DETERMINATION OF THE QUANTITY OF CARBON AND NITROGEN IN THE RHIZOSPHERE OF YOUNG PLANTS

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Determination of the Quantity of Carbon and Nitrogen in the Rhizosphere of Young Plants

HILTNER[1] introduced the concept of the rhizosphere to express the zone in which the living root exerts an influence on microbes in the soil. Much information has been gleaned since then on the microflora of the rhizosphere and on the substances given off by the roots; but there is much less information on the total quantities of organic substances which the roots lose. The facts so far known are in relation to plants grown in sterile nutrient solutions or in sterile quartz sand without any adsorption capacity[2–4]. The quantities of nitrogen given off by leguminous plants can be estimated from the total nitrogen present in non-leguminous plants cultivated together with the former in a nitrogen-free soil[5,6].

Scarcely anything is known about the total quantity of the substances given off by the roots, especially concerning their carbon and nitrogen amount and their C/N ratio in a soil with a natural absorption capacity in which the rhizosphere is somewhat limited in space. In general, the extent of the rhizosphere is insufficiently known. In a recent publication Papavizas and Davey[7] discussed this subject, and made estimations from a set of micro-borings in the rhizosphere of young lupins. In these small soil samples they estimated the total amounts of bctaeria, fungi and actinomycetes using the dilution plate technique. The R/S values (total numbers of micro-organisms in the rhizosphere/total numbers of micro-organisms in non-rhizosphere soil) were thus obtained, and indicated that the rhizosphere is rather extensive and can have a radius up to 18 mm in unamended soils. In amended soils the rhizosphere may be negligible.

We have attempted to obtain exact information concerning the quantities of organic matter (that is, carbon and nitrogen) given off by the roots and the distance which these substances spread from the root surface. The roots are forced to grow in a small chamber made from a thin nickel plate (0·1 mm thick) densely perforated with punctures 60μ in diameter. This chamber is placed in a big container, and both are filled with the same substrate. The space within the perforated chamber becomes filled with a mat of roots, and consequently may be considered to belong entirely to the rhizosphere, while the space outside the chamber is still in connexion with the roots and serves as a stock of moisture and nutrients.

The substrate used consisted of a mixture of 70 per cent pure sand, 25 per cent finely ground potassium-feldspar and 5 per cent kaolinite with some finely

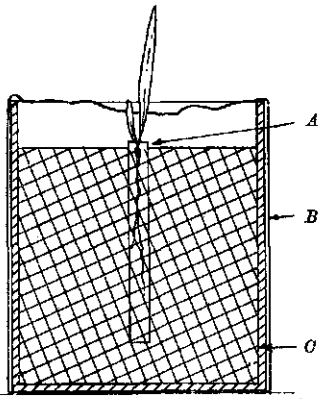


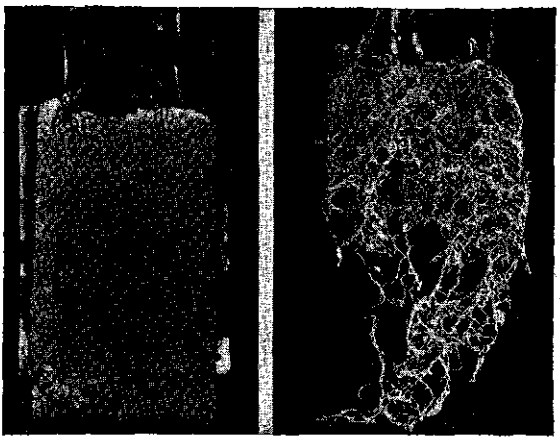
Fig. 1. Diagrammatic scheme of the apparatus. *A*, Root chamber; *B*, black plastic sheet to prevent growth of algæ; *C*, glass pot with soil

granulated pumice stone to improve the structure and aeration of this artificial soil. In some experiments the amount of feldspar and kaolinite was higher. This substrate is very poor in organic substances, containing only 0·022 per cent carbon on dry-weight basis.

200 ml. of a solution of Crone's mixture, containing 1·5 g/l., is added to the content of every container holding about 600 g of dry soil. During the experiment water is added if necessary.

The nickel plate proved not to be harmful to the roots and had scarcely any oligodynamic effect on the micro-organisms in the soil. It is also inert against the substances produced by the roots and is impervious to the roots.

In the upper part of the root chamber germinated sterilized seeds are planted and allowed to grow for a required period. A diagram of the apparatus is shown in Fig. 1.



A *B*

Fig. 2. *A*, root chamber opened; the roots grown in it are visible; *B*, the same roots, washed free from soil

Table 1. Root Excretions of Carbon and Nitrogen (mg)

Plants	Carbon Per 5 g dry soil			Carbon Total	Nitrogen per 5 g dry soil			C/N	Carbon/100 mg dry roots	Season
	a	*b*	*c*		*a*	*b*	*c*			
Wheat	1·7	—	—							winter
	*8·7	1·4	0·5		0·56	0·10	—	15–16		spring
	2·7	0·1	—		0·19	—	—	14–15		spring
Spinach	2·1	0·1	—		0·30	0·02	—	7		spring
	*2·6	—	—		0·25	—	—	10–11		spring
Vetch	1·6	—	—	11·8					2·9	late summer
	0·7	0·1	0·2	7·0					1·6	late summer
	†0·6	—	—	3·6					2·2	late summer
	†0·7	—	0·1	5·4					2·6	late summer

* Soil with an enhanced clay minerals content.

† Experiments under conditions as for sterile cultures.

—, No differences with control values.

Wheat and spinach were grown for 2 months, vetch for 6 weeks. In each pot 4 plants were grown.

To determine the amounts of carbon and nitrogen in the rhizosphere the content of the opened root chamber (Fig. 2) is washed free from soil. The washing is dried at 105° C and analysed (Table 1, *a*). Further analyses are performed on the 1-cm thick layer of soil surrounding the root chamber (*b*) and on the rest of the soil in the container (*c*).

The nitrogen is determined by the micro-Kjeldahl method; the carbon by the dry-combustion method.

The preliminary results so far obtained are given in Table 1. The carbon figures are corrected for the blank (0·022 per cent carbon); the nitrogen figures could not be corrected in this experiment since ammonium nitrate was added in the Crone mixture; they are therefore less reliable.

A distinct concentration gradient from the root chamber outward is apparent in these experiments. The technique consequently proved workable; but the distance of diffusion of the substances given off is smaller than was expected. This may be brought about by the constant flow of water and solutes towards the roots as a result of the transpiration of the plants.

Enhancement of the sorption complex of the soil seems to lead to larger amounts of carbon preserved in the rhizosphere.

When considering the figures in Table 1 it must be realized that these experiments were not performed under aseptic conditions. Part of the organic substances given off by the roots certainly had already been decomposed by micro-organisms. The results therefore represent the minimum of excretion, correct figures presumably being higher.

Following and improving this technique further, experiments are being started to obtain more information about the total quantities of carbon and nitrogen produced in the rhizosphere of different plants of various ages, grown under sterile, as well as non-sterile circumstances, in soils of different composition. It might be expected that thereby a better insight will be gained in the part played by the rhizosphere in the cycle of carbon and nitrogen in the soil, providing us also with new information about formation and disintegration of humus.

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