FILM FARMING: THE FUTURE OF AGRICULTURE

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The agricultural sector has significantly changed due to advancements in new technology. Traditional practices cannot withstand the upcoming climate crisis and future food security issues. It is no longer feasible to rely solely on traditional practices to address the imminent challenges of climate change and food security. Agriculture is the biggest consumer of water compared to any other sector accounting for 70% of global water usage and its use is often inefficient. To encounter the requirements of an emerging population, the demand for water is projected to increase by 15% by 2050. In the year 2000, approximately 22% of water depletion was attributed to irrigation water use, but this number is expected to decrease by almost 20% by 2050. In order to sustain the world population which is estimated to be 8.9 billion in 2050, there needs to be a 70% increase in food production. The most effective strategies for mitigating this issue involve improving irrigation efficiency and developing technologies for water and soil conservation. Several practices exist to utilize water and other resources in a more efficient manner, and numerous technologies are being developed to tackle the challenges of climate change and food insecurity in agriculture. This article highlights the application of film farming that uses hydrogel technique for crop cultivation.

Mori Yuichi (right) holding hydrogel film-grown plant

Film farming

Film farming is a new technology that uses hydrogel membrane as the growing medium in place of conventional soil. It is also known as IMEC (Intelligent Membrane Culture) that uses membrane and hydrogel Technologies. Here plants are grown on a transparent film (hydrogel film) which serves as the growing medium for plants.

Hydrogel is the key component in film farming system. These are polymeric substance that expands as they absorb water, and can retain a substantial amount of water within their structure without dissolving in water. It consists of monomer linked with crosslinkers. Hydrogels contain hydrophilic groups that allow them to absorb water and the cross links in hydrogel prevent them from dissolving in water. Hydrogel consist of polymers linked through crosslinks, widely used polymers includes sodium or potassium salt of acrylic acid. Hydrogels can be classified based on source,

Natural hydrogel – made from natural polymers, polysaccharides, proteins, etc.

Synthetic hydrogels – petrochemical origin, produced from acrylic monomers

Hydrogels are becoming increasingly popular in the field of agriculture due to their versatile applications, such as serving as water-absorbing materials, soil conditioners, fertilizer-releasing agents, and seed coatings. Hydrogels have the ability to retain water and fertilizer for extended periods and release them gradually to plants, and this property depends on chemical composition. When hydrated, hydrogel forms an amorphous gel-like mass. As the surrounding

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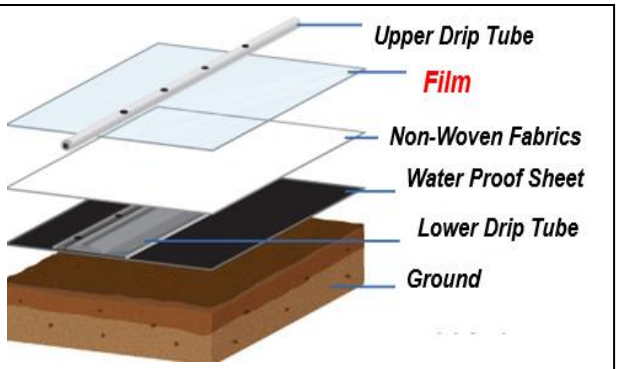
soil around the root zone of plants begins to dry up, the hydrogel releases water and nutrients due to osmotic pressure difference. This creates a reservoir of water near the root zone, which helps in plant growth and development. The ability of hydrogels to retain water and release it gradually to plants can improve irrigation and water use efficiency, as it reduces the frequency of watering needed and minimizes water loss due to evaporation or leaching. In addition, it improves the texture, aeration and microbial activity of the soil.



Structure of IMEC system

Table 1: Hydrogels from natural and synthetic sources

natural polymer hydrogels	Synthetic polymers Hydrogels
Cellulose based hydrogels	Poly(ethylene glycol) (PEG) and Poly(ethylene glycol) (PEG)
Dextran hydrogels	Poloxamer 188 and Poloxamer 407 Hydrogels
Alginate hydrogels	Poly (hydroxyethyl methacrylate) PHEMA Hydrogels
Chitosan based hydrogels	Polyacrylamide (PAAm) Hydrogels and its Derivatives
Hyaluronic acid hydrogels	Polyvinyl alcohol (PVA) Hydrogel

IMEC System

Film farming was developed by Mori Yuichi through his start up Mebiol based in Japan, established in 1995. After successfully developing cherry tomatoes using film farming in Japan, Mebiol is now conducting research on other crops and seeking to expand its venture worldwide. Recently, they have been granted many patents from different countries. Strawberry, cucumber, capsicum, and lettuce have been successfully cultivated through film farming practices.

