The Super Nutrient Film Technique (NFT) System

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HISTORY AND PURPOSE

The nutrient film technique (NFT) system was first tried out in 1941 in Shanghai, China, in a nursery called The Chemical Garden. This system was in operation until 1944, when it closed down because of the war. Its inventor stated that there were nutrient problems and that NFT was uneconomical. In 1956 the technique was again used in Sweden by a chemical firm but abandoned 2 years later because of nutrient solution problems. In 1964 BV Hydro Systems developed a system in Denmark for orchids and in the 1970s a large number of experiments were conducted. However, no really important developments occurred before 1972, when Alan Cooper in England conducted the first commercial experiments with NFT. Since then, a large number of people in different countries have attempted to use NFT with a varying degrees of success. The original NFT system developed in England is—as the name implies—a thin nutrient film running down a gully or trough. The system is based on the capillary effect (hygroscopic conductance) of the root mat and, in principle, the plants are placed on a level surface with a longitudinal slope. This layout is covered to minimize evaporation, to eliminate the build up of excess heat which will damage root development, to exclude light from the roots, and to avoid algae growth in the nutrient solution. In this covered trench, the nutrient solution is delivered at one end and drained off at the other end. Due to the slope of the underlying surface, gravity will cause the solution to flow the length of the trench. Steepness of the slope, roughness of the surface, and gully width and length determine the speed with which the nutrient solution flows down the gully. The velocity of the nutrient solution in the gully should be greater that 10 cm/sec. The slope is generally 2.5%, the length of the gully not more than 4 to 5 m, and the width approximately 30 cm in order to assure that all root exudates are transported away from the root surface.

As the name NFT implies, the nutrient film is very thin and should not exceed 0.5 mm in order to allow the nutrient solution to flow underneath the root mat. If this is the case, capillary action of the root mat will transport the nutrient solution up through the root mat and be absorbed by the roots. At the same time oxygen will diffuse down between the single roots in the root mat to be absorbed by the roots. As the roots develop over time in a NFT system they form a very dense root mat. The increased root density reduces the oxygen diffusion coefficient because of the restricted movement of the nutrient solution in the root mat and resultant running of the nutrient solution on top of the roots. A NFT system, even if good in theory, gives practical problems in commercial installations because it requires very precise regulation of solution flow in the gully. The amount of solution will also have to be changed, as the plants grow and the volume of the root mat expands, in order to assure good oxygenation at all times. If a pot or substrate block is used, it will have to be elevated above the nutrient solution as soon as the roots have formed a mat; otherwise the roots under the pot or block will die and rot from

anaerobic conditions. In addition, the flow pattern down stream of the block or pot will cause oxygen deficiency if not elevated.

THE SUPER NFT TECHNOLOGY

The Super NFT system was developed in 1992 for a project in Ukraine. The main objective was to create a NFT system that eliminated the common problems (i.e., root death) observed with ordinary nutrient film systems.

The Super NFT system was designed as a bareroot hydroponic system with a solution level of 1 to 2 cm and a distributed nutrient-feed system. This combined with a special gully geometry creates a nutrient-solution distribution pattern which in gully lengths up to 12 m gives a near perfect oxygen distribution to the plant roots. At the same time, root exudate removal becomes more efficient. Drain-off can be at the end or middle of the gully.

The fan-shaped flow pattern of the liquid further removes the majority of the used solution so that fresh solution always is available to the root system. The special tracks in the bottom of the gully also make it possible to place a pot or a rockwool cube either between them or on top of them. During the first 2 to 3 weeks the plant is placed between the tracks directly on the bottom of the gully. After a thin root mat has developed, the plant container is lifted and placed on top of the tracks. This allows the solution to flow under the pot or block and eliminates oxygen deficiency and root exudates build-up.

