Studies Of Fluoride Absorption By Plants Grown In Perlite

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Perlite is a generic term for a naturally occurring siliceous volcanic rock, grey to black in color. The crude perlite rock contains 2 to 6% combined water. During processing, the rock is rapidly heated to about 900°C causing the water to vaporize and creating countless tiny bubbles in the heat-softened glassy particles. The resulting material is the familiar white perlite, extremely light in weight, since it has expanded 4 to 20 times its original volume.

Perlite is best known for its use in plant growth media. Perlite contains fluoride which is released in appreciable quantities when it is immersed in water. There has been much concern recently about possible phytotoxicity due to available fluoride in growth media containing perlite. In the work reported lettuce, potatoes, tomatoes and petunias were grown in a media containing 75% (by volume) perlite and 25% peat moss. Treatments with and without added lime were included since fluoride availability is influenced by pH. Harvested plant material and the growth medias were analyzed for fluoride.

EXPERIMENTAL

A mixture containing 75% (by volume) of commercial perlite, 4-8 mesh and 25% Canadian peat moss was prepared. Peat moss alone was used for culturing control plants. The bulk densities of the perlite and peat moss were, respectively, 6 and 5 pounds per cubic foot. Dolomitic limestone (84 grams/cu. ft.) was mixed with each of the above medias. The crops were: "533-Pennlake MT" lettuce (Lactuca sativa), "Dream Girl" petunias (Petunia X hydrida Hort. Vilm-Andr.), "Katahdin" potatoes (Solanum tuberosum), and "Tiny Tim" tomatoes (Lycopersicon esculentum). In addition to the two treatments above with lime, potatoes were also grown on these media without lime. All of the crops were grown in 6-inch plastic pots except potatoes (10-inch). The number of plants per pot was lettuce, 2; petunia, 2; tomato, 1; and potato, 1. All treatments were replicated 5 times except those for potatoes (3 times). The plants were watered daily and fertilized biweekly with reagent grade Hoaglands solution No. 1 (HOAGLAND and ARNON, 1950).

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At maturity the plants were harvested. All harvested material was thoroughly rinsed to remove adhering dust. Potato tubers were brushed, rinsed and peeled. The samples were oven dried (80° C), ground to a powder and mixed. Up to 0.4 gm of the dry material was burned in a 1-liter oxygen-filled combustion flask constructed of polypropylene. Gases were absorbed in 20 ml of distilled water contained in the flask. Fluoride was determined in the absorbing solution using a specific fluoride ion electrode. The recovery of fluoride from the crops ranged from 80 to 120% at the 1 to 2 ppm level. Available fluoride was measured in the growth medias by immersing 5 grams of the perlite media (2 grams of the control media) in 100 ml of distilled water and allowing them to stand 24 hours. Fluoride was then determined in the solution using the electrode. Fluoride concentration in the water used for watering the plants ranged from 0.04 to 0.07 ppm. The pH of the medias was determined. Five grams of the medias were suspended in 100 ml of distilled water for 30 minutes with intermittent mixing. The pH of the resultant solution was then measured.

RESULTS AND DISCUSSION

The results of the study are summarized in Table 1. The absorption of fluoride by the crops was small and did not appear to be greatly effected by the nature of the growth media. Petunias grown in the perlite media absorbed somewhat more fluoride. Interestingly the lower leaves of the petunias in this treatment showed interveinal chlorosis at harvest but this may have been unrelated to the extent of fluoride absorption. No abnormal symptoms were visible in the other crops.

Surprisingly the concentration of fluoride in the solutions equilibrated with the various media was much higher in the case of peat moss alone (no lime added), pH 3.4, than with peat moss and perlite in the absence of lime, pH 5.6. This illustrates the strong effect of low pH on the solubility of fluoride also present in small amounts in peat moss. Several workers have reported the antagonistic effect of liming on the absorption of fluoride and its toxicity to plants (MACINTIRE et al. 1942, 1947, 1951, 1952 and 1958; and HURD-KARRER 1950). This is presumed due to the formation of highly insoluble calcium fluoride. MACINTIRE et al. (1955a, 1955b) also postulated the fixation of fluoride in soil by formation of insoluble aluminum silicofluoride. A typical elemental analysis of perlite is shown in Table 2 (PERLITE INSTITUTE INC., 1974). The presence of calcium, silicon and aluminum in perlite may result in fixation of fluoride which would normally be solubilized from unlimed peat moss alone in water.

It is difficult to explain that no appreciable increase in fluoride absorption occurred in the potatoes grown on unlimed peat moss alone. It may be that potatoes exclude fluoride by another mechanism. There was no consistant effect of the various treatments on crop yield.

Table 1. Fluoride in crops and growth medias.

Crop (part)	Growth Media	Lime Added	Media pH	Fluoride, ppm: Crop (dry wt.)[1]	Fluoride, ppm: Media Solution	Crop Yield[1,2]
lettuce (leaves)	100% peat moss	yes	6.5	1.7 ± 0.4	3.2	3.3 ± 0.4
lettuce (leaves)	75% perlite-25% peat moss	yes	6.9	1.7 ± 0.9	3.7	2.4 ± 0.5
petunia (foliage)	100% peat moss	yes		2.9 ± 1.1		7.1 ± 1.0
petunia (foliage)	75% perlite-25% peat moss	yes		4.0 ± 0.9		5.6 ± 1.3
tomato (fruit)	100% peat moss	yes		1.2 ± 0.2		26.2 ± 4.3
tomato (fruit)	75% perlite-25% peat moss	yes		1.2 ± 0.3		27.4 ± 2.9
potato (tubers)	100% peat moss	yes		2.1[3]		86.1[3]
potato (tubers)	75% perlite-25% peat moss	yes		0.8		71.9
potato (tubers)	100% peat moss	no	3.4	0.5	15.6	64.7
potato (tubers)	75% perlite-25% peat moss	no	5.6	0.4	6.6	76.5
potato (foliage)	100% peat moss	yes		3.4		2.1
potato (foliage)	75% perlite-25% peat moss	yes		3.4		0.8
potato (foliage)	100% peat moss	no		3.4		1.3
potato (foliage)	75% perlite-25% peat moss	no		3.6		1.2

1 average of replicated crops ± average deviation
2 grams dry weight per pot
3 replicates combined prior to analysis

Table 2. Typical Elemental Analyses of perlite.

Silicon	34
Aluminum	7
Potassium	4
Sodium	3
Iron	0.5
Calcium	0.4
Magnesium	0.2
Traces	0.2
Oxygen (by difference	48.2
Net total	97.5
Bound Water	2.5
Total	100.0 per cent

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