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A Suspended Pot, Non-Circulating Hydroponic Method

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Abstract

The suspended pot non-circulating hydroponic method only requires an initial application of non-circulating nutrient solution which must be of sufficient quantity to supply the entire cropping period. Electricity and pumps are not needed. Tanks are filled nearly to the top with 8 cm or more (depending upon the tank depth) of an appropriate nutrient solution for the crop to be grown. Tapered plastic containers (ideally, net pots or forestry tubes with additional apertures in their sidewalls) holding seedlings in growing medium are transplanted such that they are supported by the tank cover. The lower 2 cm or greater of the containers are immersed in nutrient solution, thus automatically watering and fertilizing the plants by capillary action. When the nutrient solution level in the tank drops below the containers, new roots will have emerged from the containers. The lower portion of these roots is immersed in nutrient solution while the upper portion resides in the moist air layer between the cover and the nutrient solution. Raising the nutrient solution level by rainfall or additions above 2 cm after this point may cause plant injury. Plant growth continues until less than 10 percent of the original nutrient solution remains when the crop is terminated and a new crop is initiated. Methods for growing cucumbers (*Cucumis sativus* L.), lettuce *(Lactuca sativa* L.*)* and tomatoes *(Lycopersicon esculentum Mill.)* are described. This methodology has been granted 2 U.S. Patents and users include hobbyists, educational institutions (no weekend watering is required!), researchers and commercial growers.

INTRODUCTION

The suspended pot, non-circulating hydroponic method is a unique and powerful technique for growing vegetables because the entire crop can be grown with only an initial application of water and nutrients. This system is extremely efficient with water use. The additional production costs and complexities associated with aeration and circulation including the need for electrical power and pumps in many conventional hydroponic systems are totally avoided by this method.

The basic concepts of non-circulating hydroponic systems (Kratky, 1996b) include: 1.) The upper part of the root system should be exposed to air with high relative humidity; 2.) Roots must not be allowed to dry out; 3.) The lower portion of the root system should gather water and nutrients; 4.) Nutrient solution level may remain the same or be lowered, but it may not be raised or else the roots will 'drown'.

In the suspended pot, non-circulating hydroponic system, plants grow in a small amount of substrate held by a perforated container which is supported by a fixed cover over a tank (Fig. 1). The lower portion of the container is originally immersed in nutrient solution. The young plant is then automatically watered by capillary wetting of the substrate. The nutrient solution level drops below the container as the plants grow. At this point, direct capillary wetting of the substrate is no longer possible, but the newly emerging roots are quite capable of absorbing the nutrient solution. These concepts are the subjects of U.S. Patents 5,385,589 and 5,533,299 (Kratky, 1995, 1996a).

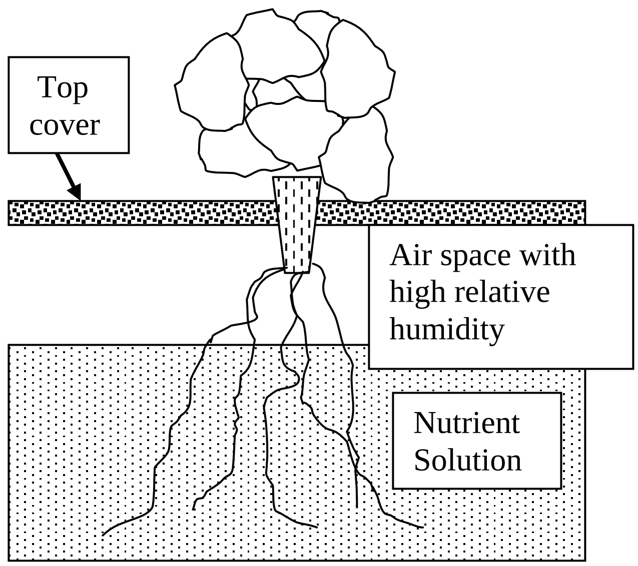

Fig. 1. A model suspended pot, non-circulating hydroponic system after the nutrient solution has dropped below the seedling container..

