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PHYSICAL AND PHYSICOCHEMICAL PROPERTIES OF THE VOLCANIC MATERIALS USED IN HYDROPONY

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Abstract

The physical and physicochemical properties of volcanic (basaltic) materials used in hydropony are treated. These materials have a real density of 2.93 g/ml and an apparent density of 0.84 g/ml. The relationship between both densities gives a total theoretical porosity of 71.3 % (v/v). The maximum hydric capacity of these materials was of 63.2 %(v/v) and the difference to the total theoretical porosity (8.1 % v/v) is the occlusive porosity which is considered as a reference for evaluating the extent of disintegration of the particles. The water retention was of 18.6 %, two times greater than that of the gravel. The exchangeable cationic capacity is very low (5 meq/100 g) and the pH of the materials ranges between 7 and 8 units.

1. Introduction

The soilless culture on substrate requires a study of the physical and physicochemical properties of the materials used as substrate. It is necessary for both the installation and the handling of the culture to be adapted to the used material, since the mixing of the substrate with different properties is not advisable (Steiner, 1968).

The main physical properties of a substrate from the point of view of its use in hydropony are: Particles size, stability, real and apparent densities, water retention capacity and maximum hydric capacity (Penningsfeld et al, 1966). The physicochemical properties are subject to the variations produced in the nutrient solution and they can be determinated by the total exchangeable cationic capacity, exchangeable cations, pH, and the retention and release of ions from the nutrient solution (Manshard, 1958).

Volcanic materials have been classified as natural substrates, porous and lacking the capacity of ionic exchange (Luque et al, 1976). As regards their use in Hydropony, the lapilli of phonollitic composition material has been rejected as it shows disintegration and it also causes variations in the nutrient solutions (Blesa et al, 1976).

The aim of the present communication is to make a short review of our results about the physical and physicochemical properties of the basaltic materials used as substrates in hydropony.

2. Real and apparent density

The determination of the real density was carried out on finely ground material by changing of weight of the picnometer. The real density of the basaltic was of 2.93 ± 0.02 g/ml.

The apparent density determined by the weight of a known volume gives an average value of 0.84 ± 0.02 g/ml. Nevertheless it is found in the fraction of the total granulometry(6 to 0.5 mm ∅). The apparent density varies between the different granulometric fractions being greater the smaller the particles are (table 1).

Table 1. Apparent densities of the basaltic materials in relation to the size of the particles (Blesa et al, 1972)

Diameter of particles	Apparent density
6.0 to 5.0 mm	0.66 g/ml
5.0 to 2.5 mm	0.73 g/ml
2.5 to 2.0 mm	0.93 g/ml
1.0 to 0.5 mm	1.10 g/ml

This property allows us to use the apparent density as a reference to estimate the extent of disintegration possible in the materials according to the time of their use as substrates. The higher their value the smaller the size of the particles is and consequently the extent of their disintegration.

The relationship between the real and apparent densities allows us to find out the total theoretical porosity of the basalts by means of the formular.

$$\text{Total theoretical porosity} = 100\left(1 - \frac{\text{Apparent Dens.}}{\text{Real Dens.}}\right)$$

In the basaltic materials studied the total theoretical porosity was of $71.33 \pm 0.77\%$ (v/v).

3. Maximum hydric capacity

The maximum hydric capacity is a similar concept to that of the total porosity used in soils, the difference being however that while in the soil the total porosity refers to the volume of pores, in hydropony we are talking about the total amount of water. The determination is carried out by means of flooding with water a known volume of substrate, maintaining it for at least four hours for its stability and shaking it to fill up all the empty spaces. The basaltic materials show a maximum hydric capacity of $63.17 \pm 1.72\%$(v/v). This value is found to be similar to the one pointed out by Favilli and Massantini (1969) for the volcanic scoria.

