Outdoor Soilless Culture of Vegetables: Status and Prospects

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ABSTRACT. The paper reviews some ecological aspects and use of outdoor soilless culture for vegetable production in various countries. A soilless technique based on Plant Plane Hydroponic (PPH) is recommended. Presented results of experiments show that yield and quality of vegetable and condiment plants (tomato, cucumber, squash, crisp and butterhead lettuce, endive, leaf parsley, dill and sweet basil) grown in PPH are superior to those grown in conventional soil culture. *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-342-9678. E-mail address: getinfo@haworthpressinc.com]*

KEYWORDS. Soilless culture, Plant Plane Hydroponic (PPH), soil culture, open air, vegetables, condiment plants, yields

INTRODUCTION

An increasing interest in using soilless culture for the production of vegetables in the open field has developed in recent years. This inter-

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est is stimulated by water deficiency, water pollution, and by environmental regulations, which in some areas restrict or prohibit the use of fertilizers or pesticides. The paper discusses various aspects and features of this new technique and presents the obtained results of experiments.

THE PAST AND THE PRESENT STATE OF SOILLESS CULTURE IN THE OPEN AIR

Soilless culture in open air dates back to the early 1940's, when the Gericke's concept of hydroponic plant production was used for large scale vegetable production on the rocky Pacific Islands, with the aim of supplying the US Navy troops, engaged in the second World War. This technique was later introduced to Japan where hydroponic farms by 1946 were producing large quantities of fresh vegetables (Resh, 1989; Anonymous, 1990; Ito, 1994). In the following years hydroponics expanded to various countries throughout the world and was used initially on small scale, until the eighties, when a fast expansion of this growing technique occurred. In most cases it moved into greenhouses and plastic tunnels. Sometimes however, for example on the Canary Islands, hundreds of hectares of hydroponic tomatoes are simply covered with plastic roofs, supported on posts. These multispan constructions, without walls, allow for necessary ventilation and they protect from heavy rains. Some open air soilless complexes are located in Mexico and in the Near East countries (Resh, 1989).

According to Glazer (1994) the area of open field soilless vegetables grown in South Africa is approximately 100 acres. This author also states that the system is ideally suited for lead salad crops, such as spinach, swiss chard, lettuce, celery, and water cress, as well as for tomatoes, peppers, baby cabbage and spring onions. As reported by Maree (1996) in South Africa, lettuce, celery and spinach are grown in hydroponics under simple cover of mini-cloches or shade nets. In Australia there are over 100 hectares of outdoor hydroponic systems, mainly growing lettuce (Donnman, 1997). According to Nichols (1995) a nutrient film technique (NFT) hydroponic system is used in New Zealand for some lettuce produced in the open field. The area grown amounts to about 2 hectares and the system is mainly used for growing oak leaf and colored lettuces.

In Taiwan, hydroponic gravel culture is used for daylily production

(Sheen, 1995). The flowers of daylily are consumed as a vegetable there. There are certainly many small hydroponics units existing outdoors in several countries. Many others are likely to appear with widening of the ecological consciousness and extension of simple soilless techniques.

ENVIRONMENT PROTECTION AND WATER ECONOMY STIMULATE NEW INTEREST IN SOILLESS CULTURE IN OPEN AIR

The commonly accepted need for protecting the natural environment through reduced use of agricultural chemicals and also the search for high quality, healthful vegetables, aroused the interest in development of a soilless culture for the production of vegetables in the open air.

Another important factor that increases the interest in open field soilless culture is the need for water protection in areas of intensive agriculture. In recent years several countries increased the protection of their water resources. Germany, for example, extended widely the water protection zones in which the use of fertilizers, plant protection chemicals, herbicides and irrigation is severely restricted (Vogel et al. 1991). In order to comply with the new legislation, farms located within the water protection zones must change their technology and production programs, which reduces income from about 2000 to 10000 DM per hectare (Uhte, 1990).

