Light Effects on Wax Begonia: Photosynthesis, Growth Respiration, and Maintenance Respiration

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INTRODUCTION

Plant growth is a result of excess carbon synthesized in photosynthesis over that lost in respiration. Continuous measurement of photosynthesis and respiration rates of whole–plants can determine dry matter production and growth rate more accurately than short–term individual leaf measurements. However, research on whole–plant metabolism is limited. The objective of this experiment was to quantify the effects of increasing photosynthetic photon flux (PPF) on whole–crop photosynthesis and respiration rates of wax begonia.

MATERIALS AND METHODS

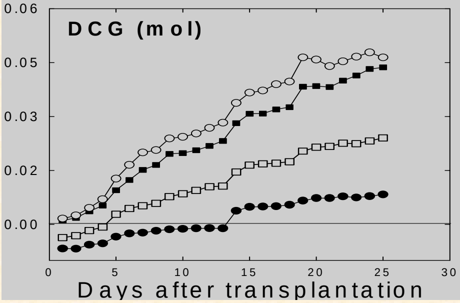
Net–photosynthesis (P_n) and dark respiration (R_d) rates of a whole–crop of wax begonia were measured continuously for a period of 25 days using a whole–plant gas exchange system (van Iersel and Bugbee, 2000) under four PPF treatments (total daily PPF flux of 5.3, 9.5, 14.4, and 19.4 mol·m^{-2}·d^{-1}).

Various physiological growth parameters, including gross– photosynthesis, daily carbon gain (DCG), carbon use efficiency (CUE), relative growth rate, coefficients of growth and maintenance respiration, and maintenance (R_m) and growth (R_g) respiration rates were calculated from the measured P_n and R_d rates.

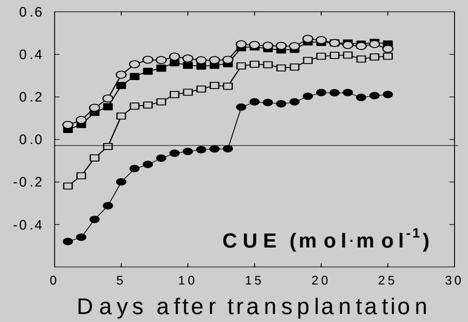
A whole–plant gas exchange chamber containing wax begonia seedlings.

RESULTS AND DISCUSSION

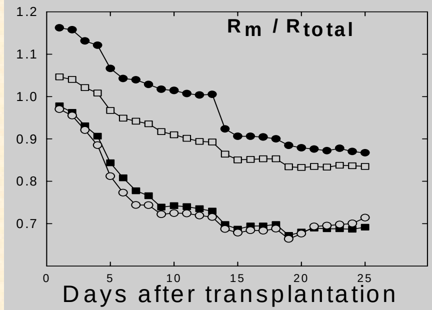
Daily carbon gain (growth rate) increased linearly with increasing PPF. Plants grown at 5.3 and 9.5 mol·m^{-2}·d^{-1} initially respired more than they photosynthesized, which resulted in a negative DCG during the initial 13 and 4 days, respectively. Symbols 'M, G, O, and F' in the graph indicate a PPF of 5.3, 9.5, 14.4 and 19.4 mol·m^{-2}·d^{-1}, respectively.



Carbon use efficiency (ratio of carbon incorporated in dry matter to carbon fixed in gross photosynthesis) of plants was lower than that reported values for other crops. Throughout the experiment, CUE increased up to a PPF of 14.4 mol·m^{-2}·d^{-1} and did not differ between 14.4 and 19.4 mol·m^{-2}·d^{-1}. Symbols 'M, G, O, and F' in the graph indicate a PPF of 5.3, 9.5, 14.4 and 19.4 mol·m^{-2}·d^{-1}, respectively.



The fraction of total respiration (R_{total}) accounted for by maintenance respiration (R_m) decreased during the growth period. However, throughout the experiment, R_m was greater than growth respiration in all treatments. At harvest, maintenance respiration accounted for 87, 83, 69, and 71 % of total respiration for plants grown at 5.3, 9.5, 14.4 and 19.4 mol·m^{-2}·d^{-1}, respectively. Symbols 'M, G, O, and F' in the graph indicate a PPF of 5.3, 9.5, 14.4 and 19.4 mol·m^{-2}·d^{-1}, respectively.



CONCLUSIONS

1. Plant growth rate increased with increasing PPF due to consistent increases in P_n and DCG.

2. Carbon use efficiency was lower than that of other crops due to higher R_m in plants. This partly may be the physiological basis of slow growth rate in wax begonias.

3. Plants at low PPF used much of the carbohydrates fixed in photosynthesis for maintenance, resulting in very slow growth.

LITERATURE CITED

van Iersel, M.W. and B. Bugbee. 2000. A multiple chamber, semicontinuous, crop carbon dioxide exchange system: Design, calibration, and data interpretation. J. Amer. Soc. Hort. Sci. 125:86-92.

See abstract #2138 for related research