EDIOTERIAL | Egyptian Journal of Agricultural Research | Agriculture

Editorial: Farming film technology for sustainable agriculture

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Received:01-08-2022; **Accepted**: 04-08-2022; **Published:** 07-08-2022 DOI, 10.21608/ejar.2022.153816.1258

ABSTRACT
Agriculture is the primary driver of growth in most developing countries, providing rural residents with a huge number of job opportunities and supporting them in reaching their food and nutrition security. Film farming (FF) is a novel agricultural procedure developed in Japan enabling soil-less crop cultivation while cutting water use dramatically. Water efficiency and food safety can both be improved by incorporating FF into vertical farming systems. To make up for the additional costs of film farming, this method relies on the potential for increased output and crop quality. Polymer-based controlled-release fertilizer nano-formulations are being developed to improve fertilizer use efficiency and reduce losses due to leaching, runoff, and volatilization. These fertilizer formulations ensure that nutrients are released at a very slow pace over a lengthy period of time, preventing nutrient losses and ensuring optimal nutrient availability in the rhizosphere. This editorial discusses the advantages of the film farming for water conservation and nutrient release, as well as their importance in increasing production and quality. More research into the intersection of nanomaterials, soil-less farming, and microgreen gardening will assist to improve food supply sustainability.
Keywords: Hydrogel, sustainable agriculture, hydro-membrane, hydrophobic film coated fertilizer

INTRODUCTION
Global population growth is expected to reach 8.9 billion people by 2050, according to the United Nations. To feed the expanding global population, food output must rise by more than 70% by 2050. According to the United Nations Food and Agriculture Organization (FAO), agriculture accounts for more than 70 percent of the world's water use (Dubois, 2011). Water resource managers will also be unable to disregard declining water supply, rising input costs, and growing environmental concerns in the future. Population growth puts constrain on agricultural land and food production, as well as contributes to global warming and resource depletion. To address all of these issues, food production per unit area must be maximized, as efficient and pollution-free as possible. To feed an ever-growing population. Soil-less farming using hydroponics is becoming more popular around the world, and these systems provide growers and consumers with numerous new chances to produce high-quality crops boosted with bioactive compounds by substituting traditional farming.

In traditional farming, the soil is employed as a medium to give a necessary nutrient to the crops via the root. Crop production without the use of soil is the literal definition of soil-less farming. The three most frequent methods of soil-less farming of aerated nutrient solutions are hydroponic, aquaponic, and aeroponic (Maluin *et al.,* 2021). Another type of soil-less farming is crop cultivation which uses porous substrate culture as a growing medium rather than natural soil. Aerated soil-less farming is said to produce larger yields and higher-quality crops than traditional farming. This is because to the controlled micro-environment of soil-less farming, which includes different variables (Lakhiar *et al.,* 2018).

Film farming (FF), developed by the Japanese physicist Yuichi Mori since 1995, is one of these urban agriculture solutions. Mori employs a transparent polymer screen constructed of permeable hydrogel, which is a very absorbent substance. The holes in the film are nanosized enough to stop viruses and bacteria without the use of harsh chemicals. Film farming, like hydroponics, is a soil-less growing technology. To cultivate plants, it combines hydrogel and membrane technologies to form a "hydromembrane" (Mori, 2013). In traditional agriculture, the hydro-membrane replaces the soil, removing the inherent variability and dangers (Mori, 2013).

To address the consequences of water scarcity on crop farming and to regulate fertilizer use, physical crosslinked superabsorbent hydrogels based on various blends were produced (Garduque *et al.,* 2020). The use of

There are a number of advantages to using biodegradable hydrogels (BHGs) in agriculture, including the reforestation of degraded land, soil enrichment, reduced irrigation water use and lower plant or crop death rates, enhanced soil retention, and increased plant growth rate (Ahmed *et al.,* 2021). The biodegradable hydrogels' value in water/wastewater treatment has also been proved, including in applications like water preservation, purification, and administration (Fig. 1). BHG formulations could also be used for the safe management of agrochemicals, reducing their harmful effects and facilitating their transport to the field. When combined with paper as a second layer, biodegradable slow-release fertilizer (SRF) hydrogels have the potential to significantly improve agricultural and horticultural production through improved nitrogen utilization and water conservation, reducing the amount of urea fertilizer and water required for irrigation (Kareem *et al.,* 2021). Different water-smart technologies can assure efficient fertilizer and agricultural water use to maximize yield (Patle *et al.,* 2020). The minuscule pores in the polymer membrane also inhibit germs and viruses, removing the need for toxic pesticides. Film farming allows us to grow fruits and vegetables without the use of soil, pesticides, or other toxic chemicals, while also using 90% less water than traditional farming. An overview of the Japanese approaches to plant growth using water-soluble polymers and hydrogels is provided here, with the goal of providing an optimal water absorption rate, progressive release of nutrients, and nutrient-rich environment.

