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PRELIMINARY OBSERVATIONS ON THE EFFECT OF BLOCKING OF THE GAS TRANSPORT THROUGH THE HYPOCOTYL OF PHASEOLUS VULGARIS

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SUMMARY

Young plants of *Phaseolus vulgaris* were grown with their hypocotyls immersed in a non-aerated nutrient solution. Blocking of the hypocotyl with paraffin oil resulted in the deterioration of the lower part of the hypocotyl and a shift of the development of adventitious roots from the lower part to the upper part of the hypocotyl. No inhibiting effect of the paraffin treatment on the growth of roots and leaves was observed in plants which were immersed in aerated nutrient solutions or in plants, the root bases of which were at water level on non-aerated solutions. The effect of the paraffin treatment is attributed to the blocking in the hypocotyl of the gas-exchange between the shoot and the roots. The importance of an internal transport of gases is briefly discussed.

1. INTRODUCTION

Several authors have demonstrated that oxygen from the shoot can reach the roots (ARMSTRONG 1967; BARBER et al. 1962; GREENWOOD 1967; VAN DER HEIDE et al. 1963; VAN RAALTE 1940).

To study the importance of the internal gas-exchange for development of the roots and the leaves, a method was needed to close the pathway of this exchange. Therefore experiments with paraffin oil were made in order to block the hypocotyl of bean plants.

2. METHODS

Seeds of *Phaseolus vulgaris*, CV. Berna, were sown in humid sand. After 6–7 days, the seedlings were placed in the greenhouse on containers with an aerated nutrient solution of the following composition: macro-elements, modified after STEINER (1968), micro-elements according to CHALLA (1976), Fe-EDTA according to STEINER & VAN WINDEN (1970). The root medium was kept at 23 °C. The plants were illuminated by daylight, supplemented with a 16 hours' light period of TLF 65/33 lamps, 60 cm above the containers.

The blocking of the hypocotyl was done one to three days before the aeration treatments started to prevent a possible wound reaction from complicating

the results. The hypocotyl was pierced at one point with an hypodermic syringe and, 2 cm lower, liquid paraffin was injected slowly into the cavity of the pith, until a drop of oil appeared from the upper opening. Control plants, pierced in this way without oil injections, reacted as intact control plants. Examination of free hand sections, stained with Sudan III, a week after the oil injection, showed orange-red colouring in the central cavity and in the intercellular spaces of the cortex.

The experiments started one to three days after the transfer from the sand to the aerated nutrient solution. The root surfaces were blackened using a tannin-ferric sulphate procedure (ERICKSON 1946) to facilitate the judging of the development of new root parts. In a preliminary experiment this staining procedure did not visibly disturb the development of the roots.

At the beginning of the experiments the aeration was stopped in half of the containers. Part of the plants were kept with their root bases at water level. The other plants were lowered until their hypocotyl was submerged. So there were four aeration situations, each with plants, impregnated with paraffin oil and with control plants. During one week the development of roots and leaves was observed.

3. RESULTS

Table 1 shows the results of five experiments. Only the non-aerated, submerged plants showed a severe reaction to the paraffin treatment. Mostly, the part of the hypocotyl below the place of the injection deteriorated. Even in the plants of which the lower part of the hypocotyl did not die within four or five days, adventitious roots developed on the hypocotyl only above the place of the paraffin injection. The intact control plants of this group started to form adventitious roots at the basis of the hypocotyl or $\pm$ 6 cm below the surface of the solution. Within any one experiment this starting point was rather consistently at the same height, but there was some variation between the experiments. In the non-aerated submerged plants the growth of the leaves was inhibited and the leaves sometimes wilted as a reaction to the paraffin treatment. The plants in the other aeration situations did not show a reduction of the development of primary root or of adventitious roots as a result of the paraffin injection. In one experiment only did the submerged, aerated plants form adventitious roots on the hypocotyl. In this experiment, the primary root systems of all groups of plants stopped nearly all growth activity after the transfer of the plants from the sand to the nutrient solution. The growth of the leaves varied between the different aeration situations, aerated plants having the largest ones and non-aerated, submerged plants the smallest. Only in the non-aerated, submerged plants the growth of the leaves was inhibited by the paraffin.

Table 1. The growth response to blocking of the hypocotyl with paraffin oil of plants in different aeration situations.

Treatment			Growth of leaves	Growth of primary root system	Adventitious roots	
Aeration	Water level	Blocking			Localization	Abundance
Non-aerated	At cotyledonary node	+	1	0	Above paraffin	xx
		−	2	0	Whole length of hypocotyl	xxxx
	At root basis	+	3	2	lower half of hypocotyl	xx
		−	3	2		xx
Aerated	At cotyledonary node	+	4	3	Whole length of hypocotyl	x
		−	4	3		x
	At root basis	+	4	3	Lower half of hypocotyl	x
		−	4	3		x

Scale of growth: 0 = none; 1 = very poor; 2 = poor; 3 = moderate; 4 = normal.
Scale of abundance adventitious roots: x = hardly any – xxxx = abundant.

4. DISCUSSION

The results strongly suggest that the effect of the paraffin oil was due to a blocking of the gas transport between shoot and root. For plants, submerged in an aerated solution and for plants with their hypocotyls in air, the exchange of gases can take place via the epidermis, but when submerged in a non-aerated solution the plant can exchange gases between shoot and root only via the internal pathway. The frequently observed deterioration of the lower part of the plant after the paraffin treatment demonstrates the importance of the internal pathway for the maintenance of the tissues in a non-aerated nutrient solution. The term gas-exchange is used here, rather than oxygen transport. Whether it is the availability to the tissues of oxygen that gives the importance to the internal pathway is being examined in subsequent experiments.

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