its swelling behavior making it widely applicable in diverse fields such as engineering, biomedical and agriculture.

Pusa hydrogel is a super absorbent polymer, made of carboxy-methyl cellulose based on cross-linked potassium polyacrylate polymer, was developed by the Indian Agricultural Research Institute in New Delhi to overcome the constraints of other available hydrogels like high rate of biodegradability and conversion to fragile structure at higher temperatures, less water absorption and potentiality of causing harm to environment due to its synthetic origin. Pusa hydrogel can absorb water up to 400 times its weight, based on simple osmosis. It absorbs mostly at temperatures between 40–50° C, is less affected by salts, and is stable for at least one year, thus is suitable in arid and semi-arid regions.

How does hydrogel work?

Hydrogels can be both cationic and anionic. The presence of charges determines the behavior of the reaction with soil and solute. However, the mechanism of action in soil is very complex as many chemical interactions ranging from hydrogen bonding to Van der Waals force occur simultaneously. The stronger the interaction greater the potentiality of the gel to absorb water and stabilize the soil structure.

Advantages of Pusa hydrogel

1. Conserve moisture by forming a continuous cycle of absorption and release of water and improve soil quality.
2. Helps in seed sprouting and seedling development
3. It is biodegradable. Moreover, since the backbone is made of cellulose there is no residue of acrylamide in the soil after decomposition as it cannot rebuild its monomer.
4. Acts as micro water reservoirs at plant roots as it absorbs available water and releases it slowly due to the root capillary suction mechanism thus preventing loss of water as well as loss of fertilizers and pesticides through leaching. Moreover, chemicals absorbed through water are slowly released to the plants thus preventing overuse.
5. Prevent seedling mortality in cold regions as water doesn't freeze when it is absorbed by the hydrogel and although in small amounts it continuously supplies water to the plant.
6. Reduce labor and water costs.
7. Low rate of application i.e., 1-2 kg ha^{-1} for nursery crops and 2.5-5 kg ha^{-1} for field crops.

Application

Dry method- To apply Pusa hydrogel, mix one part of hydrogel with ten parts of dry soil, and then the mixture needs to be broadcasted in the field before final land preparation. Also, it can be used in pot mixture at the rate of 3-5g of hydrogel per kg of soil.

Wet method- Root dipping at the rate of $2gL^{-1}$ of water and then transplanting.

Yield attributes

In a study conducted on Wheat in the West Himalayas, it was found that the plant population in hydrogel plots increased by 22% compared to the non-hydrogel-treated plots. Moreover, the total yield as well as grain yield increased significantly after the hydrogel amendment. In another study in

Chrysanthemum, it was reported that the application of Pusa hydrogel significantly improved many properties including the plant height, its spread, number of branches, length of branches, and flower stalk length.

Future perspective

Climate change is gripping the whole world with recent cases of abrupt weather changes resulting in either an increase in dry spells or heavy rainfall which rather than recharging the groundwater table is lost as runoff or evaporation. Central Groundwater Board of India, mentioned that 17 % of groundwater blocks are overexploited; meaning the rate at which water is extracted is higher than the rate at which the aquifer can recharge. Water being an essential component of survival, the growth and yield of plants are largely dependent on water. Hejazi *et al.* (2023) said that agricultural production is projected to drop by 60% by 2050 in some countries. Thus, there is an urgent need to efficiently use the available water and increase water use efficiency. Here the novel technology of application of Pusa hydrogel in agriculture paves a new way in conserving soil moisture along with conserving resources for future generations.

CONCLUSION

The use of Pusa hydrogel can be a great aid for the economical utilization of water as well as enhancing crop productivity in the future. As it is both farmer's friendly and environment-friendly Government needs to take steps such that farmers are made aware of its impact and can assess it at the right time and the right place.

SUMMARY

Day by day fresh water is becoming scarcer. The efficiency of the application of water is very low in India which can be mitigated by moisture conservation practices like the application of Pusa hydrogel. It was manufactured by IARI, Delhi to overcome the problems associated with synthetic hydrogels. Among other advantages of using Pusa hydrogel, the main is that it can retain water up to 400 times of its weight and releases slowly such that plants can uptake.

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