4-Liter bottle method

The simplest version of this method is a 4 liter plastic juice bottle containing water plus 5 grams of Chem-Gro 10-8-22 hydroponic fertilizer (Fig. 2, Kratky, 2002). The bottle should either be covered or darkened to discourage algae growth. A 7.5-cm long net pot (a tapered plastic pot with slits to allow root emergence) is filled with growing medium and lettuce is seeded or transplanted. Alternatively, a tapered forestry tube with additional holes drilled in the sides may be used. The net pot is supported by the neck of the bottle. The lower 3 cm of the net pot is immersed in the nutrient solution and the entire medium in the net pot becomes moistened by capillary action. Thus, the young plant is automatically watered.

As the plant grows, the nutrient solution drops below the net pot so that it may no longer be directly moistened by the nutrient solution. However, the lower portion of the newly developing active root system absorbs the necessary water and nutrients for the plant. Meanwhile, roots in the moist air space above the nutrient solution morphologically change by becoming thicker and more branched so that they may absorb more oxygen.

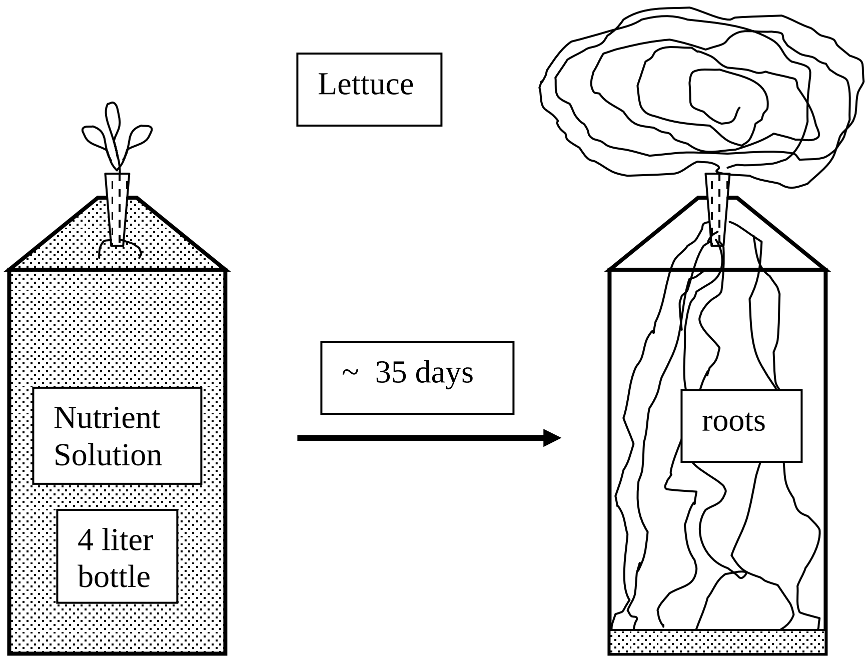

Fig. 2. Lettuce growing in a 4-liter plastic juice bottle.

The plant grows to maturity (usually about 6 weeks from seeding) and the nutrient solution level typically drops 15-25 cm below the original level because no additional nutrient solution is added to the bottle. The increasing zone of moist air between the nutrient solution and the net pot does not hinder plant growth. Lettuce experiences its normal logarithmic growth pattern with very rapid growth near maturity. In Hilo, Hawaii, a 200 gram lettuce plant typically only consumes about 3-4 liters of EC 1.5 mS nutrient solution. The lettuce is of gourmet quality.

The 4 liter bottle method is only suitable for short-term crops like lettuce which require less than 4 liters of water for their lifespan. It is possible to grow longer term crops like cucumbers and tomatoes which require huge amounts of water in a 4 liter bottle by allowing the nutrient level to drop about 20 cm and then maintain that level with a float valve or by adding nutrient solution to maintain a level in about a 3 cm range, but this is cumbersome and defeats the simplicity feature of this method. An alteration of this method is to grow 3 or 4 plants in a 20 liter plastic bucket.

Gardeners can use this method to grow plants on lanais, porches and under the overhangs of buildings. Educators may use this inexpensive method to teach students about plant growing concepts. The bottles can be prepared in one class period and require no additional maintenance so there is no need to worry about weekend watering. Researchers and farmers may use this method to conduct nutritional studies, test pesticides and produce seed.

