A METHOD OF WATER CULTURE FOR EXPERIMENTS WITH MICRONUTRIENT ELEMENTS

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SUMMARY

A water culture method is described by which the nutrient solution remains completely free of materials which may release any traces of micronutrient elements into the solution.

Certain inconveniences connected with water culture have been overcome by a method described by STEINER (1965). This concerned an automatic constant level of the nutrient solution without any addition of water or nutrient solution, and with a constant moving and mixing of the solution and an intensive aeration. A small pump is used to transport the nutrient solution.

For plant physiological experiments with micronutrient elements in water culture it is essential that the nutrient solution be kept free of materials from the installation which may release any trace of the particular micronutrient. For this reason the installation should be built exclusively of plastic materials. There are centrifugal pumps with a plastic casing: usually a polymerized methyl-metacrylate, known as Lucite, Plexiglas or Perspex. The rotating vanes are made of magnetic iron, completely encased with plastic. There is no spindle between the pump case and the motor. Magnetic power transmits the rotation from the electric motor to the pump case.

The use of a pump however may have certain disadvantages. Heat from the electric motor will increase the temperature of the nutrient solution. In water culture installations where one small washing machine pump was continuously working for the transport of 120 l nutrient solution, the temperature rose more than 5 °C above the temperature of the environment. There is less heat conduction with a plastic pump casing, but it will nevertheless affect the temperature of the nutrient solution. When working with different nutrient solutions, a separate pump is needed for each unit of water culture. This is rather expensive.

For these reasons the method mentioned above has now been modified: all principles remain the same, but instead of a pump compressed air is used for solution transport.

In *fig. 1* the installation and its details are shown. Here the storage tank is not placed underneath the plant container but beside it; tank (a) and plant container (b) are made from one open cistern, divided by a partition wall.

The nutrient solution from the tank (a) is brought into the plant container

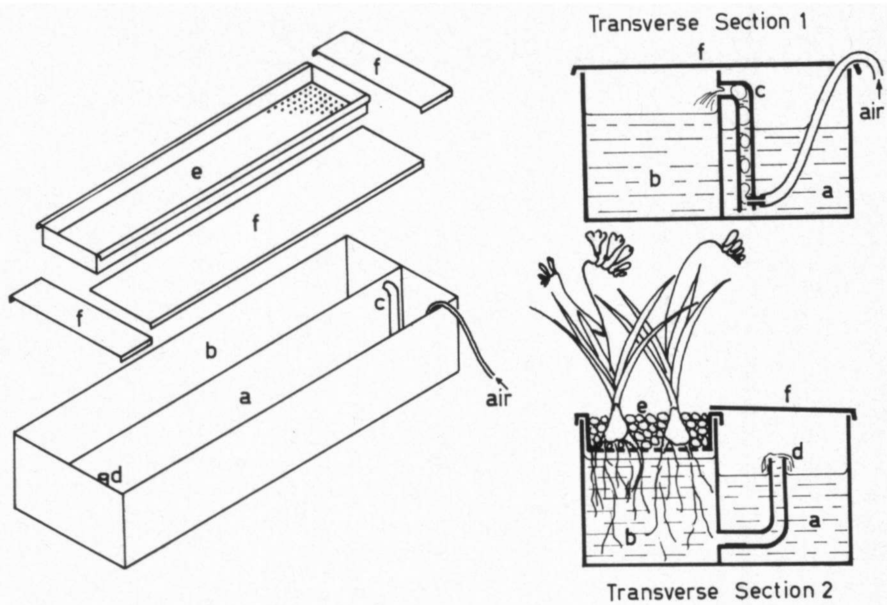

Fig. 1. Installation for water culture.

(b) by an air lift (c) as shown in transverse section 1. To maintain a constant water level in the plant container, an overflow (d) is constructed as shown in transverse section 2.

