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A CLOSED SYSTEM FOR SOILLESS CULTURE ADAPTED TO THE CYPRUS CONDITIONS

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ABSTRACT – The application of a soilless culture system using artificial substrates would result in efficient and effective use of water and fertilizers and in minimizing the use of chemicals for pest and disease control, especially after the prohibition in using Methyl Bromide for soil sterilization. This technology requires extended skills and knowledge from the growers therefore the open soilless system is mainly applied due to its lower initial cost and relative simplicity, compared to the closed one. The open system can under circumstances lead to the pollution of the underground water reserves. ARI started therefore a research program to develop a closed soilless system using local inert substrates, adapted to the local conditions of Cyprus. Such a system would minimize the loss of water and fertilizers from the system as well as minimize the running cost and the pollution of the environment.

Key words: soilless culture, artificial substrates, closed systems

INTRODUCTION

Protected cultivation in Cyprus is continuously expanding. Its acreage measures today approximately 280 ha for multispan greenhouses and another 280 ha for low tunnels. The main greenhouse crops are tomato, cucumber, sweet pepper green beans and eggplant, as well as flowers (roses, gerbera, etc). The scarcity of water together with the high cost associated with collecting and using the limited surface rainwater for irrigation, have become real constrains for our irrigated agriculture. Because of this, particular emphasis is placed on the water use efficiency and the intensive cultivations (cultivation of crops with high return per square meter and volume of water) (Chimonidou, 2000 and 2002).

The demand for increased production and better yield quality, the lack of good quality water for irrigation and the need for protection and conservation of the environment require the implementation of new technologies in greenhouse cultivation. In this respect, the first measures to be taken are the improvement of greenhouse structures and the automation of the systems. Moreover, modern techniques have to be applied such as cultivation on artificial substrates, hydroponic cultures, re-circulation of irrigation water and nutrient solution in closed systems and control of the climatic conditions in the greenhouse (temperature, air humidity, CO_2, etc). Apart from higher production of good quality (10%-25% yield increase in vegetables and up to 30% in flowers), such technology would result in efficient and effective use of water and fertilizers and in minimizing the use of chemicals for pest and disease control, especially after the prohibition in using Methyl Bromide for soil sterilization. Moreover, some cultural practices like soil cultivation and weed control are avoided, and land not suitable for soil cultivation can be used.

The first soilless culture in Cyprus started with rose cultivation on rock wool in 1996 at the area of Monagrouli (Limassol) with 2 decares and expanded in 4 decares in 1997 with a fully automated computerized open system. Since then, the cultivation of roses on substrates has rapidly expanded. The application of soilless culture in vegetables (tomatoes, cucumber, lettuce, strawberries) came later due to the low and unpredictable market prices of the products.

The cultivation of roses and other cut flowers (i.e. lysianthus, gerbera, greenery) on soilless culture using local substrates (i.e. mixtures of perlite and pomace, pine bark, straw and almond shells) has been tested at the ARI. The aim was to compare different substrates (imported and local), irrigated with the same quantity of water but with different frequency according to the holding capacity of each substrate with minimum drainage (2-5%). The productivity and quality characteristics (stem length, fresh weight, flower bud diameter and height) have been recorded. Results showed that the local substrates pine park 50% and almond shells 50% as well perlite 50% and pomace 50%, were very promising for the cultivation with the minimum drainage (Chimonidou, 2001).

The total area cultivated today in Cyprus using soilless techniques is about 116 decares. A break down of this area is given in Table 1. This area is expected to increase rapidly in the near future due to the grants schemes announced by the Ministry of Agriculture as a measure to improve the quality of the agricultural products as a result of Cyprus joining the European Community.

Table 1. Soilless cultivation in Cyprus, 2003

	Area of Soilless Culture in Cyprus [da] 1 da = 1000 m^2		
Substrate	Flowers (roses & gerbera)	Vegetables	Total
Perlite	3	2	5
Coco Peat	38	16	54
Rock wool	7	50	57
Total			116

Beside the lot of advantages that soilless culture has, there are some disadvantages that restrict the application of the method in Cyprus until now:

- High initial installation cost.
- High skill requirements on growers.
- Sensitive system with no buffering capacity of nutrients – No error tolerance.
- High water quality requirements.Risk for environmental pollution if not properly managed.Because of these reasons the growers are reserved to the method and the application of soilless culture is not yet expanded in Cyprus.

