PERLITE - Advantages and Limitations as a Growth Media

James L. Green

Perlite has been used successfully for plant propagation for the past few years, and has also been proposed as a medium for plant growth (5, 6, 7). Perlite's unique advantages are: 1) it is lightweight, odorless, and nontoxic resulting in handling ease; 2) it is a hard inorganic mineral that does not deteriorate and lasts indefinitely; 3) it is sterile, meaning it is disease and weed free; 4) each perlite granule is composed of many small air cells that effectively insulate plants from extreme soil temperature fluctuation by water so that moisture is adsorbed at the surface of the particle where it is readily available.

Wilson and Tunny (9) have reported that perlite has two defects: it can cause deformity of seedlings in some species, and it has only a limited capacity for supplying water to rapidly transpiring plants. They emphasized that these defects should not be overemphasized as deformity occurred only in some species, and normally less than 25% of the seedlings were affected. The water supply was adequate when evaporation was low, or when water is applied frequently.

One of the most important limitations of perlite as a growth media is the limited amount of water it can retain from a single watering. White and Mastalerz (10) stressed that the quantity of water available in a shallow container is dependent on the type of media as well as the container shape and depth ("field capacity" as expressed by many workers is usually less than the upper limit of available moisture for media in containers). White and Mastalerz compared the available water from perlite, soil, and peat (10) and found "container capacities" of 36.8% (by volume), 43.9%, and 63.8% respectively, and available water capacities of 34.3%, 31.6%, and 54.9% (by volume) respectively. From their data it can be seen that the percent available water from perlite for plant growth favorably compares with that from soil; and in addition, when the bulk density of perlite (0.18 g/cm^3) is compared to that of soil (1.13 g/cm^3), it is noted that perlite has a greater water-free air space at low tensions, a factor favoring healthy growth.

Other questions which need to be answered with regard to using perlite as a growth media are: a) the extent to which aluminum will be differentially removed from the tetrahedral layer and become available for plant uptake under growing conditions; and b) the stability of the perlite lattice-structure in contact with aqueous solutions.

Perlite is a siliceous rock containing 3-5% water. When it is heated, the rock expands to a mass of glass bubbles producing a lightweight aggregate with many cavities. Expanded perlite has been chemically (8, 4) and structurally analyzed (2). Perlite is presumed to be a 3-dimensional network of silicon and aluminum oxide tetrahedra having metallic cations in the holes in the framework. An average chemical analysis, in percent, of 10 perlite samples from 6 currently producing states is presented in table 1.

Table 1. Typical chemical analysis of perlite

Silicon dioxide (SiO_2)	73.2%
Aluminum oxide (Al_2O_3)	13.08
Potassium oxide (K_2O)	4.44
Sodium oxide (Na_2O)	3.31
Calcium oxide (CaO)	0.72
Ferric oxide (Fe_2O_3)	0.89
Magnesium oxide (MgO)	0.18
Titanium dioxide (TiO_2)	0.09

Traces of manganese, chromium, barium, lead, nickel, copper, boron, beryllium, molybdenum and arsenic.

Perlite is very slightly soluble (less than 1%) in dilute mineral or concentrated weak acids. It is slightly soluble (less than 2%) in concentrated mineral acids. It is soluble in hot concentrated alkali and in hydrofluoric acid (8).

To my knowledge conditions under which aluminum may be differentially removed from the tetrahedral structure of perlite have not been investigated. However, Marshall and McDowell (3) have conducted research on the reactivity of the micas in contact with water and aqueous solutions. Some indication of the conditions under which aluminum may be removed from perlite may be gained by looking at the conditions under which Al was removed from the tetrahedral layer of mica. The micas were allowed to react with HCl solutions and water. The pH dependence of aluminum released to the solution was very striking. In all cases the Al in solution dropped to immeasurably small amounts when the pH of the initial solution exceeded pH 2.1. It was also found that Mg, Al, and Fe were reincorporated into the silicate structures as the pH rose. It can be presumed that the release of Al from the perlite structure will be similar to that for micas and soil clays. As the solution pH becomes more acidic (generally considered to be below pH 5.0) there will be increasing release of Al and the metallic cations from the aluminum-silicate structures.

At this point we have indicated two possible disadvantages of using perlite as a growth media. They are: 1) perlite has a limited capacity for supplying water; under conditions where plants are transpiring rapidly, water may become limiting; and 2) under acidic pH's and possibly other undetermined conditions Al may be released into the solution in toxic amounts.

Comparisons of Soil and Perlite

A preliminary comparison of carnation growth in soil and perlite was made at CSU, 1967, in which all plants received the same nutrient solution (Table 2, solution D). The primary difference in treatment was that one group of plants was grown in soil and the other group was grown in perlite. After 11 weeks of growth the plants were harvested. The 18 plants in perlite had an average fresh weight of 148.4 grams compared to 131.4 grams for plants grown in soil; this difference was not statistically significant. There were essentially no differences in the dry weights of the plants in the two groups; plants in perlite had an average dry weight of 25.2, and those in soil had an average dry weight of 25.3 grams. There was a statistically significant increase in percent moisture in those plants grown in perlite; plants in perlite had 83.0% moisture compared to 80.7% moisture for those grown in soil. This preliminary experiment would indicate that water was not a limiting factor in growing plants in perlite under the experimental conditions (Fig. 1 and 2).