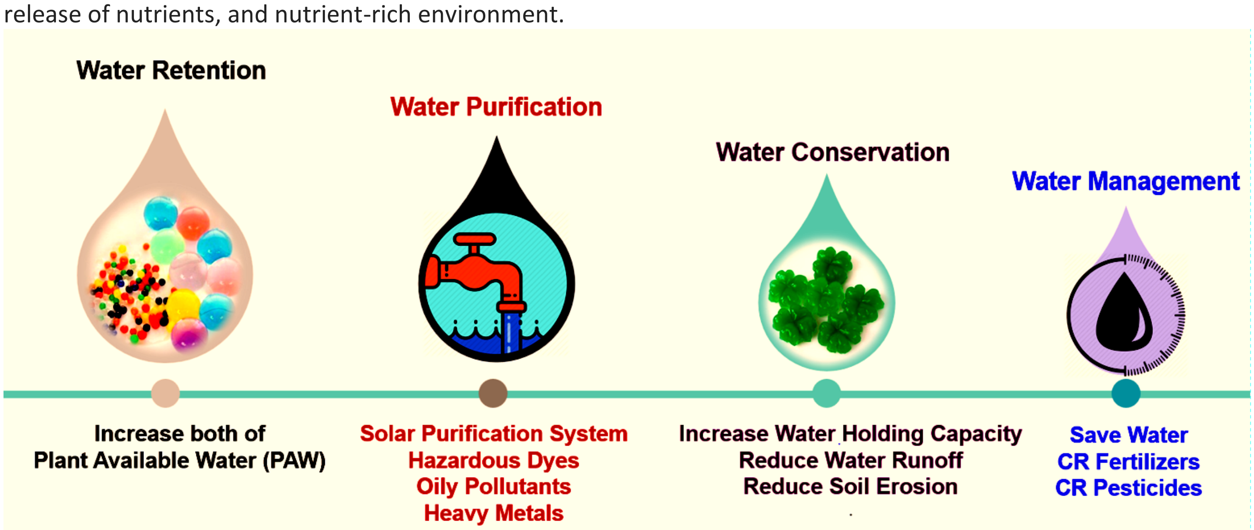

Fig. Biodegradable hydrogels are often used to promote water retention, conserve water in sandy soil, and purify wastewater, in addition to water management measures in agriculture (reprinted from Ahmed et al., 2021).

What is Film farming (FF)?

Film farming is a technique for producing plants on hydrogel films. The hydrogel is a three-dimensional polymer that comes in the form of a thin layer of film with a width of 60 cm and a thickness of 0.06 mm that can contain a lot of water in its intermolecular gaps (Batista *et al.,* 2019). A drip irrigation system and a greenhouse layout are used in this strategy. The drip system is positioned above and below the hydro-membrane to evenly provide nutrients and water to plants above the membrane. A regulating mechanism in the system measures the amount of water spread through the tubes (Mori, 2015; Zhang *et al.,* 2021), to pass through the minute pores of the hydrogel and reach the drip system beneath the film, plant roots are stated to become extremely thin. The plants can absorb high-quality nutrients because they absorb water at high pressure (Zhang *et al.,* 2021). It takes relatively little soil, water, fertilizer, or energy to grow films. Crop yields are excellent, and the crops are packed in nutrients. A vast range of crops can be grown with this method, even in deserts and concrete (Mori, 2013). If you're a small farmer and don't have access to a greenhouse, you can't utilize this method because it is time-consuming, labor- and cost-intensive, and uneconomical (Sardare and Admane, 2013).

CONCLUSION

Soil-less farming with film farming is a sustainable and environmentally safe technique as it decreases water use, pesticide use, fertilizer waste and leaching, and water contamination, all of which have been major concerns in recent years. Farming films may not seem relevant right now, but they could have a lot of potential in the future. The addition of nanoparticles to the soil-free substrate could increase its growth properties. Agricultural production in the future must be properly planned so that not just for water saving, but also for other vital input resources like labour, and pesticides, to be well managed for a sustainable agriculture

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