For fulfilling the ecological requirements, the open field soilless culture must be based on a closed system and a satisfactory water tightness, preventing leaching of nutrient solution and reducing soil and water pollution.

A SYSTEM BASED ON PLANT PLANE HYDROPONIC-SUITABLE FOR OPEN FIELD VEGETABLES

In experiments with soilless culture of vegetables in open field, carried out in 1991-1993 in Grossbeeren, a system based on Plant Plane Hydroponics was tested (Schrder and Broneske, 1990; Broneske and Schrder, 1990; Vogel et al. 1991; Vogel and Floegel, 1993). A modified PPH system with recirculation and sterilization of the nutri-

ent solution was used in work with open field soilless culture conducted since 1994 in Skierniewice (Rumpel et al. 1996; 1997). The general layout of the system is shown in Figure 1 and Figure 2. Its base features are as follows: *Beds for growing the crop*. Parallel beds are made on smooth ground surface, having a slope of 1% along and across. Single beds 1.8 m wide and 12 m long were made by using 3 plastic linings. The first lining of a black polyethelene film is laid down directly on the ground and protects it from the contact with the nutrient solution. The second lining, lying on the first one, is a fleece (non-woven polyester), which serves as a solution holding and rooting medium. On the fleece layer, drip irrigation hoses are placed along the beds. Their role is to provide uniform saturation of the fleece with nutrient solution. The third lining, coming on top, is black and white PE film, in which cuttings are made at distances of required plant spacing. Transplants, produced in mineral wool cubes, are placed through the cuttings on the fleece, where they will grow till harvest (Figure 2).

FIGURE 1. Outline of the experiment site with open field soilless culture of tomatoes.

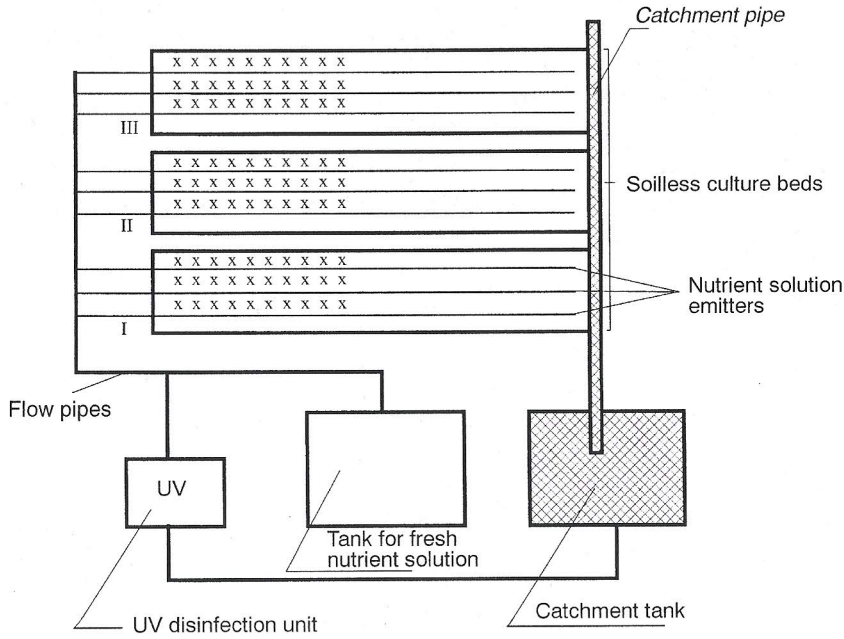
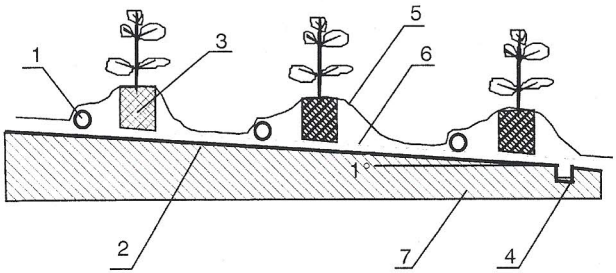