In conventional NFT systems long and narrow gullies—often with intermittent watering—have given growers many problems and the system a bad name. This has discouraged many growers from using such bareroot systems. It must be remembered that the system originally was designed with a very thin nutrient film (0.5 to 1 mm). In such a design, oxygenation was good but the removal of root exudates poor—this configuration resulted in constant problems. Later the systems came with a raised level of nutrient solution (0.5 to 2 cm) which gave better removal of root exudates but poor oxygenation especially under the rockwool cubes or peatmoss pots. It must be remembered that there is a close relationship between gully length, gully width, solution depth, flow rate, and flow pattern. If these parameters are not optimized the system will not function properly.

The idea behind the Super NFT system was to create a system that would conform to the simple hydraulic requirements presented above, give optimal growing conditions for the plant in culture, and at the same time make it possible to use a SPF (specific pathogen free) hydro system to eliminate diseases.

To fully understand the Super NFT technology it is important to realize the two main problems a plant culture encounters in a hydroponic system. The first one is lack of oxygen—most of today's systems do not supply adequate oxygen to the plant roots. The second problem encountered in hydroponic systems is high levels of COD and TOC. It is known that up to 25% of the photosynthetic products can be lost through roots. This loss creates phytotoxic problems in the root mass when these organic substances decompose consuming available oxygen in the process and at the same time serving as food for bacteria and fungi. In order to counteract this problem it is necessary to remove these substances either by frequent changes of the nutrient solution or by passing it through a biological filter.

This requires, however, that the amount of liquid supplied to each gully has to correspond to the amount of oxygen it is able to transport—this is usually between

4 and 10 liters/hour/plant. The exact amount depends on temperature and oxygenation efficiency of the solution. The removal of root exudates also requires a distributed feed system and a special flow pattern of the nutrient solution. In addition, the flow is furthermore balanced so that the hydraulic pressure created by the slope of the gully corresponds to the friction exerted on the liquid in the gully. Plant containers have to be placed in front (up hill) of the nutrient solution emitters in order to give maximum flow in the primary track. The Super NFT system is a pure hydroponic system. It can be fitted with spray emitters and will then act as a combined aeroponic and NFT system. In gully length up to 2.5 m and fitted with a special overflow valve, an ebb and flow nutrient system can be used. This requires that the gullies are mounted without slope. Figure 1 shows a Super NFT system in cross section.

