Biological Process Control in Greenhouses: A Physiological Approach

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INTRODUCTION

Photosynthesis takes place practically everywhere on the earth from the Arctic to the tropics where plants, unlike animals living in the same conditions, need to be able to adapt to changes in environmental conditions to survive. The latter phrase may sound dramatic, however, most ornamental pot plants are exposed to major changes in environmental conditions even in a greenhouse, and especially during the last journey from the greenhouse to the consumers.

The ability of plants to adapt to changes in environmental conditions partly depends on their original ecological niche. A prerequisite for optimal production of these ornamental pot plants is knowledge about their natural demands, and especially their physiological adaptability.

Photosynthesis as an expression of a plant's reaction to climatic conditions is the basis of part of the research project "Biological Process Control in Greenhouses" that is carried out in collaboration between the Department of Floriculture (Danish Institute of Plant and Soil Science) and departments at the Royal Veterinary and Agricultural University. The long-term objective is to develop computer-based management tools for climate control in greenhouses based on knowledge about the physiological responses of the plants. At the Department of Floriculture, two projects are exclusively dealing with photosynthesis while the projects at the Royal Veterinary and Agricultural University focus on microclimate and modelling, and development of the computer programme and user interface.

Today, research in photosynthesis is intensive and is carried out at several levels. A significant effort is concentrated on the description of the photosynthetic processes at the cellular level, whereas the interest with respect to the leaf and the whole plant is limited. It is, however, necessary to study at several levels in order to explain the mechanisms lying beneath the physiological responses observed.

LIGHT STRESSES DURING GROWTH?

Fluorescence measurements are used in the project to study light stress of plants—if necessary in connection with other stress factors such as shortage of water or nutrients. At this stage, it seems that the plants obtain a "knowledge" about the amount of light—the light sum—to which they have been exposed during the course of the day. If a certain threshold is being exceeded, the plants become photoinhibited—photosynthesis is inhibited thus biomass production drops. In a glasshouse, knowledge about light stress can be used to develop strategies for the use and density of shade curtains. While the curtains reduce temperature they also diminish the amount of valuable light.

