DIFFERENTIAL EFFECT OF LOW OXYGEN-TENSION ON PROTEIN AND CARBOHYDRATE METABOLISM IN BARLEY ROOTS

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1. INTRODUCTION

The anatomy of roots growing in a water-logged soil may differ considerably from that of roots of the same plant species growing in aerated soil (Mc Pherson 1939, Bryant 1934). Generally the volume of the intercellular spaces is increased in the former, often by the breakdown of cells of the root cortex. It has been demonstrated that oxygen diffuses from the leaves through these intercellular spaces into the roots (Barber *c.s.* 1962; van der Heide *c.s.* 1963; Greenwood 1967).

These anatomical changes may be considered as an "adaptation", which enables the plants to grow in soils that are poor in oxygen. Besides, in barley, other changes of the properties of the roots may contribute to their capability to grow under these conditions (van der Heide, *c.s.*).

Although these changes may lead to survival of the plants in poorly aerated soil, the growth of the plants is less than in normal soils, and usually the growth of the root system is more affected than the growth of the leaves. Apparently, the net result of the synthetic processes in the roots is decreased. As, however, also the chemical composition of these roots is different from that of aërated roots (van der Heide *c.s.* 1963), it must be concluded that anoxia affects different metabolic pathways to a different degree.

2. METHODS

Barley was germinated and subsequently the young plants were cultivated for 10 days at a temperature of 23 °C under 4 fluorescent tubes. The root medium was a Hoagland solution (0.25 normal strength) through which either air (air-plants) or nitrogen (nitrogen-plants) was bubbled at a slow rate. At the end of the culture period the roots were collected, dried at 70 °C, and weighed to determine the dry weight. The dried roots were ground and extracted with water.

The residue was dried and weighed (insoluble fraction). The nitrogen content of an aliquot of this fraction was determined by the Kjeldahl method. From the nitrogen content the "protein" in the material was calculated assuming that 1 gram of nitrogen corresponds with 6 grams of protein (Chibnall 1939). The polysaccharide content was found by substracting the protein from dry weight. It consisted mainly of cell wall material, since the roots contain very little starch.

3. RESULTS

The insoluble fraction appeared to be smaller in the nitrogen-plants, the protein content higher and polysaccharide content lower (*table 1*). The lower insoluble fraction probably was caused by the high sugar content of the roots of nitrogen-plants.

In order to be able to compare the contribution of each of these fractions to the growth of the root system the figures of *table 1* have not been corrected for the fact that the root systems of two types of plants have different weights.

Table 1. Insoluble fraction, protein and polysaccharides in the roots of air-plants and nitrogen-plants

	air-plants mg/100 mg dry roots	nitrogen-plants mg/100 mg dry roots
insoluble fraction	80,0	68,5
protein	7,3	11,0
polysaccharides	72,7	57,5

To this end, the figures for the nitrogen-plants in *table 1* have been multiplied by 0,75 being the average ratio between the dry weights of the root system of a nitrogen-plant and an air-plant (*table 2* and *fig. 1*).

It is evident, from these data, that the decrease of root growth caused by a low oxygen tension of the medium is mainly due to a decreased net formation of cell-wall materials.

The absolute amount of protein formed by the roots of nitrogen- and of air plants is the same.

The cause of this differential effect of a low oxygen tension remains obscure. It can not be ascribed to an increased rate of the breakdown of sugars (e.g. in anaerobic fermentation) in nitrogen-plants, as these consistently show a considerably higher content of soluble sugars than air-plants. It, therefore, seems probable that polysaccharide synthesis is inhibited by a low oxygen tension, whereas protein synthesis is not.

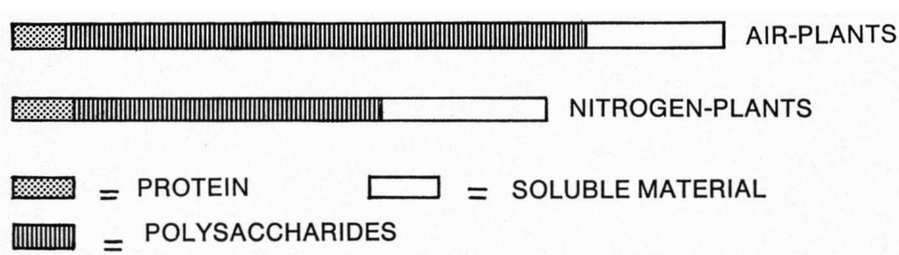

Fig. 1. Diagram of the ratio's of dry weight, protein, polysaccharides and soluble material in the root system of air-plants and nitrogen-plants.

Table 2. Dry weight, insoluble fraction, protein and polysaccharides in one root system as percentages of the dry weight of the root system of an air-plant.

	air-plant %	nitrogen-plant %
dry weight	100,0	75,0
insoluble fraction	80,0	52,0
protein	7,3	8,5
polysaccharides	72,7	43,0

REFERENCES

Barber, D. A., M. Ebert & N. T. S. Evans (1962): The movement of ^{15}O through barley and rice plants. *J. exp. Bot.* **13**: 397–403.

Bryant, A. E. (1934): Comparison of anatomical and histological differences between roots of barley grown in aerated and in non-aerated culture solutions. *Plant Physiol.* **9**: 389–391.

Chibnall, A. C. (1955) In: K. Peach & M. V. Tracey: *Modern Methods of Plant Analyses.* Vol. IV: 25-26. Springer Verlag Berlin.

Heide, H. van der, B. M. de Boer-Bolt & M. H. van Raalte (1963:) The effect of a low oxygen content of the medium on the roots of barley seedlings. *Acta Bot. Neerl.* **12**: 231–247.

Greenwood, D. J. (1967): Studies on the transport of oxygen through the stems and roots of vegetable seedlings. *New Phytol.* **66**: 337–347.

McPherson, D. C. (1939): Cortical air spaces in the roots of Zea mays L. *New Phytol.* **38**: 190–202.