THE PHOTOACOUSTIC METHOD IN MEASURING CO_2 EVOLUTION BY LEAVES AND NEEDLES OF WOODY PLANTS UNDER HYPOBARIA

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Using the photoacoustic spectroscopy method, the CO_2 *flux from the leaves and needles was measured for some trees: cedar, larch, asp, and birch. A study of the* CO_2 *emission at reduced pressure (corresponding to the altitude of* 3000 m *above the sea level) was carried out.*

The fact of respiration activization and corresponding enhancement of CO_2 evolution by plants under extreme conditions is well-known.[1] Investigators also note similar changes under lower barometric pressure – hypobaria.[2,3] Taking into account that lower barometric pressure is a native habitat for high-elevation forests' growth one can expect considerable changes in physiology of the trees and, on the other hand, in quantity of atmospheric CO_2 above the high-elevation forests. A knowledge of that fact is very important in revealing the role and contribution of the forests to the greenhouse effect. Besides, the activity and kinetics of CO_2 evolution can be used as integral characteristics of plant gas exchange in study of woody plants state and their physiology under Alpine conditions and mechanism of their resistance. The available data on influence of altitude factors on some photosynthesis reactions, respiration, and growth of plants mainly deal with herbaceous plants.[4–7] Distinctions of woody plant metabolism are studied to a considerably lesser degree. In recent years the method of laser photoacoustic spectroscopy becomes more and more popular in study of photosynthesis, registration of ethylene evolution, and respiratory gas exchange in herbaceous plants.[8–10] In particular, by this method the authors succeed to demonstrate the species distinctions of CO_2 evolution rate under rarefied air and its dependence on intensity and duration of hypobaria action on herbaceous plants.[2,3] This permits one to expect that the method can be applied to study woody plants as well. This work continues the previous ones[2,3] in order to determine

– species distinctions in CO_2 evolution intensity by woody plants;

– distinctions of CO_2 exchange in woody plants under moderate hypobaria as a model of corresponding high-altitude ecological zones.

MATERIALS AND METHODS

Four-year plants of siberian cedar (*Pinus sibirica Dur Tour*), siberian larch (*Larix sibirica*), and mature birch-trees (*Betula verrucosa L.*) and asps (*Populus tremula L.*) were the subjects of the research.

Activity of CO_2 evolution during respiration of leaves and needles of the above-mentioned woody species was determined by the method of photoacoustic spectroscopy under normal barometric pressure (control plants) and moderate hypobaria (test plants).

Hypobaria was created in an experimental chamber of 10^{-3} m^3 volume by evacuating air. Total barometric pressure in the experiment was 68 kPa, partial O_2 and CO_2 pressures were 14.5 kPa and 0.022 kPa which was equivalent to conditions at 3000 m altitude over the sea level. Simultaneously, the control plants were placed in a similar chamber under normal air pressure of 101 kPa, partial O_2 and CO_2 pressures were 21.2 and 0.032 kPa. Temperature of 22°C was kept constant in both cases.

During the experiment, the plants were placed in a dark chamber to reduce photosynthesis activity. The exposition time in the experiment varied from 3 to 170 hours.

Intensity of needle and leaf respiration was estimated by CO_2 evolution kinetics in the closed volume of the experimental chambers by the methodology described earlier.[10] The measured values of CO_2 concentration were converted in terms of 1 g of fresh plant mass.

MEASUREMENT RESULTS

Figs. 1 and 2 present the time dependence of the value B. B is the ratio of CO_2 concentration in the exposition chamber to that in the atmospheric air under 101 kPa pressure normalized to unit mass.

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Measurements of intensity and kinetics of CO_2 evolution by leaves and needles of the studied woody species under normal pressure of 101 kPa demonstrate their species distinctions. During the first 24 hours, the most intensive CO_2 evolution was observed in deciduous plants, asp and birch. Later, we observed insignificant decrease and stabilization of CO_2 evolution in deciduous species; as for conifers (cedar, larch), the process of gradual increase of CO_2 evolution took place. These specificities seem to be a result of xero- and mesomorphic distinctions of leaves and needles, and anatomical, morphological, and physiobiochemical distinctions of some species of woody organisms in the whole.

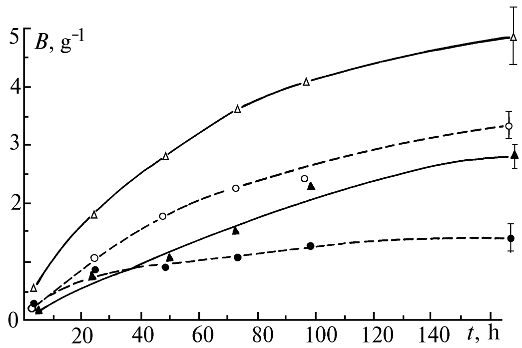

FIG. 1. Comparison of the functions B = f(t) for larch and cedar under normal conditions (*P* = 101 kPa) *and hypobaria* (*P* = 68 kPa). *Larch: hypobaria* (△), *normal conditions* (▲). *Cedar: hypobaria* (○), *normal conditions* (●)

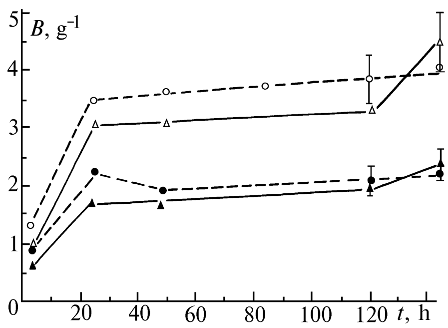

FIG. 2. Functions B = f(t) for birch and asp. Birch: hypobaria (△), *normal conditions* (▲). *Asp: hypobaria* (○), *normal conditions* (●)

Under hypobaria (*P* = 68 kPa), the assimilating surface of leaves and needles of all woody species intensifies the CO_2 evolution. The relative magnitude of CO_2 release is higher in larch as compared with cedar from the first hours of the experiment. Intensity of CO_2 gas exchange in asp under hypobaria is higher than in birch-trees but less than the larch's one, especially at longer exposition time. The difference in kinetics of CO_2 evolution during the experiment is commanding the attraction. Initial activization of CO_2 evolution under hypobaria with following stabilization is observed in deciduous species. As to conifers, CO_2 evolution under rarefied air gradually passes into the saturation stage.

Increase of CO_2 evolution together with reduction of transpiration and photosynthesis, and other physiological and biochemical characteristics is considered as an exhibition of protective reactions providing less sensitivity to extreme conditions.[11] So, based on our data, one can suppose that cedar is less sensitive to the rarefied atmosphere as compared with larch. Perhaps, it is the property that provides wider abundance of siberian cedar in high-altitude zones and possibility of its occurrence at the height boundary of forests.

More active kinetics of CO_2 evolution during the process of birch and asp respiration at small exposition time may be a consequence of their metabolism specificity under hypobaria. Perhaps, distinctions in response reactions of deciduous trees and conifers to similar hypobaria conditions reflects the variety of plants' adaptive mechanisms and shows the efficiency of the photoacoustic spectroscopy method in study of distinctions of physiological cycles in woody plants. The results obtained show that the hypobaric hypoxia stimulates the CO_2 evolution to be 1.2–2.5 times greater at 68 kPa air pressure as compared with the standard one. The peculiarities of the CO_2 evolution kinetics correlate with sensitivity of adaptation mechanisms of the wooden plants to high-elevation conditions.

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