The open system for soilless culture, Fig. 1, is at present most favored commercially in Cyprus due to its simplicity, mainly in managing the nutrient solution.

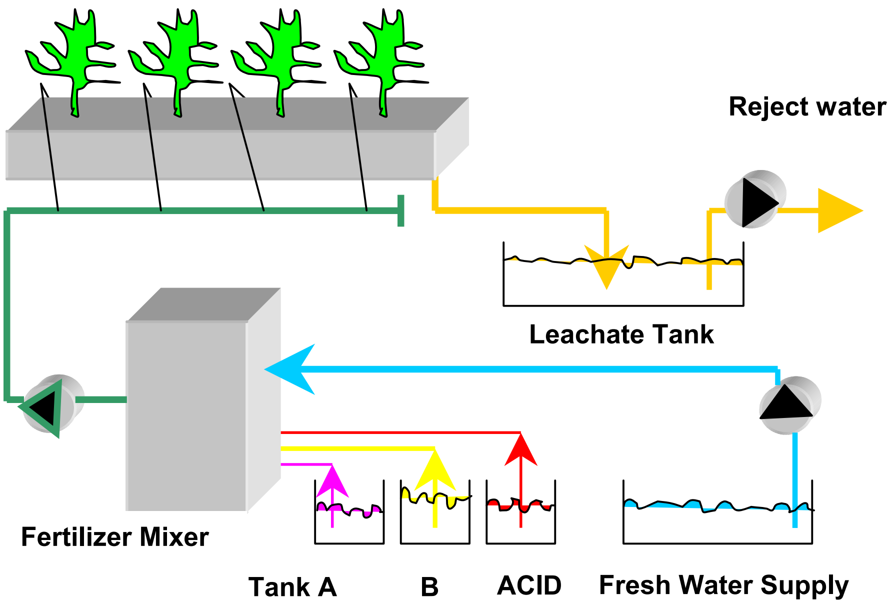

Figure1. Schematic diagram of an open hydroponics system applied commercially in Cyprus

Pollution of the environment (underground water), waste of fertilizers and water are though only some of the problems faced in open hydroponic systems. The leachate is usually collected in a reservoir and is used for the fertigation of open cultures or greenhouse cultivations in the soil. This results in approximately 30% loss of fertilizers and water from the system.

MATERIALS AND METHODS

For the above reasons, ARI started a research program in order to develop a locally adopted closed hydroponics system (Fig. 2), using locally available inert substrates, like crashed gravel produced in a copper mine in Cyprus (Victor, 1973).