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Growing lettuce in commercial-sized tanks

This concept may be expanded to commercial-sized tanks (Fig. 3). In its simplest configuration, a tank is constructed by nailing 3.8 x 8.9 cm dimension lumber to a 1.9 cm thick plywood sheet (1.2 x 2.4 m) and lined with 2 layers of 0.15 mm-thick black polyethylene sheeting (Kratky, 1993). Other embodiments of this concept include using 3.8 x 14 cm lumber, varying the width from 0.8 to 2 m wide, increasing the length up to 10 m, and replacing the plywood bottom with recycled corrugated roof iron. The tank is supported on concrete blocks or a lumber support and leveled. Tanks are covered with 2.5 cm thick expanded polystyrene bead board (0.032 g/cc density), but extruded polystyrene boards, plywood sheets or supported plastic covers may also be used. The expanded polystyrene bead boards are supported by the sides of the tanks. Soft plastic pots may be placed on the floor of the tank to provide additional support if needed. Holes are cut into the top cover with a hole saw. Plant spacing for leafy and semi-head lettuce is typically 20 x 30 cm.

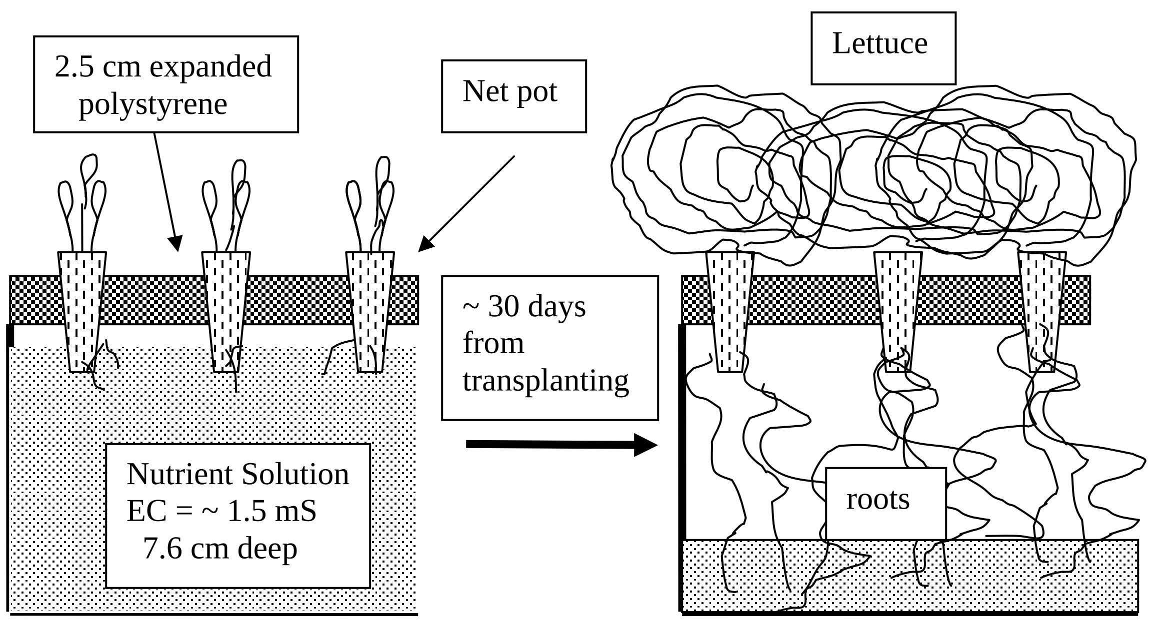

Fig. 3. Growing lettuce in a commercial-sized tank.

Usually water is added to the tank with a hose and nutrient stock solutions are added to the desired concentration. The tank is nearly filled with nutrient solution prior to transplanting. For example, the grower adds about 8 cm of nutrient solution (EC = 1.5-2.5 mS) to a 9 cm high tank. One to 2 week-old lettuce (or other short-term crops such as kai-choy or herbs) are transplanted into net pots which are then transplanted and supported by the tank cover. Tapered 5 cm x 5 cm or 3.8 cm diameter x 7.6 cm deep net pots are commonly used. Typical growing substrates include peat:perlite:vermiculite mixtures and oasis blocks.

