Effect of Stomatal Differences Among Species on Leaf Photosynthesis

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It was reported in a previous paper (3) that there was no relation between photosynthesis and the numbers, lengths, and arrangement of stomata in a leaf. These data were for species with rates of 20 to 60 mg CO₂ dm⁻² hr⁻¹. Species with stomata on only the lower surface of a leaf had photosynthetic rates of 5 to 15 mg CO₂ dm⁻² hr⁻¹; among these species stomatal arrangement seemed to be limiting rates. In recent studies with cotton and soybeans, it was observed that numbers of stomata in the top surface of a leaf were much less than in leaves of species studied previously. Thus it seemed desirable to repeat the previous experiments, in hopes of clarifying how number of stomata in the top surface of a leaf can become limiting.

**TECHNIQUE**

Net photosynthetic rates (Net P) of leaves were measured, using the leaf chamber technique, and methods of measuring stomata were used under artificial lights as described earlier (3) and modified later (1). For studies on the effect of vaselined surfaces on net photosynthesis, leaves were removed from the chamber after a rate was established and either the upper or lower surface was covered with vaseline. Measurements were obtained on these leaves immediately after treatment. All measurements were determined at 300 ppm CO₂, 35°C, and 2.3 ly min⁻¹ light intensity.

Species used in these studies were ‘Mammoth Russian’, *Helianthus annuus* L.; ‘Hegari’, *Sorghum vulgare* L.; ‘Turkish Samson’, *Nicotiana tabacum* L.; *Tithesia populnea* (L.) Soland; and ‘Deltapine Smoothleaf’ cotton and other strains of *Gossypium hirsutum* L.

**RESULTS AND DISCUSSION**

New data on the effect of numbers and lengths of stomata on net photosynthesis are presented in Figure 1. The product bxn is that obtained by multiplying numbers of stomata (n) per square centimeter of leaf area by the greater axis (b) of the stomata in microns. This is the same bxn that was calculated previously (3).

The experimental data suggest that top stomata become limiting as bxn decreases in a manner denoted by the hatched line B of Figure 1, with 20 to 25 mg CO₂ dm⁻² hr⁻¹ as the limiting rate as bxn approaches zero. Such a relationship is not compatible with the kinetic theory of limiting factors as derived by Rabinowitch (4) and others. As a limiting factor approaches zero, the response curve should asymptotically approach a limiting slope from under the limiting line, and as bxn becomes nonlimiting, the response curve should approach a horizontal line representing the maximum Net P possible. Such a slope was observed for sunflower and soybean lines.

Figure 1. Net photosynthesis as a function of bxn of the top surfaces of leaves among species. Line B was sketched to represent the function suggested by experimental data. It was drawn through species or leaves with minimum top bxn; there are many species with greater top bxn than sorghum. Lines A and C were sketched to represent the function suggested by leaves covered with vaseline on the top surface and by chemical kinetic theory. Standard error for bxn of sunflower was 33 × 10⁻³.

Published November, 1964