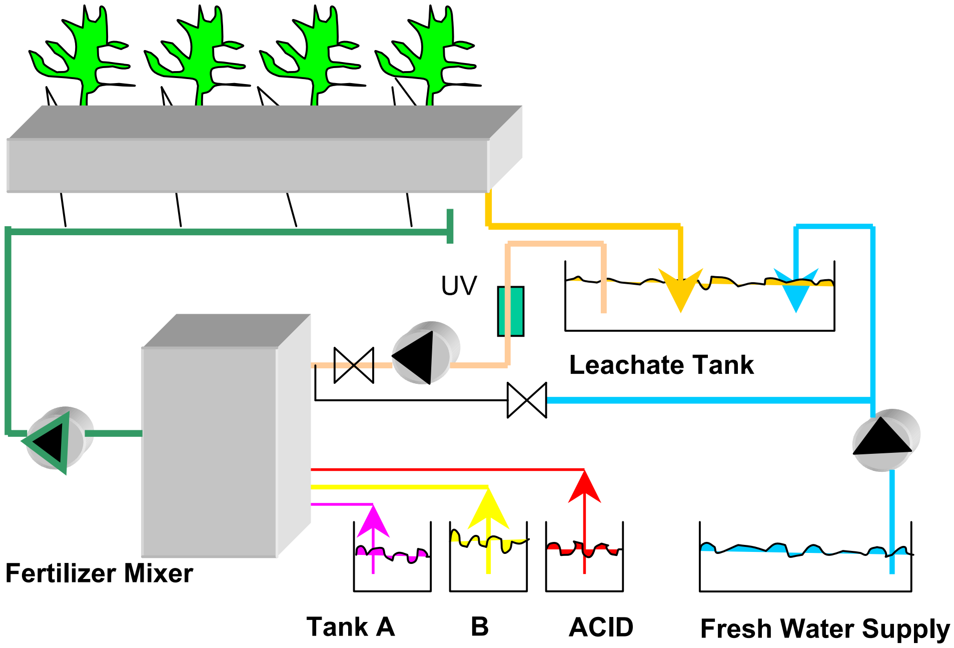

Figure 2. Schematic diagram of a closed recirculating hydroponics system applied at the ARI in Cyprus

The following soilless mixtures are compared in performance: 70% Perlite + 30% Expanded clay, 70% Gravel + 20% Perlite + 10% Expanded clay, 100% rock wool. The leachate from the substrates is collected in a tank and is recirculated after being sterilized passing through a UV lamp (Ehret *et al*., 2001; Os *et al*., 2001; Sutton *et al*., 2000; Zhang and Tu, 2000). The EC and pH of the water are regulated using an automatic fertilizer-mixing unit as by the open system.

The water consumption of a good managed closed system is reduced to the evapotranspiration level of the plants. The experiments are carried out at the ARI research station at Zygi on tomato cultivation in a modern greenhouse of 600 m^2 ground area. The climatic conditions during the day are adjusted by natural ventilation using automatic side and roof ventilation openings or at higher temperatures by the use of a fan and pad cooling system, whilst during the night by the operation of an automatic humidity control system.

RESULTS AND DISCUSSION

In designing and operating such a closed hydroponic system the following main parameters are to be considered:

- Crop related matters such as the life span of the crop, the water and nutrient requirements (recipe), and the cultural practices needed.Method for fertilizer mixing and supply of irrigation water (using simple volumetric fertilizer injectors or automatic fertilizer mixing units).
- Use of locally available inert substrates like perlite, coarse sand, crashed gravel vs. imported inert materials like rock wool.

- Climate control in greenhouses, like monitoring the aerial climate requirements (temperature, relative humidity, light, CO_2, etc), the root zone requirements (root temperature and O_2 supply in the root zone) and improving the PAR transmission of covering materials and lowering their NIR transmission.

The system requires water of very good quality that is difficult to find in Cyprus. At the coastal areas where greenhouse cultivation has developed due to the favorable climatic conditions, the ground water salinity ranges from 1.5 to 4 dS/m, whilst the salinity of water coming from dams is around 1 dS/m. The fresh water supplied to the closed system can be therefore rainwater collected from the greenhouses or water treated by a small reverse osmosis unit. Thus the need for replacing the nutrient solution due to the increasing concentration of chlorides and sodium is minimized (Bar *et al*., 2001).

Due to the advantages of the closed hydroponic system compared to the open one (CastAnon and Branas, 2002), ARI is investing a lot of effort in optimizing its parameters, simplifying its operation and planning the appropriate training the growers in its effective management and utilization.

On going research at the ARI concerns the following subjects:
1. Substrate selection (imported vs. local materials).
2. Water saving techniques.
3. Irrigation control (moisture sensors, time-based control, solar radiation control, etc).
4. Integrated control of root and aerial environmental conditions.
5. Soil less culture under saline conditions.
6. Train the growers in applying modern greenhouse management techniques (application of new technology, fertilization recipes, etc).

It is important that a suitable closed system is developed that is based on low cost local materials, which are both effective and easily disposable after use in order to avoid environmental pollution. The system should be easily adaptable to the growers according to their potential skills. The technology used should be locally supported in order to avoid long-term maintenance problems.

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