The plants are grown in screened, plastic-covered rainshelters or greenhouses. No additional watering or fertilization is needed for the crop. Leafy or semi-head lettuce is ready for harvest in about 5 weeks from transplanting depending upon the season and cultivar. The grower typically plants one crop and harvests a previous crop every week and always has multiple stages of lettuce growth in the rainshelter(s) so it is possible to continuously supply a market.

Lettuce is harvested with a knife or scissors. The net pots are removed and cleaned. Some growers do not empty the remaining nutrient solution; additional solution is added to fill the tank. Other growers, drain the tanks after each crop. It is possible to complete several crops without draining the tanks. Growers often harvest and replant a tank within 24 hours so there is little downtime for the tanks.

A suspended pot method for tomatoes

Tomatoes typically require 25 to 40 liters of water to produce one kg of fruit. A large tank is needed to support this high water requirement (Fig. 4). The expense associated with constructing these tanks limits this *fill it and forget it* method to an academic curiosity except in special situations.

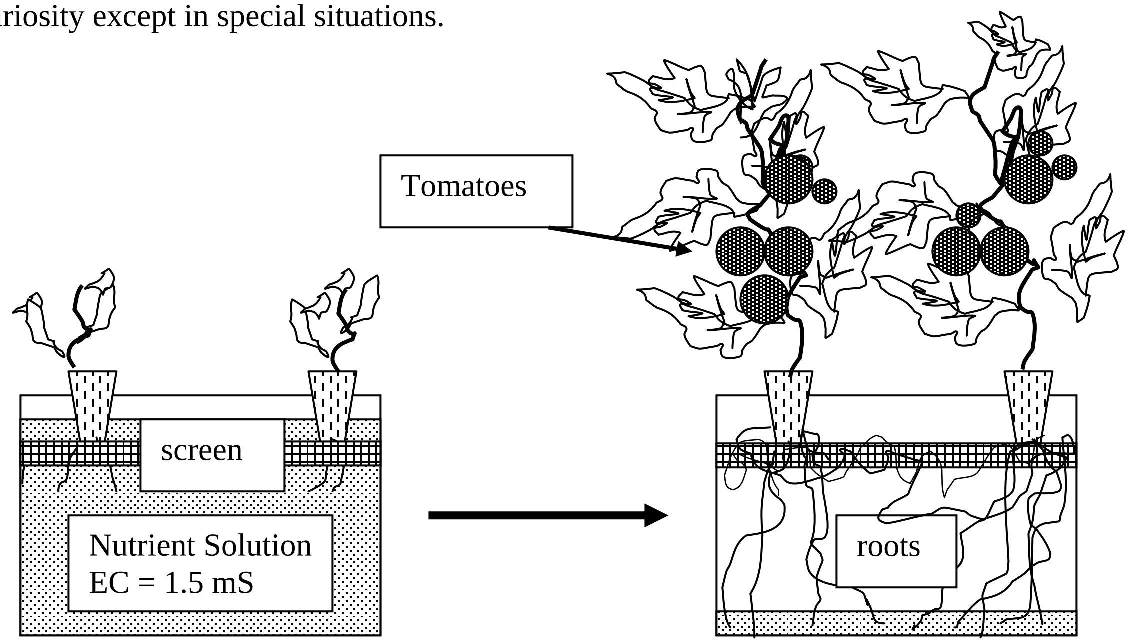

Fig. 4. A suspended pot method for growing tomatoes.

A 0.6 m wide x 3.6 m long x 0.4 m high tank was constructed and filled with 757 liters of nutrient solution with an EC of 1.5 mS. Twelve tomato plants were transplanted into 3.8 cm x 7.6 cm long net pots and these were transplanted into the top cover of the tank. The crop was harvested until the nutrient solution ran out. A total salable yield of 24.79 kg was harvested to give a water use ratio of 30.5 liters of nutrient solution per kg of fruit. A commercial version of this system would require a tank which was several magnitudes larger. Placing a screen 10 cm below the top cover encouraged development of fine roots and also served as anchor point for the to better support the plant (Kratky et *al*. 1988).

