ECOPHYSIOLOGICAL ASPECTS IN HORTICULTURAL RESEARCH

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INTRODUCTION

Through their ages exchange processes (photosynthesis, transpiration and respiration) plants exchange major inorganic elements (carbon, hydrogen, oxygen) with their environment. Therefore these processes have an important influence on plant growth and productivity (i.e. accumulated carbohydrates) as well as on the interrelationships between plants and their environment. The study of these gas exchange processes (ecophysiology) in relation to different environmental conditions (both physical and physico-chemical) and to genetic differences among different cultivars or genotypes can provide interesting information in view of selection toward enhanced productivity, (greenhouse) climate control, etc. Different applications of ecophysiological studies in horticultural research could also be envisaged: the use of physiological indices in breeding and selection programs of horticultural plants, determination of optimal or non-limiting environmental conditions (temperature, humidity, CO_2 concentration) -which might certainly have important significance in glasshouse horticulture— or the evaluation and prediction of technico-cultural or management applications (fertilization, salinisation, use of antitranspirants) on horticultural production.

Examples of all these possible applications will be given here under, but first some general methodological features will be given.

METHODOLOGY

In the laboratory gas exchange processes (transpiration, photosynthesis, respiration) are studied on single leaves, single plants or small vegetations in environment controlled gas exchange chambers (or cuvettes). Environmental conditions in these assimilation chambers (with an inner volume ranging from 6 dm^3 to 30 dm^3 according to plant or leaf dimensions) are controlled by means of highly sophisticated electronic control systems. Further specific advantages of these laboratory techniques next to the simultaneous measurement of both CO_2 and water vapour exchange processes include the continuous and natural air movement over the plant material enclosed in the cuvette, as well as the non-destructive character of the measurements. Typical long-term experiments can be performed under ideal circumstances using these laboratory chambers.

Under field or glasshouse conditions a portable gas exchange unit consisting of an infrared gas analyser, a twin set of membrane pumps and a small laboratory-constructed plexi gas exchanged cuvette is used. The dimensions, form and design of the gas exchange cuvettes can also be adapted to the specific plant or leaf characteristics. Contrary to the above mentioned laboratory assimilation chambers, environmental conditions (e.g. temperature) in these cuvette types can only be partially controlled. A small inner fan provides a considerable wind speed over the enclosed plant organ. However, very fast and short-term sampling times make the use of highly sophisticated environmental control mechanisms unnecessary as well as bulky in the field or in the glasshouse.

The so-called electrical analogon model originally described by Gaastra (1959) is used in order to split up the resistances to both gas exchange processes in boundary layer, stomatal and internal contributions. Together with some other underlying anato-morphological and biochemical leaf characteristics, these basic gas exchange resistances are very helpful in understanding the gas exchange processes.

EXAMPLES AND RESULTS

Use of ecophysiological studies as a preliminary growth or selection index

For a number of azalea (*Rhododendron simsii* Planch.) cultivars net photosynthesis — light response curves were made up under optimal and controlled environmental conditions. Good agreement was obtained between light satured net photosynthetic rate (expressed either per plant or per unit projected crown area) and growth performance of different cultivars. Growth was expressed in this case as crown diameter which determines —together with flower size— the azalea parket price.

Similar considerable differences in net photosynthesis were observed among a population of seedlings of the New-

Zealand laurier (*Corynocarpus laevigatus*) as well as among a number of *Bromelia* and *Vriesea* cultivars (fam. *Bromeliaceas*) with relation to their responses to light and temperature. Here it might be possible to select among a population for seedlings or cultivars that are optimally adapted to certain temperature and light conditions.

Influence of light and temperature on plant growth or productivity

In view of the rentability problems in horticulture caused by the increased energy (oil, gas) prices, the introduction of new cultivars or selections with low energy requirements (light, temperature) is a basic prerequisite. It has been shown that certain New-Zealand laurier (*Corynocarpus laevigatus*) and *Ardisia crenulata* seedlings performed optimal net CO_2 uptake and optimal growth at moderate temperature (10 to 15 °C) and light (ca. 23 klux) combinations. From the ecophysiological data obtained on these plants —that are both originating from New-Zealand with quite low mean annual temperature— it could be concluded that in winter time —when incoming light in the greenhouse is the main limiting factor —considerable heating and increase in air temperature is unnecessary. Moreover, it has been shown on some other ornamentals (*Dieffenbachia* spec., *Schefflera arboricola, Ficus lyrata* and *Epiprennum aureum*) that optimal temperature for net photosynthesis is reflected in the main underlying biochemical CO_2 fixing reactions and processes at the chloroplast level (photophosphorylation, ATP-production...). For *Schefflera arboricola* (cv. Compacta) optimal temperatures for net photosynthesis —hence for growth— were found at 25 °C under an incident photon flux density of 450 μmol m^{-2} s^{-1}. With increasing vapour pressure deficit transpiration increased while diffusive conductance as well as leaf temperature decreased. However, differences in vapour pressure deficit had no significant influence on net photosynthesis nor on xylem water potential.

Effects of cultural management techniques or applications

For *Ficus benjamina* and an azalea (*Rhododendron simsii* Planch.) cultivar the effects of different fertilization levels in several ecophysiological as well as morphological characteristics were studied. For *Ficus benjamina* optimal fertilizer concentration for maximum growth was indicated by minimal light compensation point while maximal photosynthetic rates fertilization level as optimal crown diameter, hence productivity class.

The effect of antitranspirant application on transpiration, photosynthesis and growth of azalea could also be evaluated through ecophysiological studies. Because of the fact that both gas exchange processes were limited by the antitranspirant application, long-term use would reduce growth considerably.

Finally, effects of salinity or water stress on gas exchange of *Schefflera arboricola* have been studied and indicated that stomatal conductance and leaf water potential were significantly influenced by salinity and water stress. However, *Schefflera arboricola* showed interesting prospectives for horticulture under saline irrigation conditions.

CONCLUSIONS

Through different examples on several horticultural and ornamental species and varietes it has been shown that ecophysiological gas exchange studies whether or not in combination with morphological or plant architectural measurements could provide interesting and useful information that could be valuable in view of breeding and selection programs, for determinations of optimal or non-limiting environmental conditions (greenhouse climate control programming), for preliminary evaluation of cultural management strategies or early indication of water stress situations.

LITERATURE

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