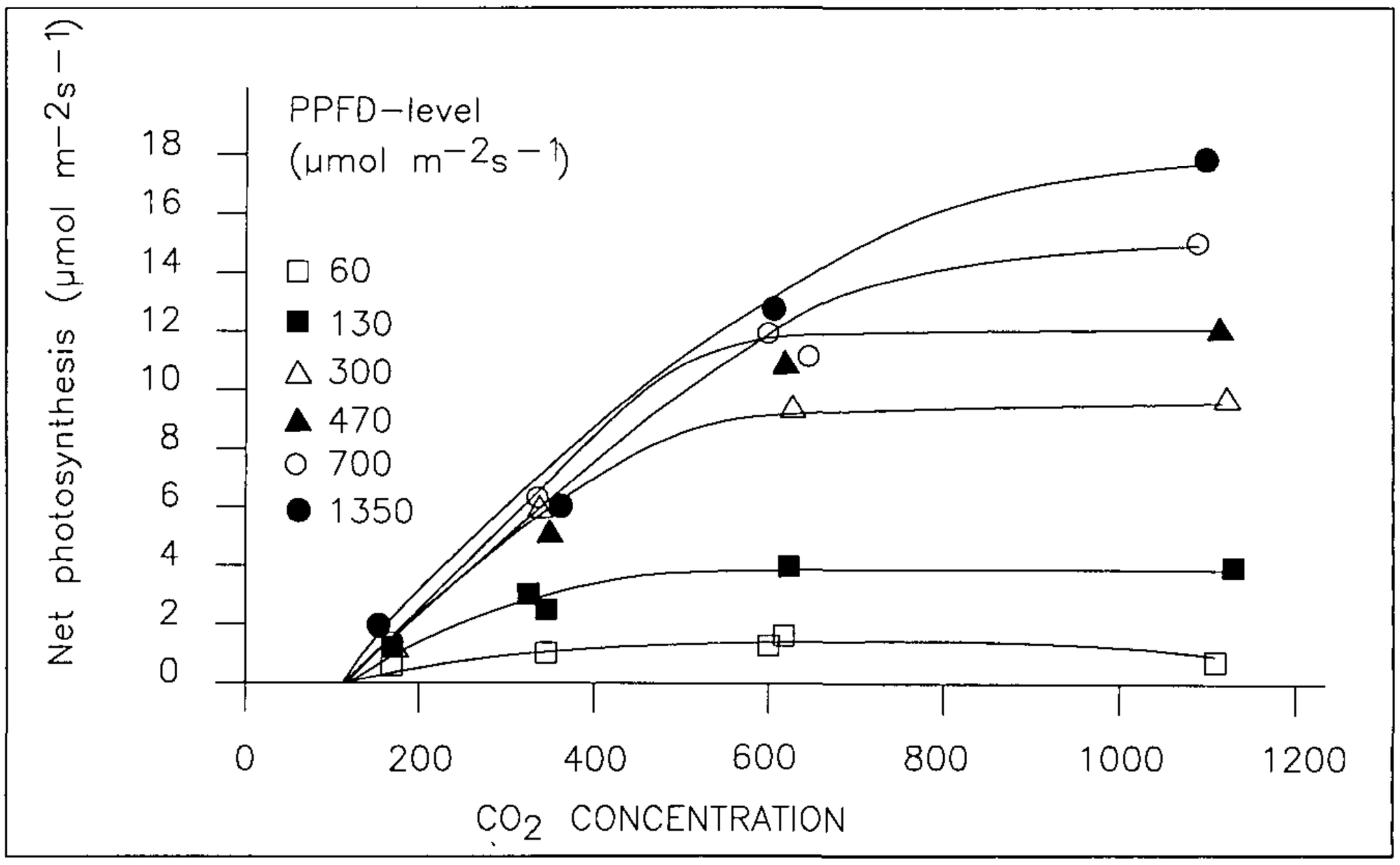

Figure 1. Net photosynthesis as a function of CO_2 concentration and irradiance level.

EFFECTS OF CO_2 UNDER SUBOPTIMAL CONDITIONS

For the last 40 years it has been routine to supply CO_2 to greenhouses to stimulate growth of plants. The increasing CO_2 concentration in the atmosphere and the subsequent problems related to the greenhouse effect have given rise to many recent investigations. The effects of CO_2 on growth under low irradiance conditions do not seem to be as evident as previously believed. Plants may adapt to elevated CO_2 when grown for a prolonged period under elevated CO_2 conditions. When photosynthesis is measured under a combination of different CO_2 concentrations and irradiance conditions results from experiments with several foliage species, such as *Ficus benjamina* and *Schefflera arboricola*, indicate quite clearly that during low light conditions in the winter period, the effect of elevated CO_2 conditions is limited. Gas exchange studies showed a maximum rate at a CO_2 concentration of 5 to 600 ppm at low irradiance conditions (<343 µmol $m^{-2}s^{-1}$) (Fig. 1).

HOW DO WE IMPROVE THE QUALITY OF POT PLANTS

Pot plants are in principle grown under optimal conditions, therefore, they tend to become more sensitive to both biotic and abiotic stresses. In this context, stress conditions refer to the capabilities of plants to sustain the environmental influences that they are subjected to during packaging and transport and so, before they end up in the window sill. Our knowledge about the genetic background for stress tolerance and the effect of growth conditions on this is limited. One reason could be the differences in the sensitivity to ethylene. However, when otherwise similar plants from different nurseries react very differently to a keeping quality test, the causes may be physiological. A physiologically based keeping quality test is, therefore, one of the important steps to include in order to adjust a biologically controlled greenhouse system.