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Plastic trash container method for growing cucumbers

Cucumbers may be grown in a large plastic trash container (100-130 liters) by a simple non-circulating hydroponic method that does not require electricity or a pump (Fig. 5). Alternatively, 208 liter metal barrels with plastic liners may be used (Kratky et al. , 2000). The plastic trash containers may be used in outside areas because cucumbers tolerate rain fairly well and the sloping sides of the trash container lid prevent most of the rain from entering the container. The grower fills the container with water to within 2 cm from the top and adds hydroponic fertilizer to achieve an EC of 2.0 to 2.5 mS. No additional water and fertilizer are needed because the crop is normally terminated when most of the nutrient solution is consumed.

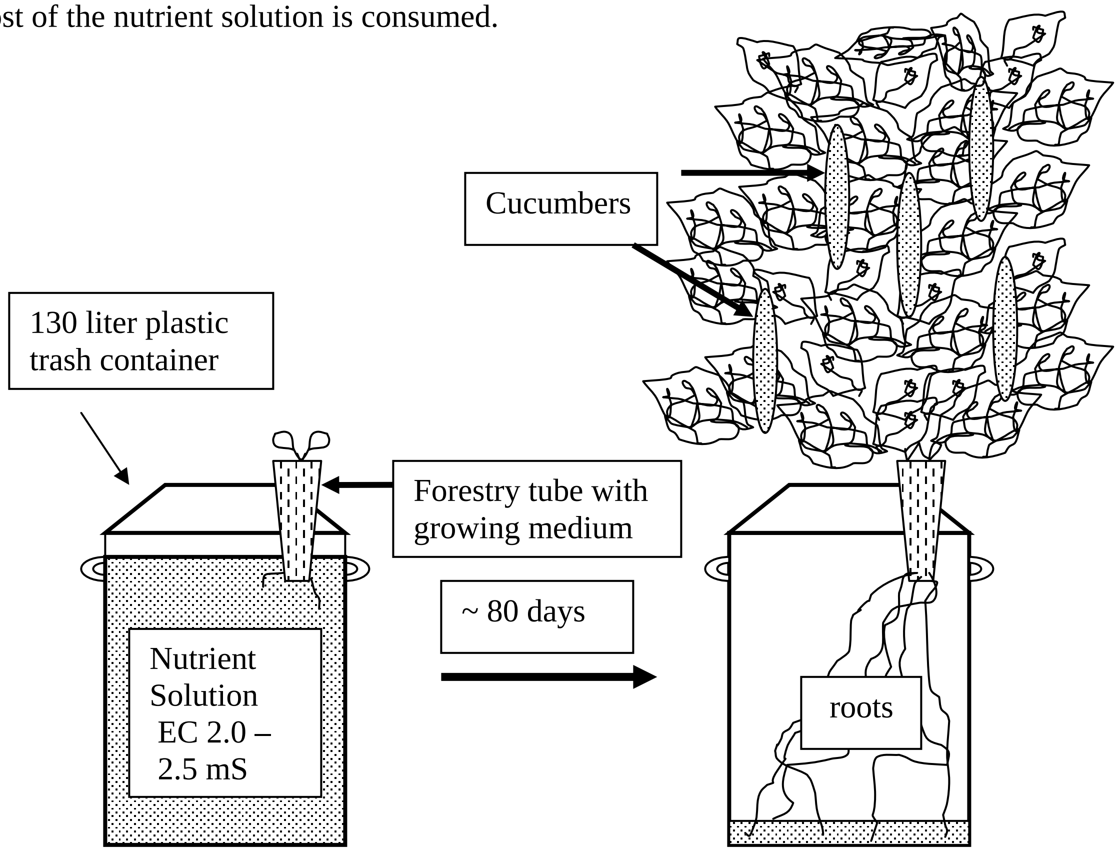

Fig. 5. The suspended pot method for growing cucumbers in a plastic trash container.

