ION ABSORPTION BY ROOTS: THE ROLE OF MICRO-ORGANISMS

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SUMMARY

Theoretical considerations and experimental evidence are adduced to the effect that ion absorption by plant tissue from solutions in the range of low concentrations (< 1 mM) is due to the type I mechanisms of ion transport of the plant cell membranes, not to bacteria associated with the tissue.

Barber and Frankenburg (1971) conclude on the basis of experiments in which sterile and non-sterile roots of barley (Hordeum vulgare) absorbed labelled rubidium or phosphate that the kinetics of ion absorption as studied with non-sterile roots may to a considerable extent reflect the kinetics of uptake by the micro-organisms associated with the roots. Their conclusion is surprising for several reasons.

(1) The mass of the micro-organisms is extremely small, compared with that of the tissue with which they are associated. Let us assume a bacterial volume of 0.01% of that of the tissue, surely a large estimate. Let us assume, in keeping with their Figs. 3 and 5, that 30% of the uptake of rubidium in 1 hour from a 0.1 mM solution is uptake by bacteria, or an actual uptake, by the bacteria, of about 1.5 µmole per g fresh weight of roots. Taking the volume of a gram of roots to be 1 ml, and the bacterial volume to be $1 \times 10^{-4}$ ml, the bacteria would contain 1.5 µmole rubidium per $1 \times 10^{-4}$ ml, or 15 M rubidium—at least 100 times any reasonable value that may be expected.

(2) The kinetics of the absorption of ions of numerous elements have been examined for a wide range of plant materials, from unicellular algae to fibrous roots, from discs of storage organs to leaf tissue of aquatic and terrestrial higher plants, with remarkably consistent results for the range of concentrations included in Barber and Frankenburg’s (1971) experiments; see Tables 6-1 and 6-2 in Epstein (1972a) and Table III in Epstein (1972b). Both the extent of the bacterial populations associated with these diverse plant materials and their qualitative composition must have varied greatly; the consistency of the results therefore argues against any great effect of bacteria.

(3) Among the elements which have been studied are sodium and chlorine, which are scarcely accumulated by the vast majority of bacterial species.

(4) When experiments are done with excised leaf tissue, the correspondence between the characteristics of the absorption processes with those observed in roots is close—so close as to lead to the inescapable conclusion that the ion carrier mechanisms in root and leaf cells must be identical; see Smith and Epstein (1964) and Fig. 9-5 in Epstein (1972a). Yet with green tissue, the energy supply to these carriers may be from the chloroplasts, as evidenced by the large differences in absorption rates in light and darkness (Rains, 1968;
Do Barber and Frankenburg propose that the bacteria associated with the plant material photosynthesize?

(5) Epstein (1968) reported results on the absorption of rubidium by barley roots grown under sterile and non-sterile conditions. Up to 1.0 mM rubidium in the external solution, the former absorbed slightly more rubidium than those grown under non-sterile conditions, but the differences were of no statistical significance. Barber and Frankenburg (1971) fail to make reference to these results.

Their own results can mainly be attributed to the manner in which they did their experiments. The final test of their conclusion that 'micro-organisms contribute directly to the apparent absorption of ions by roots' was by finding more uptake of labelled ions by cotton thread which had been incubated in a non-sterile root medium than by sterile thread. However, the authors failed to desorb the superficial, exchangeable fraction of the labelled ions at the end of the experiment by means of an exposure to an unlabelled solution of the same ion—the procedure universally adopted in short-term experiments on the absorption of labelled ions for reasons explained elsewhere (Epstein, Schmid and Rains, 1963).

I have repeated the experiment on uptake of radio-rubidium by cotton thread which had been treated in non-sterile root medium, as described by the Letcombe Laboratory workers, but with the addition of a final half-hour period of desorption in a solution of unlabelled rubidium. I also included 0.5 mM CaSO₄ in both the labelled and unlabelled solutions, in keeping with the common practice in experiments in ion absorption. At 0.1 mM labelled rubidium, 0.1 g cotton-thread pre-incubated in non-sterile root medium took up 0.002 µmole rubidium, which is 0.15% of the amount taken up under identical conditions by 1 g fresh weight of barley roots. This, our usual sample size, corresponds in dry weight to the amount of cotton thread used, although the latter, with a much smaller diameter, had a far larger surface area than the roots.

It follows from the above considerations (1-4) and experimental evidence (5, and the above paragraph) that the conclusion of Barber and Frankenburg (1971) must be rejected. Except for phosphate absorption at very low external concentrations, already discussed (Epstein, 1968), the evidence is to the effect that the measured ion absorption by plant cells at low concentrations (<1 mM) is not due to bacteria associated with the tissue but to the type of mechanisms of ion absorption of the plant cell plasmalemmas. Effects of the bacteria on the physiology of the roots themselves cannot, of course, be ruled out. Roots with a complement of associated bacteria should be considered normal, sterile roots being in the nature of experimental artifacts.

REFERENCES


