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Photosynthesis and transpiration of desiccating poplar leaves

The relation between water content of detached leaves of *Populus euramericana* 'robusta' and the rate of photosynthesis at various light intensities and carbon dioxide concentrations of the air was investigated. A reduction of water content was obtained by simply depriving the leaf in the assimilation chamber from any water. It takes some time before photosynthesis reaches a steady state level. A piece of elastic plastic tube, slipped over the petiole, contained a small amount of water, just sufficient for this period. The total amount of water transpired, as calculated from the area of the recording of transpiration rate, should be equal to the loss of weight of the leaf + tube during the experiment. Both measurements agree very well. Differences between + 30 and + 55 mg were found on a total weight loss of about 800 mg in experiments which lasted more than 6 hours and in which the water content of the leaves diminished from 80 to 50%. The moment at which the water was used up, was marked by the well known Ivanov effect. From thereon the amount of water in the leaf diminished at a rate equal to the transpiration rate. At the end of the experiment the fresh and dry weight of the leaf was determined. From the fresh weight at the end of the experiment and the transpiration data, the course of the fresh weight and water content, since the beginning of the desiccation, were calculated.

The relation between the water content and the degree of limitation of photosynthesis by diffusion naturally depends on the CO₂-content; it has been measured at 0.3% and at 5% CO₂ in the air. At 0.3% CO₂ the decline of light saturated photosynthesis occurs between 77 and 64% water content. The reproducibility of this S-shaped relation depends to some extent on the vigour of the plants.

A carbon dioxide content of the air of 0.3% is clearly insufficient for CO₂ saturation of the photosynthetic apparatus when the stomata are practically closed. An increase in the carbon dioxide content of the air to 5% eliminates this CO₂ limitation and does not affect the maximum of light saturated photosynthesis. Then the relation between water content and the light- and CO₂-saturated rate of photosynthesis in the range of water contents investigated appears to be linear and the efficiency and the CO₂- and light-saturated rate are affected similarly by water content. The decrease begins at a water content of 72%. By extrapolation it is estimated that efficiency and rate are 0 at a water content of 50%. The fact that efficiency and maximum rate are affected to the same extent is not easily explained on the basis of photosynthesis as a catenary process unless they react in the same way, by e.g. an all or nothing reaction of the photosynthetic units to drought.

As shown by the measurements at 5% CO₂, the slight decline in the efficiency of the photosynthesis light intensity curve measured at 0.3% CO₂ is in full agreement with the reduction of activity of the enzymatic system by water stress.

It is clear that the reduction of the photosynthetic rate at light saturation by water stress of leaves exposed to normal air is mainly determined by stomatal closure, but that at low light intensities it is determined by the reduced activity of the enzymatic system.

The calculated stomatal resistance for water vapour is too high to permit the rate of photosynthesis found. A plausible explanation of this divergence may be that the pathways of diffusion of CO₂ or H₂O are not identical or a rejection of the assumption that the relative humidity in the intercellular spaces deviated only weakly from 100% in these desiccating leaves.