Plants may be supported in the plant container by the various ways usual in water culture. In *fig. 1* a method has been chosen which is suitable for bulbs such as Freesias, or stooling plants such as *Asparagus* spec. or grasses. Here plants are supported in a completely inert substratum of plastic pebbles, placed in a shallow trough with a perforated bottom (e), hanging in the plant container.

To prevent growth of algae, plastic covers (f) are placed on the tank to keep the solution as dark as possible.

In the described installation experiments were made with air lifts of different diameter to determine the most suitable output, i.e. the most suitable relation between the quantity of air and the quantity of transported solution.

The output of an air lift will increase as the upright pipe and the point of air injection are placed deeper in the liquid to be transported and decrease as the height of elevation becomes greater (= distance between water level in the tank and highest point of elevation). In the installation the place of the air injection is fixed as close as possible to the bottom of the tank. The more nutrient solution taken up by the plants, the lower the water level in the tank will be, diminishing the depth of the air injector under the water level. The height of elevation will increase in inverse proportion. Consequently the sum of the height of elevation and the depth of the air injector under the water level will always be a constant value. During the experiments concerned with the output this sum was always 17 cm.

Experiments were made with air lifts with an internal diameter of 13, 16, 21 and 28 mm (standard diameters of available plastic pipes) and with an elevation height of 3, 6 and 9 cm (air injector resp. 14, 11 and 8 cm below water level in the tank). In these experiments the greatest quantity of air was 12 litre per minute. The results are given in *table 1*.

From *table 1* it can be seen that with an air lift diameter of 13 mm and an elevation height of 3 cm we need $2.5 \times 2000 = 5000$ ml air for a yield of 2000 ml water. For the same result with an air lift diameter of 16 mm we only need $1.5 \times 2000 = 3000$ ml air.

Table 2 shows the most suitable air lift diameters for the various elevation heights.

Table 1. The ratio air: water, up to a maximum air support of 12 litres a minute.

Airlift diameter	13 mm			16 mm			21 mm			28 mm		
elevation height	3 cm	6 cm	9 cm	3 cm	6 cm	9 cm	3 cm	6 cm	9 cm	3 cm	6 cm	9 cm
Yield of water in ml per min.	Air: water quotient											
500	1.6	4.0	14.0	1.8	5.6	14.0	5.2	9.2	**	9.4	19.6	**
1000	1.3	3.4	*	1.3	3.9	*	3.0	6.0		5.4	**	
1500	1.6	*		1.6	3.8		2.2	4.8		4.0		
2000	2.5			1.5	*		1.9	4.5		3.4		
2500	*			1.6			1.7	**		3.0		
3000				2.0			1.7			2.7		
3500				*			1.7			2.6		
4000							1.7			2.4		
4500							1.9			2.4		
5000							*			**		

* higher yields are impossible
** higher yields are only possible with an air supply greater than 12 litres per minute.

Table 2. The most suitable air lift diameters for the various elevation heights.

elevation height air: water quotient	3 cm 1.3–1.9	6 cm 3.4–4.5	9 cm 14
Yield of water in ml per minute	Air lift diameters in mm		
500	13 or 16	13	13 or 16
1000	13 or 16	13	
1500	13 or 16	16	
2000	16 or 21	21	
2500	16 or 21		
3000–4500	21		

With the maximum air consumption of 12 litres per minute during the experiments, it was impossible to obtain a higher capacity than 500 ml nutrient solution per minute at an elevation height of 9 cm. A higher air consumption will give a higher capacity, but for practical purposes 12 litres of air has been chosen as a maximum. So if the water level in the tanks falls below 6 cm it is advisable to renew the solution or to add water or solution.

For this method it is very important to use pure air, unpolluted by fluor or organic impurities caused by industries. The air must also be free of oil from the pump, for which a good filter is necessary.

REFERENCE

Steiner, A. A. (1965): A new method for growing plants in water culture. *Acta Bot. Neerl.* **14**: 400–402.