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RELATION BETWEEN ROOT RESPIRATION AND ROOT ACTIVITY

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KEY WORDS

Root respiration Ion uptake Emergy utilization

It is generally assumed that the major part of the energy derived from respiration in higher plants is used for growth and maintenance processes [2, 4, 6]. In roots a considerable part of the respiration is used for uptake and transport of ions [3], so that for a quantitative approach to the relation between root activity and root respiration three processes have to be taken into consideration: root growth, uptake and transport of ions and maintenance processes.

Root respiration and other root activities such as ion uptake and root growth mutually influence each other. For instance, a decrease in root respiration under low oxygen conditions has a negative effect on ion uptake, whereas decrease in ion uptake by low ion concentrations has a negative influence on root respiration.

The aim of the experiments is to quantify the respiratory costs of uptake and transport of ions, root growth, and maintenance processes of a maize root system. Maintenance respiration is considered to be linearly related to root fresh weight.

METHODS AND RESULTS

Simultaneous measurement of nitrate and potassium uptake, water uptake, root growth and root respiration [5] were carried out for a period of 7 days. Under our growing conditions as a rule the NO_3^- uptake rate in equivalents was twice the K^+ uptake rate.

Because NO_3^- and K^+ are the main elements taken up, NO_3^- is chosen as a measure of the total ion uptake. Root respiration could be separated into three components by multiple regression analyses, using root growth, ion uptake and root volume as the independent variables. To increase the relative differences

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Table 1. Oxygen consumption of a maize root in relation to ion uptake, growth and root size. (S_d = standard deviation)

Oxygen consumption per unit of:		S_d
ion uptake mg O_2.meq.$^{-1}$.NO_3^{-1}	36.8	2.1
root growth mg $O_2.g^{-1}$	24.5	1.2
root weight mg $O_2.g^{-1}.h^{-1}$	0.032	0.005

Table 2. Relative energy consumption of uptake, growth and maintenance processes

Day nr	Light int. W.m^{-2}	Per cent of total respiration used for		
		ion uptake	growth	maintenance
1	35	13	78	8
2	35	16	75	9
3	70	39	52	9
4	70	49	42	9
5	35	48	38	14
6	70	60	24	16
7	0	41	25	33

between root growth, ion uptake and root volume, two days before the first experimental day part of the root system was cut away. Only the youngest 5 unbranched crown roots were left on the plant. For the same reason different light intensities were used as indicated in Table 2. Table 1 shows the oxygen consumption per unit of NO_3^- uptake, per unit of root growth and per unit of root volume.

The uptake respiration amounts to 36.8 mg O_2 per meq. NO_3^-. The NO_3^- uptake is about 90% of the total anion uptake, so that on basis of unit anion uptake the oxygen consumption is 33.1 mg O_2.

