Comparison of the Changes in Net Photosynthetic CO₂ Uptake and Water Vapour Efflux during Leaf Ontogenesis with the Differences between the Leaves according to Their Descending Insertion Level

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Dedicated to Academician S. Prát on the occasion of his 80th birthday

Abstract. The differences between leaves of different age according to their descending insertion level (starting from the youngest, 18th leaf) were compared with the changes occurring during the corresponding period of ontogenesis of the 18th unshaded leaf using the gas exchange [net photosynthetic CO₂ uptake ($P_N$), water vapour efflux (E)] of the adaxial and abaxial surfaces of tobacco leaves as an example. Experimental elimination of the influence of shading during the involved period of ontogenesis of the 18th leaf manifested itself by a relatively slower decrease in $P_N$ and by fluctuation of the E values at approximately the same level. Thus the differences between leaves of different insertion levels cannot be exclusively ascribed to the effect of their ontogenetic age.

Additional index words: photosynthesis; transpiration; productivity of transpiration.

The differences between the leaves according to their descendent insertion level demonstrate to a certain extent the ontogenetic trend of the development of the individual leaves. This fact is often used for an indirect estimation of the effect of leaf age on the physiological processes, the anatomical structure etc. Using the insertion level instead of the leaf ontogenesis is advantageous especially in cases when collection of samples may lead to irreversible damage of the leaves and the samples cannot be drawn from the same spot. However, when using this method the influence of changes of the external conditions, mainly irradiation, due to mutual shading of the leaves, may manifest itself besides the effect of leaf age. This fact has to be taken into account especially in investigations of the gas exchange in leaves (e.g. BEUERLEIN and PENDLETON 1971, JEWISS and WOLEDGE 1967, SAEKI 1959, TICHÁ 1968, WOLEDGE 1972, 1973).

In the present communication the differences caused by the descending insertion level of the leaves (from the youngest, 18th leaf) were compared

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with the changes occurring during the corresponding period of ontogenesis of the 18th (numbered from the stem base) unshaded leaf in tobacco as to net photosynthetic CO₂ uptake, \( P_N \), water vapour efflux, \( E \), and their ratio, \( P_N/E \), at the adaxial and abaxial leaf surfaces.

**Material and Methods**

Tobacco (*Nicotiana tabacum* L. cv. ‘Wisconsin 38’) plants were grown in Mitscherlich pots filled with clay soil and placed in a growth cabinet (Sherer CEL 37-14) at an irradiance of 55 W m⁻² (400—700 nm, fluorescent tubes Sylvania). The plants were cultivated at a day-length of 16 h at a day/night air temperature of 25/18 °C and day/night relative air humidity of 70/80%.

The plastochron index, PI, and leaf plastochron index, LPI, were determined by measuring the length of all leaves at regular intervals (ERICKSON and MICHELINT 1957). The gas exchange measurements according to the insertion level were performed once when the plants had reached an age of PI 19.0, the 19th leaf from the stem base having acquired a length of 10 cm. The leaves were numbered from the top according to the LPI. Thus the index leaf (the 19th one) was designated LPI 0.0, the next older (18th) one LPI 1.0 and so forth. At the same time the gas exchange was measured in a second series of experimental plants during ontogenesis of the 18th leaf (also expressed by means of LPI) up to a plastochrone age of LPI 13.0 corresponding to the age of the oldest leaf (i.e. the 6th one) after measuring to the insertion level. If needed, newly formed and expanding leaves were successively bent aside in order to prevent shading of the 18th leaves investigated and to ensure their full exposure to incident irradiation.

During the gas exchange measurements the leaves were exposed in a bilateral air-conditioned assimilation chamber (simplified type of the chamber according to JARVIS and SLAT'ZER 1966) at an irradiation density of 300 W m⁻² (400—700 nm) (photoflood incandescent lamp with an internal reflector 500 W with water cooling) in an open air system (25 °C, 60% relative air humidity, ca. 350 ppm CO₂). The changes in CO₂ and water vapour concentrations were determined for both leaf surfaces separately using differential infra-red gas analysers (URAS 1 — Hartmann and Braun).

**Results and Discussion**

The initial values of the gas exchange showed approximately the same level in both experimental series (Figs. 1 and 2). The same is true of the initial changes of \( P_N \) at both the adaxial and abaxial surfaces (Fig. 1). However, at later stages \( P_N \) decreased more rapidly according to the insertion level than during ageing of the 18th unshaded leaf. Similar results were obtained for \( E \) at the adaxial surface (Fig. 2). However, at the abaxial surface distinct differences in \( E \) appeared between “ontogenesis” and “insertion level”. While during the investigated period of ontogenesis of the 18th leaf the \( E \) values preserved approximately the same level they decreased progressively after having reached a shallow maximum in the leaves with the largest area (LPI 5.0—LPI 7.0), if estimated according to the insertion level (Fig. 2). This smoothed out somewhat the differences between “ontogenesis” and “insertion level” in \( P_N/E \) in older leaves with a LPI 10.0—13.0 (Fig. 3). However, in both cases a decisive influence on the character of the changes in \( P_N/E \) was exerted by the values of \( P_N \).

When measuring the gas exchange according to the insertion level the deteriorating conditions of irradiation at the lower levels influenced more (\( E \)) or less (\( P_N \)) the gas exchange at both leaf surfaces. This was most conspicuous in \( E \) at the abaxial surface where the values of \( E \) corresponding to the minimum stomatal resistance, \( r_s \) (\( E \) was shown to be closely correlated to leaf diffusion resistance, \( r_d \), and \( r_s \), resp., VÁCLAVÍK 1973) were not reached during the investigated stages of ontogenesis of the 18th unshaded leaf. Similar conclusions concerning the influence of age and irradiation conditions