The difference between the total theoretical porosity and the maximum hydric capacity gives us another physical property, exclusive to porous materials, which is occlusive porosity (8.16% v/v). This part of the pores "intraparticles" are closed to water and air. Occlusive porosity in the case of basaltic materials acts as another reference for the extent of disintegration of the substrate, being smaller when the substrate materials have been used for longer periods of time in hydropony. It ranges from 13.3% (v/v) in unused materials to 4,0% (v/v) in materials used as substrates for a period of 6 years (Luque et al, 1976).

4. Water retention capacity

The quantity of water which after a complete flooding, followed by drainage, is still retained in the substrate is the capacity for water retention. The basaltic material show an average capacity for water retention of 18,61$\pm$0.73% (v/v). This value is higher than the 13% shown by Favilli and Massantini (1969) for the volcanic scoria and the double the water retention of gravel (Perez-Melian et al, 1977).

The capacity for water retention will vary according to granulometry being greater when the diameter of the particles is smaller, since the interparticle microporosity increases, but with excessively fine particles root asphyxia may occur. In our case the diameter fluctuated between 6.0 and 0.5 mm. The percentage of particles being lower than 0.5 mm, less than 1% (w/w).

Penningsfeld and Kurzmann(1966) point out that a good substrate in hydropony should have 50% (v/v) of its total porosity as microporosity (water retention capacity). This means that the capacity fot water retention should be 35% (v/v) of the total volume. In our case it is half.

However in the hydroponic cultivation of tomatoes in greenhouses good crops are obtained with one daily irrigation, there not existing any significant differences between yields obtained with 2,3 or 4 daily irrigations (Perez-Melian et al, 1977).

5. Physicochemical properties

The total exchange capacity of the basaltic materials is close to 5 meq/100 g, values lower than those found in sandy soil. Nevertheless the non-existence of clay impurities is of great interest, which even when very small the total exchangeable capacity increased to over 20 meq/100 g (Blesa et al,1972).

On studying different granulometrical sizes no differences appear, which indicates that the finest fractions do not show grater physicochemical activity than the gross particles fraction (Blesa et al, 1972).

The pH values of these materials are slightly alkaline (about 7.5).

The retention of ion is weak and also the changes produced in the nutrient solution (Luque, 1981).

References

Blesa,C., and Luque,A., 1972, Contribucion al estudio de los materiales volcánicos de las Islas Canarias para su utilización en los cultivos hidropónicos. I.Estudio general y de las propiedades físicas y químicas. Ann. Edaf. y Agrobiol. 31:583-599.

Blesa,C., and Luque,A., 1976. Contribución al estudio de los materiales volcánicos de las Islas Canarias para su utilización en hidroponía. II.Tratamiento con soluciones nutritivas. Ann.Edaf. y Agrobiol. 35:1079-1091.

Favilli,R., and Massantini,F., 1969, La coltivazioni idroponiche in Italia. Situazione actuale e prospettive de sviluppo. Proc. 2nd Inter. Congress of Hydropony. Las Palmas. Spain. 91-99.

Luque,A., 1981. Retention of ions by volcanic sand used in hydroponic cultures. Acta Horticulturae 126. 1981.

Luque,A., y Pérez-Melián,G., 1976. Substratos y sus propiedades. Proc. of 4th Intern. Congress on Soilless Culture. Las Palmas. Spain. 303-312.

Manshard,E., 1958. Uber das Sorptionsvermögen von Quarzkies, Bimskies und Vermiculite für Phosphat-Kalium- und Ammonium Ionen und die Aufnahme der sorbierten Ionen durch Pflanzen. Gartenbauwissenschaft, 23, 308-326.

Penningsfeld,P., et Kurzmann,P., 1966. Cultures sans sol on hydroponiques et sur tourbe. La Maison Rustique. Paris.

Pérez-Melián,G., Luque,A., and Carpena,O., 1977. Estudio comparativo del cultivo hidropónico de tomates sobre cuatro substratos diferentes en relación con el número de riegos. Ann.Edaf. y Agrobiol. 36, 555-564.

Steiner,A.A., 1968. Soilless Culture. Proc. 6th Intern. Coll. Potash Inst. Florence. Italy. 324-341.