CANOPY PHOTOSYNTHESIS OF DRY BEAN: MEASUREMENT AND PREDICTION

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As part of a drought stress study with dry bean (Phaseolus vulgaris L.), canopy apparent photosynthetic (CAP) rates of fully irrigated plants were measured to determine optimum CAP and maximum light use efficiency as a function of LAI and crop age, and to use published canopy photosynthesis functions to fit the field measured CAP data. The experiment was conducted at the Irrigation Park at the University of Florida, with a Millhopper fine sandy soil (loamy, siliceous, hyperthermic, gosarenic Paleudult). For this study daily irrigated plots of both cultivars, e.g. "Porrillo Sintetico" and "BAT-477" were used. Growth and yield data have been reported by Mahamadou et al. (1987).

At weekly intervals a portable canopy photosynthesis chamber and a LI-6000 were used to determine CAP of the two dry bean cultivars. CAP was measured by recording the rate of CO2-depletion for one-to-two minute intervals for the whole canopy within the chamber. Measurements were taken at full, half, and one quart of total sunlight, and under dark conditions. CO2-efflux of the bare soil was also measured. The field measured data points as a function of photosynthetic photon flux density (PPFD) are given in fig. 1. All plants inside the chamber were harvested for LAI and dry weight determination.

Boote and Jones (1987) reported several equations which can be used to calculate canopy photosynthesis as a function of light or quantum use efficiency (QE), maximum leaf photosynthetic rate (LFMAX), light extinction coefficient (K), leaf area index (LAI), and PPFD. The field data of this study were fitted to the equation reported by Acock et al. (1978) and others:

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\text{CAP} = \frac{\text{LFMAX}}{\text{K}} \ln \left[ \frac{(1 - M) \times \text{LFMAX} + \text{QE} \times K \times \text{PPFD}}{(1 - M) \times \text{LFMAX} + \text{QE} \times K \times \text{PPFD} \times \exp(-K \times \text{LAI})} \right]
\]

K was calculated, based on the relationship between % light penetration through the canopy and LAI determined for all plots as a function of time. Because no light reflection data were recorded, the leaf transmission coefficient (M) was assumed to be 0.2. A light response curve was fitted to the field measured CAP data, using non linear regression analysis techniques and QE and LFMAX were estimated. Net and total carbon photosynthetic rates were calculated by correcting CAP with dark respiration and soil CO2-efflux rates. Initial calculations showed that there was a high negative correlation between QE and LFMAX. Because QE also varied strongly as a function of time, QE was assumed to be fixed at 0.0524 mole CO2/mole absorbed PPFD, a value generally reported for C3 plants (Ehleringer and Bjorkman, 1977). Figure 1a shows the results of the light response curves as predicted by the Acock model for open canopies at

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low LAI, while fig. 1b shows the predicted light response curves for closed canopies. In all cases, the predicted CAP were very similar to the field measured CAP, although the fit at low LAI's was less accurate than at high LAI's.

The predicted LFMAX was in most cases lower than measured single photosynthesis. Fitting the data to a canopy photosynthesis model reported by Charles-Edwards (1981) resulted in higher predicted LFMAX than measured in the field. Based on the overall results, the Acock-equation will probably be used for calculating CAP as a function of PPFD, LAI, and LFMAX.


Figure 1. Measured and predicted Canopy Apparent Photosynthesis Rates as a function of Photosynthetic Photon Flux Density.