

## New Agro-Technology (Intelligent Membrane Culture, Imec)

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Received: 12 Aug 2024

Accepted: 26 Sep 2024

Published: 30 Sep 2024

J Short Name: JCMI

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**Citation:**

Mori Y. New Agro-Technology (Intelligent Membrane Culture, Imec). J Clin Med Img. 2024; V8(3): 1-12

**1. Abstract:** Agriculture is an environmental control technology for plants. Although the environmental conditions of the aerial part of plants such as temperature, light intensity, humidity and administration of agricultural chemicals can be easily controlled by the greenhouse technology, the environmental control technology of the underground part of plants hasn't been developed. This is because the soil which is a central player in the underground part,

has the unknown

### 2. Background

We have developed a new agro-technology (Intelligent Membrane Culture, Imec) using a functional Hydrogel Membrane ("Hydro-membrane") which plays the roles of soil (Figure 1).

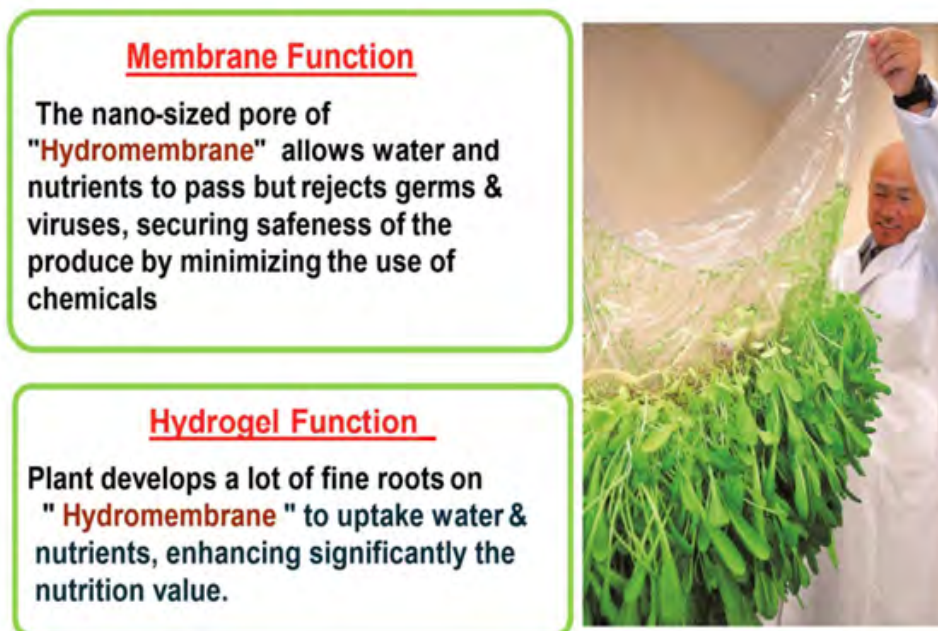


Figure 1: The Functions of "Hydromembrane" in Imec.

### 3. The Principle of Imec

“Hydromembrane” has been used in the environmental (e.g. de-salination), the energy (e.g. battery separator) and the medical (e.g. hemodialysis) fields, but none have applied the technologies in agriculture field. We have developed a new plant cultivation technology (Intelligent Membrane Culture, Imec) by using “Hydromembrane” which is developed by combination of membrane and hydrogel technologies.

### 4. The Cultivation Principle by Imec

As shown in Fig.2, Imec is a technology which cultivates plants to supply the culture medium through “Hydromembrane”. “Hydromembrane” plays the following roles;

1) “Hydromembrane” is composed of Hydrogel which absorbs only water and nutrients such as various ions, amino acids and sugar but excludes viruses and microbes. Therefore, even if the culture medium is contaminated or decayed, the plants are not diseased. “Hydromembrane” minimizes use of chemicals and also eliminates the need of circulation and sterilization of the culture medium in current hydroponics, leading to significant reduction in the facilities and the running costs.

2) The hydrogel function of “Hydromembrane” absorbs the culture medium from non-woven fabric wetted with the culture medium but releases none culture medium to the plant side. The plant side surface of “Hydromembrane” is completely dry. This is very useful and important property of hydrogel in this

system. So, the plant generates a lot of fine roots which closely adhere onto “Hydromembrane” in order to aggressively suck the culture medium in “Hydromembrane” as shown in Fig.1. However, since it is still insufficient, the plant synthesizes a large quantity of sugar and amino acids to raise the intracellular osmotic pressure. As a result, the culture medium is transferred from “Hydromembrane” to the plant by osmolality gap, leading to high nutrition by water stress. The traditional method of the acceleration of the sugar synthesis has been to raise ionic strength of the culture medium by 10 to 20 times. The method significantly reduces the productivity in high-salinity environment. Imec achieves high quality of products without reduction in the

productivity, using the pure water stress caused by hydrogel instead of conventional ionic stress, which is totally innovative technology.

3) “Hydromembrane” plays a role of soil in Imec. Soil is most difficult substance to define, control, etc. So, soil has been the biggest hurdle for farming. “Hydro-membrane” which is an industrial product, is definable, controllable and reproducible. So, anyone can be a skilled farmer anywhere, anytime. In addition, the production cost is overwhelmingly reduced by the production volume.

Furthermore, the used “Hydromembrane” is safely incinerated and also recycled by dissolving used one in hot water.