Tapered plastic forestry tubes (3.8 cm diameter x 21 cm long) are utilized as growing containers. Forestry tubes typically only have holes at the bottom of the tubes so we drill 6 or more holes (5 mm diameter) in the sides of the forestry tube to allow the roots to emerge from both the bottom and the sides of the forestry tube. The forestry tube is filled with moist growing medium and tapped to help settle the growing medium, but it is important not to pack the growing medium too tightly. One cucumber seed is planted in each tube.

A 3.8 cm diameter hole is cut into the trash container lid with a hole saw about 8 cm from the edge and the forestry tube is placed into the lid. Only one forestry tube is needed for each trash container. The forestry tube should fit snugly in the trash container lid. This will help to prevent mosquitoes from entering the trash container which could then become a breeding ground for mosquitoes. The lower 2 to 8 cm of the forestry tube should be immersed in the nutrient solution. A small amount of growing medium may fall into the nutrient solution. The growing medium becomes moistened by capillary action. If the growing medium remains dry, slowly add a small amount of water to the growing medium in the forestry tube.

After the roots have emerged from the forestry tube, the lid should not be lifted from the container or else the roots may be damaged. The nutrient solution level will recede as the plant grows. Adding more water or fertilizer to the trash container may cause injury to the plant since raising the nutrient solution level in a non-circulating hydroponic tank typically causes damage to the plant. Plants prefer that the nutrient solution level remains the same or lowers as the plants grow. Eventually the nutrient solution level will drop such that less than 10 percent of the original solution remains. The crop is usually terminated shortly thereafter. In the case of a 208-liter barrel, the nutrient solution level at the end of the cropping period was more than 70 cm below the bottom of the seedling container and no mechanical assistance was needed to nourish the plants. Yields exceeding 7 kg/120-liter container were obtained in cool growing conditions, but half of that yield would be a more normal expectation.

Weed control may be accomplished by placing a weed control mat on the soil under the trash containers. A permanent trellis system may be established since there is no need to dismantle the trellis system to till soil beds. This hydroponic technique is ideal for elementary and high school projects, because the materials are inexpensive and readily available and weekend watering is not necessary.

Other considerations

Mosquitoes can breed in non-circulating nutrient solution and become both a health menace and a nuisance to workers. They can be controlled by *Bacillus thuringiensis subspecies israelensis* toxins (Furutani and Arita-Tsutsumi, 2001) pesticides or by salt-tolerant fish.

Good water quality is required for this method, because salts will concentrate as the nutrient solution is consumed. For example, water with an initial EC of 0.2 mS from salt contaminants will concentrate to 2.0 mS when only 10 per cent of the original nutrient solution remains. We have been able to complete the cropping cycles for these methods without altering pH, with our commercially available hydroponic fertilizers.

CONCLUSIONS

An entire crop can be grown with only an initial application of water and nutrients with the suspended pot, non-circulating hydroponic method. Electricity and pumps are not needed. Tanks are filled nearly to the top with 8 cm or more (depending upon the tank depth) of an appropriate nutrient solution for the crop to be grown. A cover is placed over the tank. Tapered plastic containers (ideally, net pots or forestry tubes with additional apertures in their sidewalls) holding seedlings in growing medium are transplanted such that they are supported by the cover. The lower 2 cm or greater of the containers are immersed in nutrient solution. The entire growing medium in the containers becomes wet by capillary action, thus automatically watering and fertilizing the plants. The nutrient solution level in the tank drops below the containers within a few weeks such that direct capillary wetting of the growing medium is no longer possible. However, by this time, roots have emerged from the containers and their lower portion is immersed in nutrient solution while the upper portion of the roots resides in the moist air layer between the cover and the nutrient solution. The crop is terminated when less than 10 per cent of the original nutrient solution remains. The most elementary technique involves filling a 4-liter plastic juice bottle with water, adding fertilizer and planting in a net pot. No additional watering or fertilization is required for the duration of the crop. Lettuce may be produced commercially utilizing the same concept in shallow (9-14 cm high) of nutrient solution covered with a polystyrene bead board. Cucumbers and tomatoes may be produced in a similar manner except they require a large nutrient solution tank. A plastic trash container serves as a nutrient solution tank for cucumbers. Current users of this methodology include hobbyists, educational institutions (no weekend watering is required!), researchers and commercial growers.

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