Short Communication

Phosphorus Contamination in Polyethylene Glycol

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ABSTRACT

Concentrations of Fe, Mn, Cu, Zn, Ca, Mg, and P were examined in untreated and ion exchange resin-treated solutions of polyethylene glycol, molecular weight 3000 to 3700, polyethylene glycol (PEG 4000). Relatively high levels of P were found in untreated PEG 4000, even at high water potentials (−1 to −3 bars), was greater than what is usually found in soil solution. Occurrence of significant amounts of P in untreated PEG could introduce problems in experiments where 32P and PEG are used together and where phosphate interactions may occur.

Polyethylene glycols of various mol wt have frequently been used as osmotic agents for subjecting plant tissues to known levels of water stress. Although PEG has gained wide acceptance as an osmoticum with few undesirable characteristics, several investigators have had reservations concerning its suitability because of apparent toxic properties. Inhibition of growth processes unrelated to water potential effects have been attributed to several properties, such as heavy metal contamination (4), toxic ionic organic compounds (3), and physical blockage of water transport pathways (5). The reduction in O2 availability in PEG solutions has also been considered as a possible cause of growth inhibition (7).

Although Lagerwerff et al. (4) reported that unpurified PEG 20,000 contained large amounts of Al and Mg, Lawlor (5) concluded that inorganic impurities in commercial unpurified PEG of 1000, 4000, and 20,000 mol wt were at levels unlikely to cause damage to plants (e.g. impurity concentrations [µg/ml] in PEG 4000: Al, 0.5; Mg, 0.4; Fe, 2.5; Cl, 2.5; SO4, 0.5). Greenway et al. (3) reported that after passing PEG 1540 through ion exchange resins of Amberlite IR45 and ZeoKarb 225, the “purified” PEG contained less than 0.3 µg/ml of Al and 0.002 µg/ml of Cr and Cu, but that an unknown toxic property developed with time when purified solution was stored at room temperature.

During preliminary studies on the effects of osmotica on ion absorption processes by roots, we observed unexpected results. Consequently, in this paper we report relatively high levels of P in commercial PEG 4000 which could significantly affect similar types of studies which utilize PEG 4000 as an osmoticum in nutrient solutions.

MATERIALS AND METHODS

Two commercial sources of polyethylene glycol 4000 (PEG 4000), average mol wt 3000 to 3700, were used in this study. One source was of a fine granular form (source A), the other a coarse flake form (source B). Each source was prepared as a 60% (w/v) solution with distilled H2O.

Deionization by Ion Exchange. A fraction of the 60% solution of source A was sequentially treated with the ion exchange resins AG 50WX2, 50 to 100 mesh, (H+) and AG1-X2, 50–100 mesh, (Cl−). Approximately 40 to 50 ml of each resin was added to 1 liter of 60% PEG 4000 in a 2-liter flask and shaken for 3 hr. The resin was removed by filtering through Whatman No. 2 paper.

Analysis for Inorganic Ions. Duplicate samples from the solutions of source A (deionized and untreated) and source B were analyzed for Fe, Mn, Cu, Zn, Ca, and Mg, by atomic absorption, and for K by flame photometry. Phosphorus was determined by the phosphomolybdate method, directly and after dilution where necessary, using a multichannel autoanalyzer and a system essentially described by Williams and Twine (10).

RESULTS

All samples tested for Fe, Mn, Cu, Zn, Ca, Mg, and K proved negative (concentrations below the reference standards). Concentrations (µg/g) of the standards used were: Fe, 60; Mn, 6; Cu, 0.2; Zn, 0.4; Ca, 20; Mg, 1.2; and K, 10.

However, high levels of P were found in the untreated samples of source A and source B (Table I). In the deionized source A, P was below the level of detection (0.2 µg/g).

As shown in Table I, the amount of contaminating P in PEG 4000 solutions used for decreasing the water potential of rooting medium, even at high water potentials (−1 to −3 bars), is likely to give a P concentration greater than that usually found in soil solution. Fried and Shapiro (2) state that the concentration of P in soil solution is commonly 0.003 to 0.03 µg/ml, and data of Pierre and Parker (9) as cited in Adams (1) show a range in concentration of P from less than 0.02 µg/ml to 0.32 µg/ml in soil solutions from seven different soils.

The occurrence of significant quantities of phosphorus in untreated PEG could introduce errors into experiments where 32P

Table I. Phosphorus concentrations in two commercial sources of PEG 4000

<table>
<thead>
<tr>
<th>Source</th>
<th>P concn (µg/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>3.3</td>
<td>5.2</td>
</tr>
<tr>
<td>11.9</td>
<td>13.1</td>
</tr>
<tr>
<td>24.8</td>
<td>25.9</td>
</tr>
<tr>
<td>60.0</td>
<td>60.1</td>
</tr>
</tbody>
</table>

1. P determined in 60% (w/v) stock solutions and corrected to µg P/g PEG 4000, P concentration at other PEG percentages is calculated.
2. Concentration of PEG 4000 required for each specific water potential from Mexal and Reid (6).
3. A-fine granular form; B-coarse flake form.

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and PEG are used together and where phosphate interactions may occur, e.g. uptake of trace elements (6). Deionizing PEG 4000 solutions with ion exchange resins appears satisfactory in removing contaminating P and is strongly recommended. Although we examined only PEG 4000, other mol wt PEGs may have similar contamination.

LITERATURE CITED

CORRECTION

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Page 708, author's name should be corrected to read: Stanley McLeod.