MEAPLANT MISSION EASY AGRICULTURE

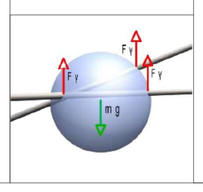
A REVOLUTIONARY CULTIVATION SYSTEM - Inventors: Dr. Caterina ALLERA - Dr. Enrico MASELLA (Sanremo - Italy)

Patented in the World: USA, CHINA, AUSTRALIA, INDIA, EUROPE…

An extraordinary intuition of Dr. Caterina ALLERA, Biologist and Dr Enrico MASELLA, Engineer, from Sanremo (Italy), who revolutionized the idea of substrate, no longer a material that absorbs water and mineral salts, imitating the soil, but a new material that adopts a different strategy, like water drops on a spiderweb after the rain. This Bio-inspiration has given rise to a substrate that no longer concentrates the salts, but retains them dissolved in the drops of water. Water and salts are fully available to the roots, which absorb them without doing any work, which is instead necessary for absorbent substrates. When the drop, not absorbed by the plant, reaches such a weight that it falls off, it ends up in the recovery container, this avoids the danger of overwatering and consequent root asphyxia. In addition, the absence of micropores, present instead in the absorbent substrates, also prevents the formation of fungi and bacteria inside them. The drops are available depending on the plant's water needs and this allows different types of plants together which have different water and nutritional needs, to grow all together with the same irrigation cycle and the same type of nutrition. This uniqueness makes it possible to cultivate not only a wide variety of horticultural or ornamental plants, but also fruit plants in a small space. From the idea to the creation of a substrate consisting of a structure of hydrophobic and chemically inert threads that intersect with each other skillfully retain the right number of drops of water and mineral salts sufficient to make the plants grow luxuriantly. A three-dimensional structure designed to make the plants take root in the best possible way for its lightness, softness and empty spaces rich in oxygen, which has been conceived to be a cultivation ideal soil. The inventors called this new cultivation system MEAPLANT.

BIOINSPIRATION

PHYSICS OF MICROFLUIDICS



DROPLETS CAUGHT IN THREADS's MESH OF THE NEW MEAPLANT SUBSTRATE

MEAPLANT's PROTOTYPES

SOILLESS CULTIVATION OFFERS IMPORTANT ADVANTAGES COMPARED TO SOIL CULTIVATION

- Higher quality productions; water savings of up to 90% in a closed-loop system; elimination of the use of pesticides; use much smaller spaces with more production,vertical cultivation.

IN SHORT THE DIFFERENT SOILLESS CULTIVATION TECHNOLOGIES

The best soilless cultivation technique is in substrate (perlite, pumice or pumice stone, zeolite, rock wool, coconut coir, etc.), because it allows to cultivate most plants. This technique can be used in an open circuit in which the nutrient solution is dispersed in the soil with consequent environmental damage and in a closed circuit in which the nutrient solution is recirculated, less used because it is very complex to manage.

Hydroponics
Roots are immersed directly in the nutrient solution.

Aeroponics
The nutrient solution is sprayed cyclically on the naked roots.

Aquaponics
It is a food production system that couples aquaculture with hydroponics.

- The problem is that all these cultivation systems are complex to use and with high manufacturing and management costs.