### 5. Imec System

Imec system is shown in Figure 2. The waterproof sheet, through which nothing can pass is spread on the ground, and the lower drip tube is put on it. Then the non-woven fabric which absorbs the culture medium supplied from the lower drip tube and let it widespread, is set on it. Then “Hydromembrane” is set on it, and the upper drip tube is put on “Hydromembrane”. The system is composed of “Hydromembrane”, waterproof sheet, drip tubes, non-woven fabrics, and “Hydromembrane” should be changed after each culture cycle but the other parts can be used again. Imec system shows the following functions;

1) The plant is cultured by supplying culture medium from both sides of “Hydromembrane” by using the upper and lower drip tubes. The culture medium from the back side of “Hydromembrane” raises the quality such as high nutrition and safety by the water stress as mentioned above. However, the growth of the plants becomes slow since it is hard to absorb the culture medium in “Hydromembrane”. Therefore, the culture medium is supplied directly onto the top of “Hydromembrane” to promote the growth. The coexistence of the growth (high productivity) and the high nourishment (high quality) has been difficult by the conventional farming technique. Imec enables the coexistence by using both of the bound water in “Hydromembrane” which improves the quality and the free water supplied directly onto the top of “Hydromembrane” which improves the productivity.

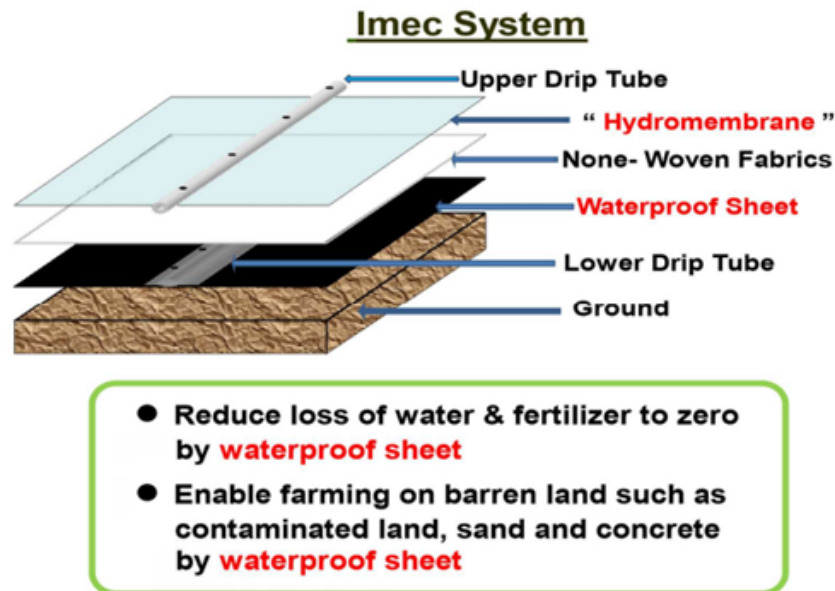
2) At the soil culture, a large quantity of soil, fertilizer and water is necessary since the plant roots deeply in soil. In Imec, the plant can be cultivated with extremely little soil, fertilizer and water, since a large amount of fine root sticks onto “Hydromembrane” surface in the state of a thin sheet. Therefore, the agricultural resources can be significantly reduced.

3) In Imec, the culture medium supplied to the both sides of “Hydromembrane” is totally consumed by the plant and the waterproof sheet fully blocks the dissipation of the supplied culture medium to the outside,

leading to up to 90 % saving of culture medium and alleviation of environmental burden.

4) The waterproof sheet totally blocks the migration of hazardous stuffs such as harmful microbes & viruses, residual chemicals, salt in soil to plants, leading to less need of chemicals and stable production of safe produces.

5) The waterproof sheet enables farming at the places where the current farming is impossible, such as desert, concrete, contaminated places, etc.



**Figure 2:** The Construction of Imec System.

## 6. Current Domestic State of Imec

Within 3 years since the start of spreading, the total area of Imec facilities amounted to over 100,000m<sup>2</sup>, the numbers of facilities are over 60 and the numbers of delivery shops of Imec tomato are over 25 in Japan. Imec has widely spread sooner than expected by the following reasons.

1) In Japan, many young farmers leave farming, since the farming business stays in low profitability. As the result, the percentage of famers older than 65 years amounted to over 50 %. As mentioned above, even inexperienced young people can acquire Imec technology within one year, because “Hydromembrane” of an industrial product eliminates difficulties related to soil.

2) In these several years, the consumer consciousness of food safe-

ty and nutrition has become stronger. Imec tomato gets very high evaluation from consumers.

3) Japanese Government accelerates export of Japanese infrastructure technology like agro-technology. In 2009, seven “Plant Factory using Imec” Projects received subsidies from Ministry of Agriculture of Japan. The total area amounted to over 21,000m<sup>2</sup>. One of projects is shown in Figure 3.

4) Lately, so many companies such as general constructions, ship building and railroad companies and even securities corporations, have entered farming business due to the business stagnation. The companies are apt to adopt more industrialized farming like Imec, compared to the conventional farming.



**Figure 3:** One of Imec Tomato Farms in Japan.

## 7. Future of Imec

As mentioned above, Imec converts any place where current farming is impossible (concrete, sand, polluted land, a barren, etc.) to farm land by separating crops from the earth by the waterproof sheet. As shown in Figure 4, we tested to produce tomato at Dubai by Imec. The productivity and the quality were superior to those

of Japan by strong sunlight, long daytime and consecutive fine weather. Imec could change the barren desert to the production base of farm products. Using Imec patents that have been applied in 127 countries and already registered in over 80 countries, we will deploy Imec all over the world. In Japan, we started to recover the farmland contaminated with sludge of tsunami in Great East Japan Earthquake.



**Figure 4:** Imec Tomato Farm in UAE.