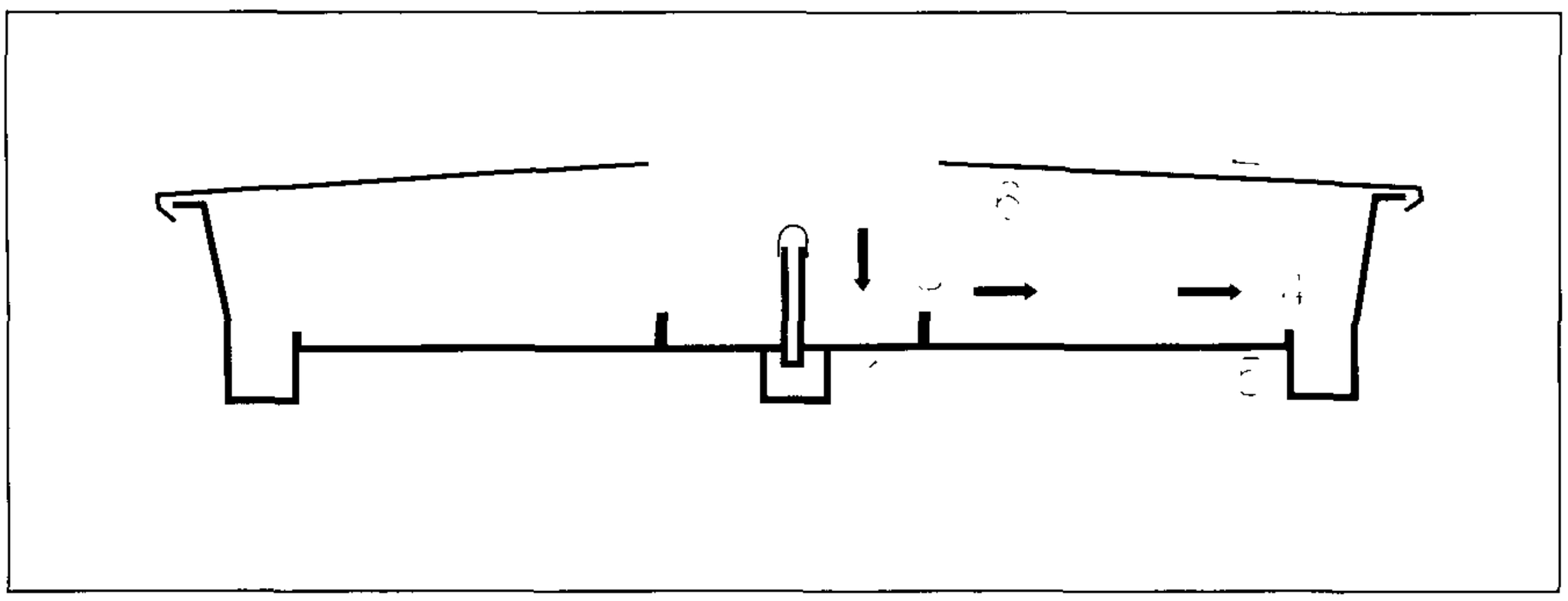

Figure 1. The Super NFT system with the feed tube (1), the nutrient solution emitter (2), the first track (3), the second track (4), the drain-off channel (5), and the lid (6).

Figure 2 shows the flow pattern in the gully with the plant containers placed on the gully bottom and on the top of the primary tracks. It illustrates how the development of the root mat forces the nutrient solution to flow from the primary tracks to the secondary and finally into the two drain channels in each side. It will be necessary to remove the roots which have grown into the main drainage system from time to time.

TOMATO GROWING IN SUPER NFT

The Super NFT system was specially developed for growing tomatoes. The following are recommendations on how to set a Super NFT system up for growing tomatoes. The gully should have a slope of 0.4% with a plant spacing of 33 cm. If plant spacing is 30 cm, the slope should be increased to 0.5%. Higher plant densities are not recommended. Nutrient solution flow should not be less than 4 liters/hour/plant and 5 liters/hour is recommended. The plants should be placed before the nutrient solution emitter (see drawing). If plants are grown in a region with poor winter light the water flow can be restricted the first 2 weeks to induce stress. The plants should then be placed between the tracks and the water turned on and off at intervals. Care must be taken not to let the plants dry to the point that the roots are damaged. If high conductivity is used to stress the plants, they should also be placed between the tracks on the bottom of the gully. When a thin root mat has developed in about 3 weeks, the plants are lifted out of the nutrient solution to allow the solution to flow

