

Effect of Low-Phosphate Pretreatment of Plant Species with Different Relative Growth Rates on Subsequent Phosphate Uptake

A recent report by Chapin (1) illustrates a fundamental point about plant nutrition which I feel merits more attention. Chapin grew nine species in a range of phosphate concentrations, having first "acclimated" them for 4 weeks in a solution containing 1 μ M phosphate, which would be likely to induce mild phosphate deficiency in the plants. He does not say how carefully the 1 μ M concentration was maintained, but, even if this was done successfully, the species with higher relative growth rates might tend to become more deficient than those with lower relative growth rates because the plants with higher relative growth rates require higher phosphate fluxes across the root and this induces greater reductions in the phosphate concentration outside the plasmalemma membrane where uptake occurs. Thus it is likely that, by the end of the acclimation phase, the species differed in their degree of phosphate deficiency, and from the work of Hoagland and Broyer (2) we know that this will profoundly affect the uptake rate of the excised roots.

What I am suggesting is that the observed differences in uptake rate are the consequence of more fundamental differences in relative growth rate, the Arctic species growing faster when placed in the same environment as the temperate species. It would therefore be of great interest to know the phosphate status of each species at the beginning of the uptake measurement period. This information is very frequently

lacking in uptake studies, which makes it impossible to reconcile data from different sources.

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References

1. F. S. Chapin, III, *Science* **183**, 521 (1974).
2. D. R. Hoagland and C. Broyer, *Plant Physiol.* **11**, 471 (1936).

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Scaife's comments are well taken. The acclimation of plants to different root temperatures certainly causes differences in the relative growth rate and nutrient status (1). As Scaife has pointed out, rapid growth in a low-phosphate medium such as I used (2) would result in plants with a low-phosphate status. This in turn would lead to a high capacity of plants to absorb phosphate when the uptake rate is measured under standard conditions (3). Hence plants with the lowest-phosphate status would be expected to have the highest capacity to absorb phosphate.

In the experiments previously reported (2) there were distinct differences in phosphate status and probably in production between plants grown at different root temperatures (Table 1). Plants grown at low root temperatures (cold-acclimated plants) produced less root biomass than warm-acclimated plants. Perhaps because of lower total production rates (4), cold-acclimated plants had lower phosphate require-

ments and hence the observed higher-phosphate status than the warm-acclimated plants of the same population (Table 1). The increase in the phosphate absorption capacity resulting from cold acclimation (2) was apparently a specific response to root temperature rather than to phosphate deficiency.

Similarly, interpopulation differences in phosphate absorption capacity could not have resulted directly from differences in relative growth rate and phosphate status during the pretreatment. There was a slight tendency for roots of populations evolving in warm soils to grow more rapidly than those of tundra plants (Table 1). The interpopulation differences in root production were not reflected in differences in root phosphate concentration. Nonetheless, the warm-adapted species and races (those with greater root production) had lower capacities to absorb phosphate than the cold-adapted populations (2). These observations conflict with Scaife's hypothesis that a high relative growth rate in cold-adapted species might lead to phosphate deficiency and thereby cause the observed (2) high capacity of tundra plants to absorb phosphate (5). If, however, tundra plants have unusually high phosphate requirements, as may be the case (6), phosphorus concentration (Table 1) may not be an unbiased indicator of plant phosphorus deficiency, and Scaife's hypothesis may indeed be correct.

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References and Notes

1. R. L. Davidson, *Ann. Bot. N.S.* **33**, 561 (1969); A. Kleindorfer and R. Brouwer, *Neth. J. Agric. Sci.* **18**, 140 (1970); R. P. Patterson, D. L. Grunes, D. J. Lathwell, *Crop Sci.* **12**, 227 (1972).
2. F. S. Chapin, III, *Science* **183**, 521 (1974).
3. D. R. Hoagland and C. Broyer, *Plant Physiol.* **11**, 471 (1936); E. C. Humphries *J. Exp. Bot.* **2**, 344 (1951).
4. There were no measurements of total production since the experiment began with well-developed rhizomes and shoots transplanted from the field. Qualitative observations suggested that the production of new leaves and tillers was generally correlated with root production (that is, greater total production at warmer root acclimation temperatures).
5. During the actual measurement of the phosphate absorption rate, roots were exposed to 32 P for only 10 minutes. This brief exposure to different phosphate concentrations was unlikely to alter the capacity of roots to absorb phosphate. Roots were not "grown" at a series of phosphate concentrations, as suggested by Scaife. Further procedural details are presented elsewhere [(2); F. S. Chapin, III, thesis, Stanford University (1973); *Ecology*, in press].
6. F. S. Chapin, III, in *Structure and Function of the Barrow Tundra Ecosystem*, J. Brown et al., Eds. (Dowden, Hutchinson and Ross, Stroudsburg, Pa., in press), vol. 2.

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Table 1. Root phosphorus concentrations in and production by species and races of marsh plants originating from different soil thermal regimes and acclimated to different root temperatures. Phosphate absorption rates and acclimation potentials from this experiment have been presented elsewhere (2). The phosphorus concentration was determined by the molybdenum blue method on a nitric-perchloric acid digest of roots. Phosphorus values are averages of duplicate analyses with an average 5 percent coefficient of variation. Root production values were determined on aggregate samples of 12 to 24 plants (4).

| Species | Site | Root phosphorus concentration (%) at an acclimation temperature of | | Root production (mg dry weight per plant per week) at an acclimation temperature of | |
|---------------------------------|----------------------------|--|------|---|------|
| | | 5°C | 20°C | 5°C | 20°C |
| <i>Eriophorum angustifolium</i> | Barrow, Alaska | 0.29 | 0.13 | | 61 |
| <i>Dupontia fischeri</i> | Barrow, Alaska | .17 | .15 | 11 | 14 |
| <i>Carex aquatilis</i> | Barrow, Alaska | .13 | .10 | | 32 |
| <i>Eriophorum scheuchzeri</i> | Fairbanks, Alaska | .28 | .15 | 23 | |
| <i>Scirpus microcarpus</i> | Los Gatos, California | .34 | .15 | 14 | 82 |
| <i>Eleocharis palustris</i> | Fairbanks, Alaska | .21 | .15 | | 41 |
| <i>Carex aquatilis</i> | Circle Hot Springs, Alaska | .49 | .24 | 14 | 136 |
| <i>Eleocharis palustris</i> | Corvallis, Oregon | .21 | .11 | 28 | 92 |
| <i>Scirpus olneyi</i> | Thousand Palms, California | .14 | | | |

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