Lundegardh [3] estimated the ratio

$$\frac{\text{equivalents absorbed anions}}{\text{mols consumed oxygen}} = 1$$

under optimal conditions for ion uptake. This means that in his experiments

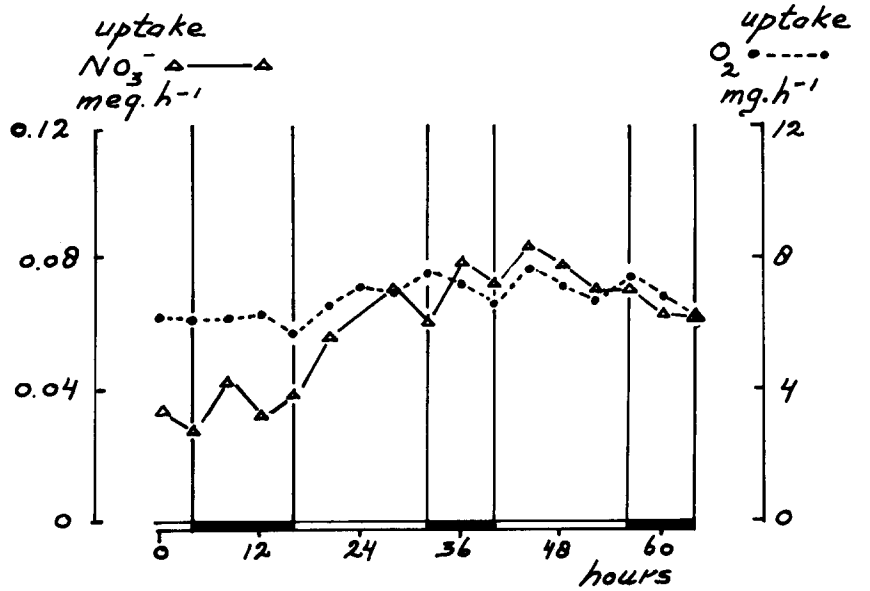

Fig. 1. Effect of changing the light period from 12 h to 16 h on NO_3 uptake and root respiration.

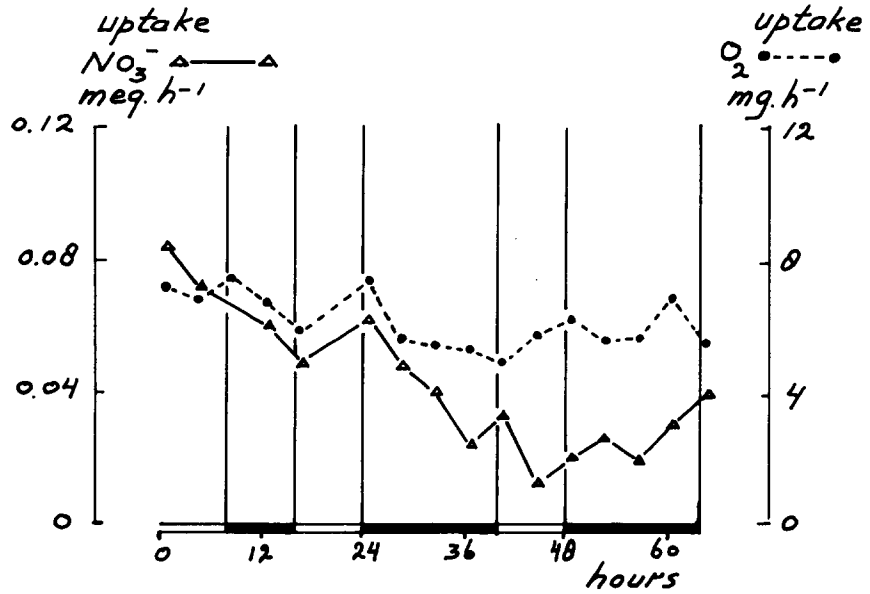

Fig. 2. Effect of changing the light period from 16 h to 8 h on NO_3 uptake and root respiration.

32 mg O_2 was used per meq. absorbed ions, which is in good agreement with our estimation of 33 mg O_2/meq. anions. Table 2 shows the relative amounts of oxygen used for the three processes during the 7 experimental days. Although the influence of light intensity and root cutting are not strictly separated, the data show a relative large growth respiration and a relative small uptake respiration during the first days, because the root size limits the uptake rate [5], while root cutting induces a high relative root growth rate [1].

Uptake respiration is of considerable importance and amounts under normal conditions to 60 per cent of the root respiration.

The last experimental day, when no light was provided, the relative decrease in uptake respiration was greater than the influence on growth- and maintenance respiration.

Although an important part of the root respiration is used for ion uptake, its relative amount is not constant, and is influenced by the amount of light supplied to the shoot. This is demonstrated in the Figs. 1 and 2. Changing the light period from 12 h to 16 h per day, has a strong positive effect on the ion uptake, but only a small effect on root respiration (Fig. 1). Decreasing the light period from 16 h to 8 h per day has a strong negative effect on ion uptake, but only a small effect on root respiration (Fig. 2). A possible explanation for the effects of light on root respiration and ion uptake is, that after decreasing day length, a decreased carbohydrate availability reduces root respiration. Forced to decrease its activities, the uptake of ions by the root is given the lowest priority.

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