FIGURE 2. Outline of a cross section of soilless culture bed



1. Nutrient solution emitter
2. Polyester film
3. Plants in mineral wool cubes
4. Catchment pipe
5. PE film
6. Non-woven polyester
7. Ground

2 nutrient solution tanks. One tank is for the primary, fresh solution and the other one is for the catchment (returning) solution. The tanks are equipped with circulating electric pumps that deliver the solution through flow pipes to the beds. The pumps work intermittently by means of an automatic timer. Depending on plant growth stage and season, the pumps are programmed to provide 4 to 8 irrigations per day.

Flow pipes. These pipes conduct the nutrient solution to the beds and next through the perforated emitters over the bed surface.

Catchment (return) pipes. For collecting the overflow nutrient solution and conducting it gravitationally, into the catchment tank.

An UV disinfection unit. For disinfection of the nutrient solution, recirculating from the catchment tank.

RESULTS OF EXPERIMENTS WITH VARIOUS VEGETABLES GROWN IN OPEN FIELD PPH CULTURE

In experiments carried out since 1991, various vegetable species and often also their cultivars, were grown in soilless PPH culture in the open air, and in most cases were compared with the traditional soil culture. Some of the results are presented below.

Tomato. In Grossbeeren and Skierniewice yields from soilless culture surpassed considerably these from the conventional soil culture. Average marketable yield of tomato fruits for the soilless and the soil culture in Grossbeeren was 13.4 kg/m^2 and 8.6 kg/m^2, respectively. Yield of these cultures obtained in Skierniewice was 10.4 kg/m^2 and 6.0 kg/m^2, respectively. Tomato plants grown in soilless culture showed greater earliness, higher fruit quality and lower susceptibility to diseases as compared with those in soil culture (Vogel and Floegel, 1993a; Rumpel et al. 1996).

Cucumber. Pickling cucumber grown in Plant Plane Hydroponic produced yield of 8.6 kg/m^2 with 96% share of marketable quality. Fifty percent of the harvested fruits were in the small, pickling size, up to 9 cm long. This yield surpasses that obtainable in traditional soil culture (Vogel and Floegel, 1991).

Squash. Summer squash grown in PPH gave a yield of 3.3 kg/m^2 as compared to yield of 1.8 kg/m^2 from the soil culture. Since fruits were harvested only in the young growth stage (7-14 cm long), the results obtained in soilless culture were considered as very good (Vogel, 1995).

Bean. Climbing bean grown in Plant Plane Hydroponic, harvested 12 times, gave a marketable yield of 4.45 kg/m^2. This yield was similar to that obtained in soil culture (4.14 kg/m^2), and both cultures shoved similar plant behavior (Vogel, 1995).

Leaf vegetables. Leafy or salad vegetables such as iceberg lettuce, butterhead lettuce, and endive grown in soilless PPH culture gave earlier and higher yields as compared with those from soil culture. (Vogel and Floegel, 1991; Vogel and Floegel, 1992).

Condiment plants. Yields of fresh plant parts used for bunching of sweet basil, dill and leaf parsley were in soilless culture (PPH) always higher than in soil culture. Yield increases amounted to 141% for sweet basil, 78% for dill and 94% for leaf parsley (Vogel and Floegel, 1993b).

CONCLUSIONS

1. Outdoor soilless culture can be applied successfully for growing of a wide range of crops.
2. The Plant Plane Hydroponic system of soilless culture seemed to be very suitable for outdoor growing of fruit and leaf vegetables

(tomato, cucumber, squash, lettuce and endive) and condimental plants (sweet basil, dill and leaf parsley).

3. Growth, yield and quality of plants grown in soilless culture are usually better compared with those from the conventional soil culture.

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