The IMEC system utilizes combination of hydrogel and membrane Technology. The whole system consists of

i. Waterproof sheet: that is spread on the ground to prevent contamination
ii. Non-woven fabric: placed above the water proof sheet, to absorb the nutrient medium
iii. Hydro membrane: is placed above the non-woven fabric where the plants grow
iv. Drip irrigation tubes: there are two drip tubes positioned, one situated below the non-woven fabric and the other placed above the hydro membrane which supplies the nutrient medium to crops.

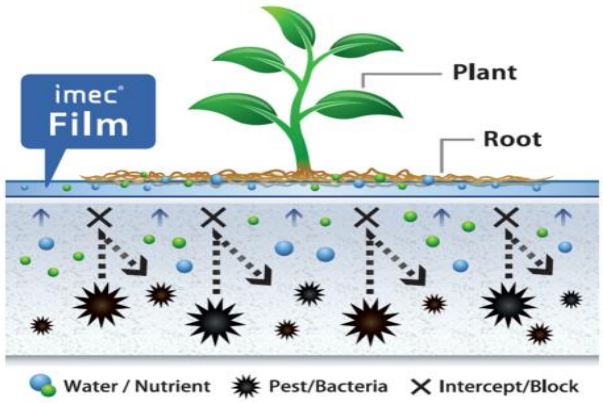
The nutrient solution is delivered through the drip irrigation tube from top and bottom of the hydrogel film, while nutrient solution from the bottom causes a water stress that encourages the emergence of fine roots that sticks to the film's surface to absorb water efficiently. The hydro membrane receives water from the top to support the normal growth of plants. This system is highly efficient and requires fewer resources.

Production of high-quality crops

Water stress created in this system help to improve nutritional quality of crops. The hydrogel has limited ability to provide moisture to the plant when it absorbs water, and its surface remains dry. Therefore,

to obtain the necessary moisture, the plant increases its sugar and amino acid content, which attracts water through osmotic pressure. This causes water to move from lower concentration of solutes towards areas with a high concentration of solutes. This increases the nutrient content in plants.

Tomatoes cultivated through IMEC system



Mechanism of hydrogel film blocks viruses and microorganisms.

Disease Free Crops

The hydrogel film, (hydro membrane), is made up of minuscule pores that are on a nano scale. These pores allow for the passage of nutrients while simultaneously preventing the entry of viruses and other harmful microorganisms, which helps to maintain disease-free crops. Additionally, because the roots attach to the surface of the film, they can be more easily examined and diagnosed. Hydrogel membrane permits water & other nutrients and blocks viruses and other microorganisms.

Sustainability and future aspects of IMEC system

Considering the impact of climate changes, rising population, and the availability of resources, the IMEC system offers a significant advantage to the agriculture sector. It enables the production of high-quality crops with increased productivity, utilizing fewer resources. The system optimizes the use of nutrient solutions, resulting in a 90% reduction in nutrient solution waste. Additionally, this system can be implemented in any location, including deserts, arid, and barren lands.

The IMEC system has been successfully implemented in Japan, where tomatoes grown using this method have gained popularity among consumers. This system has the potential to transform barren lands and other unused areas where traditional agriculture is not feasible into productive agricultural areas. Furthermore, the IMEC system has been tested successfully in the Dubai deserts. Based on data from 2013, it was reported that the IMEC system had applied for patents in 127 countries and was registered in 40 countries. According to recent reports given by India today several countries, including Singapore, China, Dubai, and Europe, have adopted film farming technology for cultivating fruits and vegetables. Mebiol, holds patents for this technology in 116 countries across the world. Therefore, owing to its notable achievements, film farming technology is currently being implemented in other countries, and there are future plans for expanding its usage even further.

Considering the emerging water crisis both globally and in India, innovative technologies such as hydro membrane will play a crucial role in the coming years. It is projected that by 2030, 40% of the Indian

population may lack access to water, making food production more challenging and impacting the livelihoods of many. According to surveys conducted by economic experts, India is projected to face severe water insecurity by 2050. In this context, the use of hydro-membrane in agriculture can help conserve water resources, improve crop productivity, and ensure food security for a growing population.

This system is boon to agricultural sector where water and land resources are limited to feed the rising population and to sustainably produce food for future generations. IMEC system is a great solution for addressing these challenges.

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