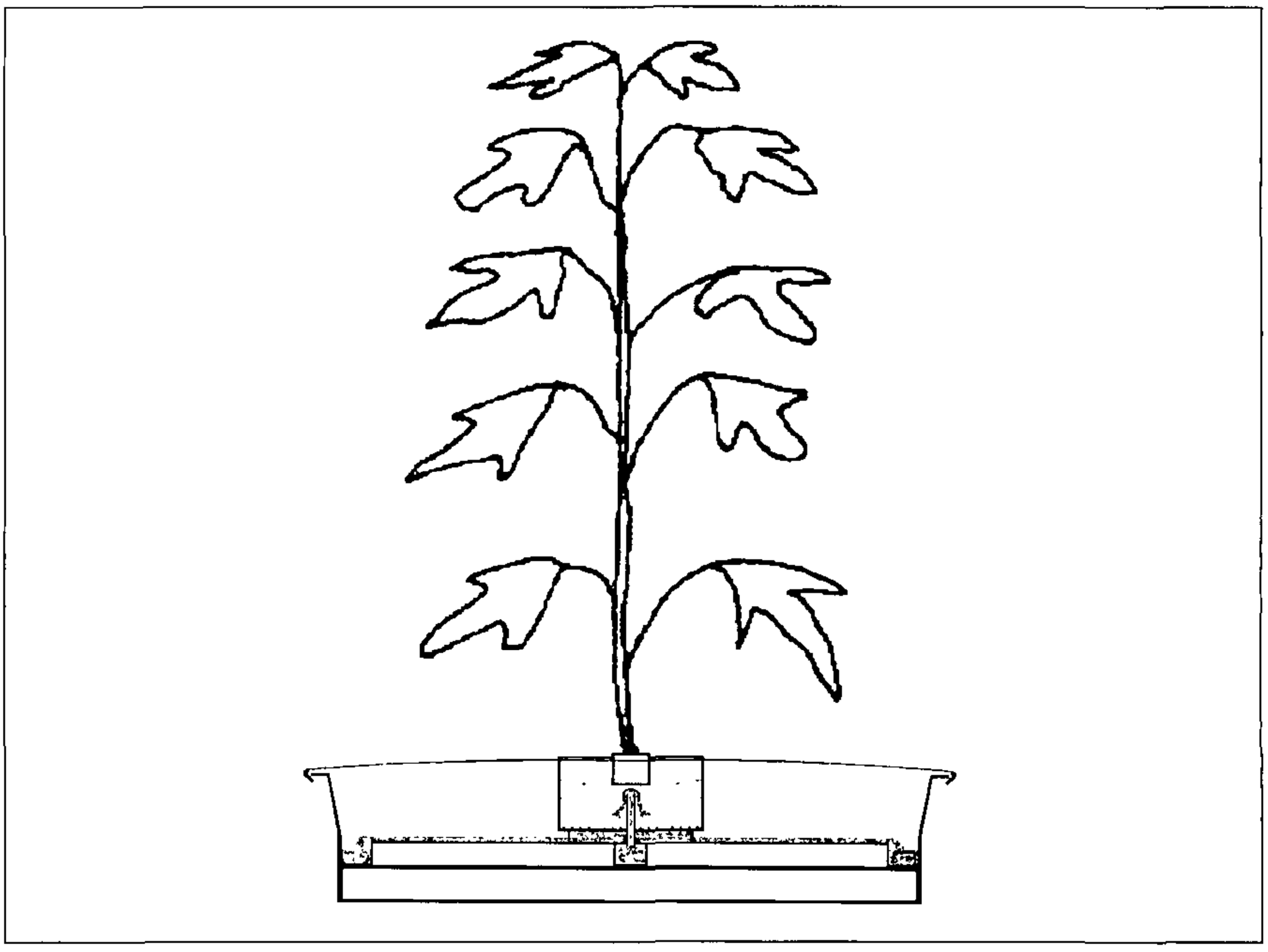

Figure 2. Flow patterns in the gully with the plant containers placed on the gully bottom and on the top of the primary tracks.

under the blocks or pots to remove the root exudates and aerate the roots.

This operation is best done by using an asymmetric block (e.g., 6 cm × 7 cm) and turning it 90 degrees so it rests on top of the two center tracks. If a smaller pot is used, it can be placed on one of the tracks. The roots will grow into the main drainage tube and must be removed manually at intervals (3 to 4 weeks).

CUCUMBERS IN SUPER NFT

Cucumbers grow more vigorously than tomatoes and need more space and oxygen. Therefore, a between-plant distance of 35 to 40 cm is recommended. The flow should be increased to minimum 8 liters/hour and in hot climates up to 10 liters/hour is recommended. With cucumber it is important to keep the root neck dry to avoid attack by fungi. This can be achieved by using a growth substrate with a high air to water ratio and making certain that the pot or block is well above the lip of the gully. While the growing block in a tomato culture can be as low as 5 cm it is recommended with cucumbers that blocks 5.5 to 10 cm in height be used. Further the top of the pot can be covered with white EPS shavings to create a dry surface.

OTHER CULTURES IN SUPER NFT

Other plants worth considering for cultivation in the Super NFT system include aubergines (eggplant), green peppers, melons, and other plants which have large root systems in culture and require distance between the plants.

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