A second experiment was conducted with rooted carnation plants grown for 26 weeks in a perlite media. At harvest, plants from 6 different solution treatments designated 1, 2, 3, 4, 5, and 9 (1) were analyzed for aluminum. All nutrient treatments had a similar pH of about 6.5. There was no clear relationship between aluminum accumulation in the plant leaf tissue and differences in the external nutrient solution treatments. This would indicate that when pH is held constant the various nutrient solutions and nutrient solution concentrations had little effect in differentially removing aluminum from the perlite tetrahedral structure.

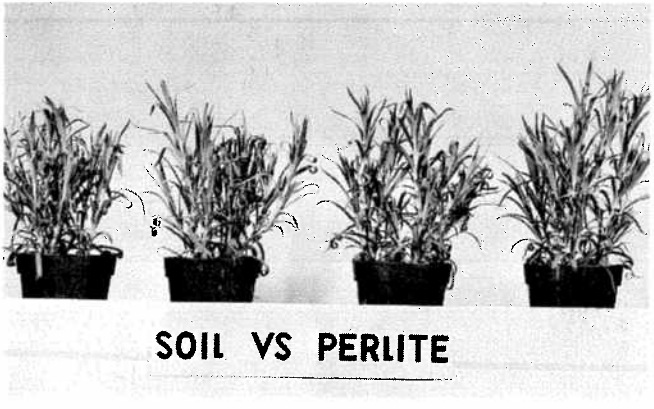

Fig. 1. Visual comparison of carnation growth in soil and perlite after 9 weeks' growth.

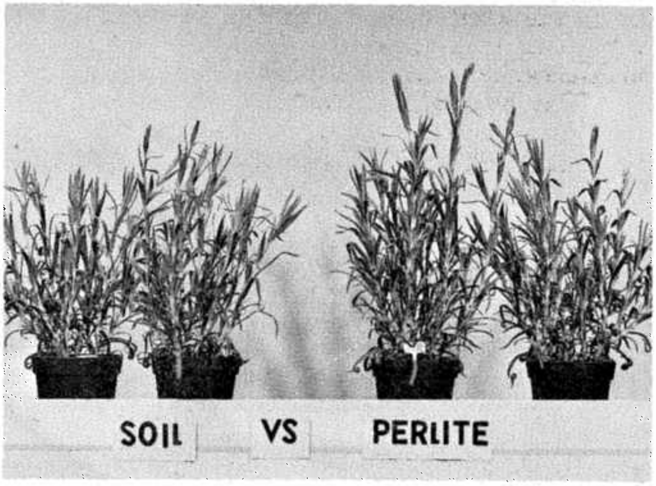

Fig. 2. Comparison after 11 weeks' growth.

Aluminum Accumulation in Tissue

In a third experiment, rooted chrysanthemum and carnation cuttings were grown for a period of 14 weeks in a perlite media. The plants were divided into 3 groups. Each group received a different nutrient solution -A, B, and C (See Table 2 for nutrient solution compositions). The main differentiating characteristics of the solutions were their pH's. Solutions A and B had a pH of 6.5 while solution C had a pH of 3.5. External nutrient solution pH had a striking effect upon the quantity of aluminum accumulated in the plant leaf tissue as determined by plant tissue analysis at time of harvest. In the carnation there were 46, 40, and 148 ppm Al accumulated by the plants growing in nutrient solutions A, B, and C respectively. In the chrysanthemum there were 46, 46, and 82 ppm Al accumulated by the plants growing in nutrient solutions A, B, and C. This would indicate that at acidic pH's, aluminum in the perlite became more available for plant uptake.

The toxic levels of aluminum have not been established for carnation. In soil culture the aluminum accumulation in the leaf tissue generally ranges from 6 to 49 ppm. In perlite culture using nutrient solutions having a pH of about 6.5, the aluminum accumulation in the leaf tissue ranged from 40-76 ppm. But in perlite culture using a nutrient solution with a pH of 3.5, aluminum accumulation was as high as 148 ppm. At pH 3.5 there was stunted growth and the leaves became necrotic suggesting a nutrient toxicity.

However, in this experiment it was impossible to determine whether the detrimental effects on growth were due to aluminum toxicity, general nutrient imbalance, pH, or a combination of factors.

It may be concluded that under greenhouse environmental conditions using a nutrient solution whose Ph is greater than 5.0, carnation plants may be satisfactorily grown in perlite.

Table 2. Composition of the treatment nutrient solutions in milligram equivalents per liter. All solutions received 5 ppm Fe Sequestrene 330, 1 ppm manganese sulfate, and 1 ppm boron.

Trtmt	pH	Milligram equivalents per liter K	Ca	Mg	Na	NO_3	SO_4	H_2PO_4
A	6.5	6	2	2	2	8	2	2
B	6.5	4	4	2	2	8	2	2
C	3.5	2	2	2	2	8	2	6
D	6.1	5	5	1	1	6	2	4

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Your editor, W D Holley

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OFFICE OF EDITOR
W. D. Holley
Colorado State University
Fort Collins, Colorado 80521

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