# RADIATION USE EFFICIENCY OF SUNFLOWER GENOTYPES

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## SUMMARY

Crop growth rate can be calculated as the product of intercepted photosynthetically active radiation (IPAR) and radiation use efficiency (RUE). A field experiment was conducted during 1990 at Cordoba, Spain, to study the RUE of four sunflower hybrids (Alahama Extra, Florasol, RP-4106 and Arbung E353), which had shown different crop growth rates in previous experiments. Measurements of noon and daily IPAR, leaf area index (LAI) and shoot dry matter were performed between emergence and anthesis. Measured extinction coefficient for incoming photosynthetically active radiation (PAR) at noon was 0.86 for all the four studied genotypes. The extinction coefficient for PAR on a daily basis was 1.02. Plots of shoot dry matter versus IPAR showed that RUE increased slightly as crop developed, ranging from 1.2 g $MJ^{-1}$ (30 days after planting (DAP)) to 2.7 g $MJ^{-1}$ (55 DAP). Average RUE for the studied period was 1.85 g $MJ^{-1}$. No differences, neither in average RUE nor in its seasonal trend were found among the four hybrids studied.

## INTRODUCTION

Accurate estimates of Radiation-Use Efficiency (RUE) are needed for modeling crop dry matter accumulation. Several crop growth models assume that RUE is constant for a given crop in non-stress environments (e.g. Jones and Kiniry, 1986).

This assumption is supported by several works summarized by Kiniry et al. (1989). These authors emphasized that even though, in temperate regions, RUE should decrease as crops develop due to increasing temperatures and biomass, both causing increased maintenance respiration (McCree and Silsbury, 1978), the relationship between dry-matter and IPAR was linear for all the data sets analyzed. Few data of RUE have been published for sunflower. Reported values ranged from 1.9 g $MJ^{-1}$ (Connor et al., 1985) to 5 g $MJ^{-1}$ (Kiniry et al. 1989). None of these works have studied intra-specific variation in sunflower RUE. The objective of our study was to compare the RUE of four sunflower hybrids, which had shown different growth rates in previous experiments (Orgaz, unpublished data).

## MATERIALS AND METHODS

Four sunflower hybrids (Florasol, RP-4106, Alhama Extra and Arbung-E353) were sown on a deep sandy-loam soil at the Agricultural Research Center of Cordoba, Spain (38°N 4°W) on 21 May 1990, in 0.7 m-rows oriented East-West. The crop was thinned to 7 plants $m^{-2}$ on 6 June. Preplant fertilizer was applied at rates of 100 Kg $ha^{-1}$ of N, 100 Kg $ha^{-1}$ $P_2O_5$ and 100 Kg $ha^{-1}$ of $K_2O$. An additional 100 Kg $ha^{-1}$ of N was applied on 15 June, before the first postplant irrigation. Four more irrigations were applied at 6 to 8 days intervals until 14 July. The plots were arranged in a randomized complete-block design with three replicates. Individual plots consisted of twelve 8-m rows.

Aerial biomass was determined by harvesting five plants per replicate on 6, 14, 19, 22 and 26 June, and 4, 12 and 18 July (anthesis of the earliest hybrid, Arbung E353). Leaf area of harvested plants was measured in a LI-COR 3100 area metter. On the indicated dates, prior to harvesting, noon light interception was measured in the same samples with a DECAGON line sunfleck ceptometer. Six measurements were taken below and two above the canopy for each replicate. Two ceptometers were continuously placed beneath the canopy for 9 whole days along the season in order to calculate the relationship between noon and daily light interception.

Intercepted PAR was calculated as the product of incoming PAR (50% of measured solar radiation) and the fraction of daily intercepted PAR ($Q_d$). Solar radiation was measured at a weather station located 400 m from the experimental plot.

## RESULTS AND DISCUSSION

The relationship between the fraction of incident PAR intercepted by the canopy at noon ($Q_n$) and LAI for the four hybrids (Fig. 1) was:

$$Q_n = 1 - e^{-0.86\ LAI} \qquad [1]$$

The relationship was the same for the four cultivars. The fraction of PAR intercepted on a daily basis ($Q_d$) was higher than $Q_n$ (Fig.2):

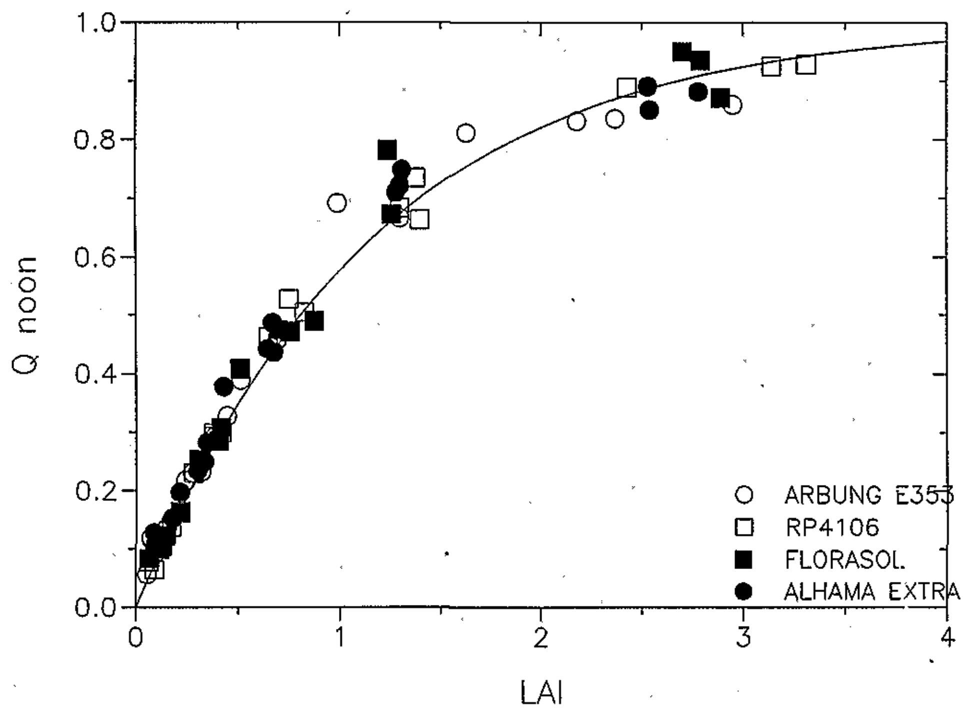
$$Q_d = 1.72\ (1 - e^{-0.863\ Qn}) \qquad [2]$$