MEAPLANT MAKES EASY SOILLESS CULTIVATION FOR EVERYONE EVERYWHERE
COMPARISON WITH CURRENT SYSTEMS

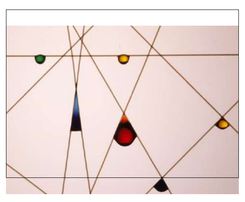
- MEAPLANT is an universal cultivation closed loop system, in which it is possible to grow all the plants usually grown in different systems of soilless cultivation and additional plants that are not usually grown in soilless: vines, citrus fruits, apples, currants, already tested in our system.
- MEAPLANT allows the cultivation also in open air because the plants are rooted as in the natural soil and there is no risk of root asphyxiation in the event of heavy rain: usable on balconies, terraces, roofs, green walls, urban outdoor spaces and in the countryside.
- In the current soiless cultivation systems the roots are rooted weakly or not rooted because the roots grow inside perlite, pumice, zeolite, rock wool, coconut coir, etc. which are inconsistent materials, or grow in water (Hydroponics), or in air (Aeroponics).In these systems plants can not withstand the elements and are usually used only in protected environments, as inside the greenhouses or inside buildings equipped with artificial lighting systems (vertical farming).This means high costs of these cultivation systems.
- MEAPLANT hasn't risks of asphyxia of the roots.The substrate never becomes saturated with water because the water is drained and always leaves empty spaces rich in oxygen. The absence of micropores, present instead in current substrates, also prevents the formation of fungi and bacteria; futhermore this substrate is bacteriostatic and doesn't need of special disinfections.
- In hydroponics the roots are in water not respecting the physiology of the plants which are therefore weaker and subject to fungi and bacteria. Complex disinfection and oxygenation management systems of the recirculating water and nutrient solution are required. It is possible to cultivate only plants which have a short cultivation cycle such as: salads, spinach, basil, parsley, strawberries. In AEROPONICS the roots are in the air and do not respect the physiology of the plant which is therefore weaker and subject to fungi and bacteria. This system is very vulnerable as with the roots in the air, it is enough for just one irrigation cycle to fail to lose the entire crop.
- MEAPLANT growing medium does not absorb salinity. The nutrient solution supplied by the irrigation system is the same as that present at the roots because the solution is not modified by the salts previously absorbed by the substrate.Therefore it is not necessary to carry out continuous checks on the supplied and drained solution. The substrate does not have to be washed and an exhausted solution is not generated which should be poured into the environment . It only needs to add water and mineral salts based on the consumption of the cultivated plants.
- In closed loop systems with the current substrates, which absorb salinity, it is necessary to wash the substrate to increase the duration of the recirculating solution with a frequency that can reach once a week. If the substrate is not washed, the frequency of replacement of the nutrient solution, with its spillage into the environment, can reach once every 4 days. Due to these frequent washings of the substrate the plants are subject to stress due to sudden changes in salinity. It is very complex to calculate the concentration of mineral salts at the roots because the solution provided is altered by the salinity present in the substrate.For this reason, continuous checks on the salinity of the supplied and drained solution are necessary.
- Irrigation management in MEAPLANT is easy, no need to measure the drainage quantity. The water droplets provided by the irrigation system remain suspended on the substrate's threads mesh. When the suspended droplets increase their mass, they come off the threads by gravity and fall into the tank to be ricirculeted. The risk of over-irrigation is completely eliminated. There are no risks of root asphyxiation because the substrate is always well oxygenated as it never becomes saturated with water. Therefore it does not require particular skills in choosing the duration and frequency of irrigation. For example, you can increase the frequency of irrigation during the hottest hours of the day without the risk of overwatering or increasing the salinity in the substrate.
- MEAPLANT allows the simultaneous cultivation of plants with different water needs, watermelons can be grown together with succulents with the same irrigation cycle.
- In current soilless cultivation systems, in substrate, hydrponics and aeroponics, it is possible to simultaneously grow only one species of plant which must be grown with a specific nutrient solution and a specific irrigation cycle.
- In MEAPLANT cultivation substrate all the droplets are available for the roots, the water potential is equal to 0. The roots do not have to do any work because there is no absorption force exerted by the medium as instead happens in current substrates.
- MEAPLANT's substrate minimizes water loss due to evaporation using the same strategy as the cactus. The speed of absorption of water drops by the roots is greater than evaporation due to the hydrophobic-hydrophilic gradient that is established between the substrate and the roots.(Kiwoong Kim et al (2017). Hydraulic Strategy of Cactus .... Frontiers in Plant Science vol.8.
- MEAPLANT's cultivation substrate is made of recyclable materials or biomaterials for food use.
- Current cultivation substrate, for e.g. perlite, pumice, zeolite, rock wool, coconut coir, etc., are not recyclable and for some, particular attention must be paid in use and disposal.

PHYSICS OF MICROFLUIDICS IN MEAPLANT INNOVATION

Scientific Studies referring to the physical phenomena on which the functioning of MEAPLANT's substrate is based

Droplets on bent fibers - authors: Weyer, Floriane, (GRASP, University of Liege);Pan, Zhao (Splash Lab, Utah State University); Pitt, William (Brigham Young University); Truscott Tadd (Splash Lab, Utah State University); Vandewalle, Nicolas (GRASP, University of Liege) Publication: APS (American Physical Society) March Meeting 2017, abstract id. L12.011

ABSTRACT:
Droplets on fibers are part of our everyday lives. Many phenomena involve drops and fibers such as the formation of dew droplets on a spiderweb, the trapping of water droplets on cactus spines or the motion of droplets on wetted moss hairs. These topics have been widely studied. In particular, Lorenceau et al. determined the critical volume of a water droplet hanging on a horizontal fiber. Here, we address a similar question : we try to find out the maximum droplet size on bent fibers, which are able to hold significantly more water than horizontal fibers. Indeed, we noticed that, in nature, some specific plants can hold large rain droplets thanks to their Y-shaped leaves. We try to mimic these structures with nylon fibers, of different diameters, bent with various angles. For each set-up, the critical water volume is determined. Finally, we propose models of the physics involved in determining droplet size that could be implemented in future fiber-based microfluidic devices.