This relationship is expected to be dependent on row arrangement. When $Q_d$ (estimated using Equation 2) was plotted against LAI, the resulting exctintion coefficient was 1.02 which is close to previous reported values (e.g. 0.9; Monteith, 1969).

Cumulative intercepted PAR was calculated from measured LAI and incoming PAR data using Equations 1 and 2. The relation between shoot biomass and intercepted PAR (Fig.3) shows that RUE increased as the crop developed, ranging from 1.2 g $MJ^{-1}$ at 30 days after planting (DAP) when LAI was 0.05 to 2.7 g $MJ^{-1}$ at 55 DAP, when LAI was close to 3. These results contrast with the constant RUE obtained in previous experiments summarized by Kiniry et al. (1989), but confirm experimental results of Trapani et al. (1991). The increase in RUE with crop development may be associated with light saturation at the leaf level in a crop which has heliotropic behaviour. Therefore, light saturation at the canopy level probably decreased as LAI increased. Average RUE for emergence-anthesis period was 1.85.

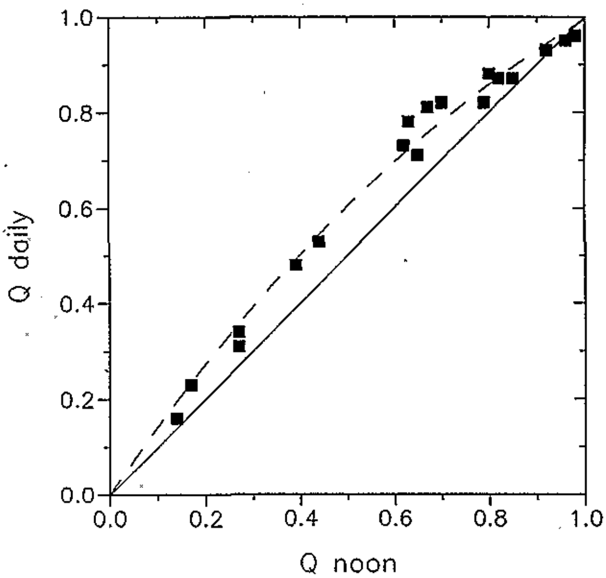
No differences were found among the four hybrids studied either in extinction coefficient or in RUE.

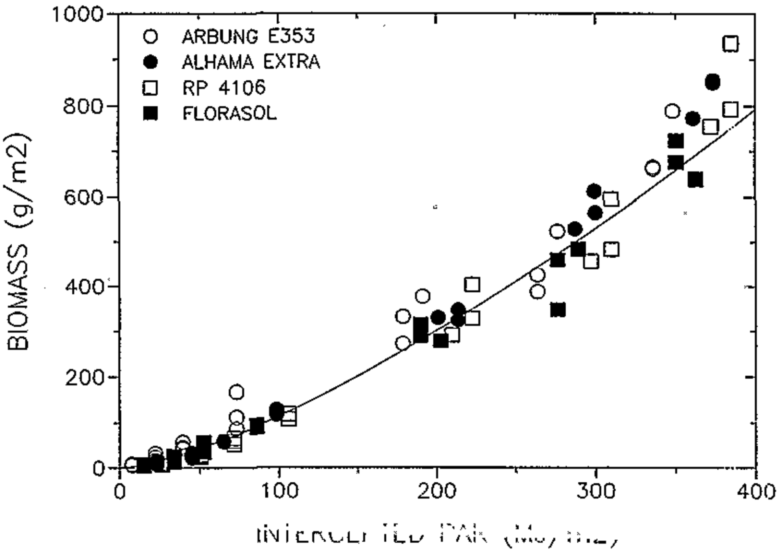
These results have important implications for modelling dry matter accumulation in sunflower.




1. Fraction of the incident PAR intercepted at noon (Q noon) as a function of leaf area index (LAI) for the cultivars studied. The line shows the regression function: $Q_{noon} = 1 - e^{-0.86\ LAI}$ ($r^2$=0.98).

2. Relationship between the fraction of the incident PAR intercepted on a daily basis (Q daily) and at noon (Q noon). The dotted line shows the regression function: $Q_d=1.72\ (1-e^{-0.863Qn})$ ($r^2$=0.99).




3. Aerial biomass versus cumulative intercepted PAR for the four hybrids. The line shows the fitted potential relationship: BIOMASS = 0.1825 $IPAR^{1.4}$ ($r^2$=0.95).

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