Capturing drops with a thin fiber - Authors: Élise Lorenceau et al - du Laboratoire de Physique de la Matière Condensée, UMR 7125 du CNRS. Publication: Elsevier Journal of Colloid and Interface Science 279 (2004 192-197)

ABSTRACT
We study experimentally the dynamics of drops impacting horizontal fibers and characterize the ability of these objects to capture the drops. We first show that a drop larger than a critical radius cannot be trapped by a fiber whatever its velocity. We determine this critical size as a function of the fiber radius. Then we show that for smaller drops, different situations can occur: at a low impact velocity, the drop is entirely captured by the fiber, whereas some liquid is ejected when arriving faster. We quantify the threshold velocity of capture.

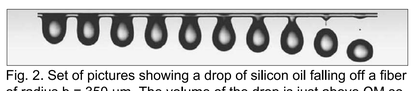
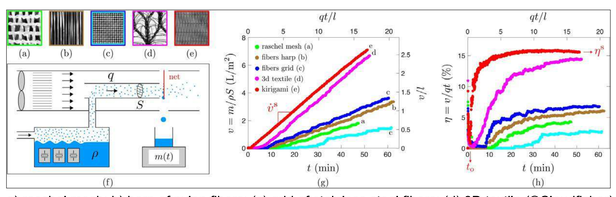


Fig. 2. Set of pictures showing a drop of silicon oil falling off a fiber of radius b = 350 µm. The volume of the drop is just above ΩM,so that gravity dominatesthe capillary force: the drop falls (interval between two successive pictures: 1 ms).

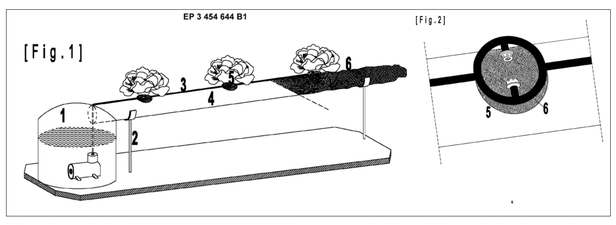
Bintein, PB., Cornu, A., Weyer, F. et al. Kirigami fog nets: how strips improve water collection. npj Clean Water 6, 54 (2023). Published on NATURE 20 July 2023

ABSTRACT
As scarcity of water is expected to intensify with global warming, unconventional water sources such as advective fogs may become essential. In numerous arid regions, nets are used to harvest such water droplets. However, many current fog nets are either not durable or expensive, and have poor performances for short time or low intensity fog events.With a dedicated test bench, we show here that a low-cost net with kirigami design offers a higher and faster fog collecting ability than the usual fibers nets. This kirigami fog net consists of a continuous network of strips where water quickly forms a stable film, accounting for its superior capture efficiency. We rationalize this mechanism with a simplified structure composed of disconnected strips whose optimization paves the way to the shaping of original fog nets such as the kirigami one.



a) raschel mesh; b) harp of nylon fibers; (c) grid of stainless steel fibers; (d) 3D textile (®Cloudfisher) made of polypropylene; (e) kirigami fog net

- MEAPLANT is made up of a three-dimensional network of threads in which they are crossed with each other forming countless angles between them which allow a greater number of droplets of solution to be retained and larger in size to give the substrate water retention capacity (physical principle illustrated in the study by Weyer, Floriane et al). The substrate is placed horizontally with respect to the sprinklers, favoring the collection; the speed, at which the droplets fall from the sprinklers, is low because they are placed very close to the substrate. When the droplets increase in size they detach by gravity and the risk of overwatering the substrate is eliminated (physical principles illustrated in the study by Élise Lorenceau et al). The materials used are hydrophobic or weakly hydrophobic to prevent the threads from soaking in and allow the droplets to detach (physical principles illustrated in the study by Pierre-Brice Bintein et al.)



Drawings of the MEAPLANT PATENT - representation of the substrate made up of a 3D network of threads crossing each other.

MEAPLANT is the only system that allows you to cultivate a real vegetable garden for everyone, everywhere, due to its simplicity of use: it is only necessary to periodically add water and mineral salts into the tank and turn on the irrigation timer, without any particular checks and wait for the plant growth. An effortless and autonomous vegetable garden ! MEAPLANT can also be an important solution for growing in arid and dry areas due to its significant water savings.

WHO IS MEA PLANT FOR ? Private individuals - Architects (green walls and roofs) - Professionals in the sector (greenhouses-vertical framing) - NGOs

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