FILLING IN THE GAPS: MODELING AS A SPUR TO RESEARCH IN SUNFLOWER

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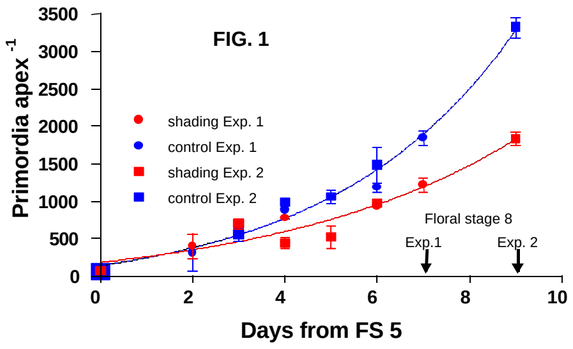
INTRODUCTION

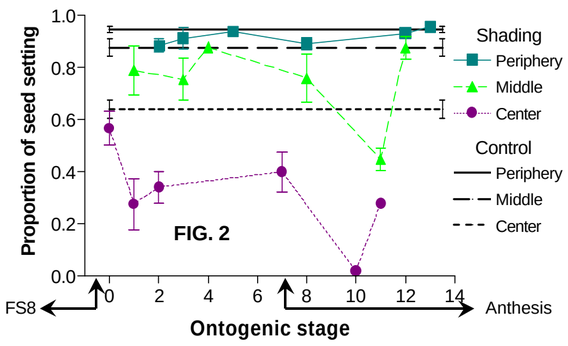
Formulation and testing of OILCROP-SUN (Villalobos et al., Agron. J. 88:403-415, 1996) served to expose a number of missing links in information about how the sunflower crop responds to the environment. Much of the work with this crop carried out in Buenos Aires over the subsequent years focused on these knowledge gaps. This poster summarizes four case studies.

CASE 1.

Radiation and grain number determination.

Problem: How does radiation during the critical period (floret initiation to end seed setting period) affect grain number?
Approach: Experiments involving short periods of shading (80 %, 7-10 days) during floral initiation (Exp.1 and 2) or at intervals between floral initiation and [anthesis+20d] (Exp. 3).
Conclusions: Shading reduced floret primordia number per capitulum (Fig. 1) without altering grain set (filled grains/floret, data not shown). Shading after floret differentiation was completed altered grain set differentially according to floret position and timing of shading (Fig. 2). Floret differentiation and the immediate post-anthesis periods exhibited maximum sensitivity to shading (Fig. 3). Reference: Cantagallo, J., Hall, A.J., 2000 – Reduction in the number of filled seed in sunflower (*Helianthus annuus* L.) by light stress. - 15th International Sunflower Conference – Toulouse – France, pp. D-35-40





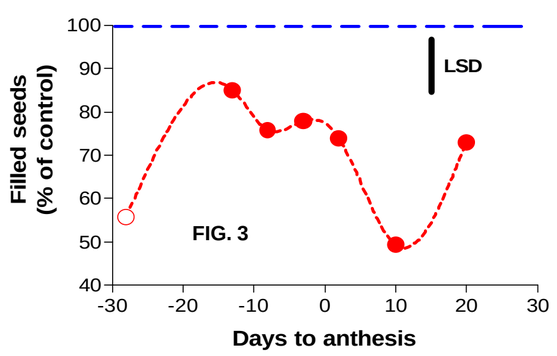


Fig. 1. Relationship between number of floral primordia per apex and days from floral stage (FS) 5. (start of floret differentation). Floret differentiation ceases at FS 8. FS5 occurred 32 days before anthesis, which, in turn, take place 56 days after emergence.

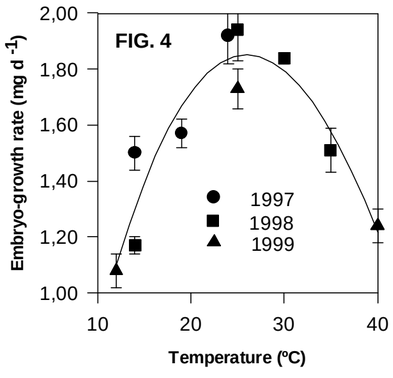
Fig. 2. Proportion of seed setting, in each sector of the head, as a function of the ontogenetic stage at the beginning of the shading treatment.

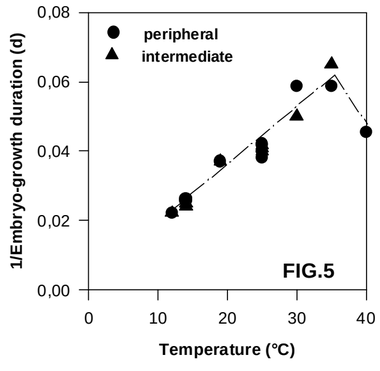
Fig. 3. Number of filled seed (expressed as percentage of the Control treatment) as a function of time to anthesis for mid-shade interval. Open circle: shading treatments from Exp. 2; filled circles: shading treatment from Exp. 3. LSD: least significant difference.

CASE 2.

Temperature effects on grain size.

Problem: No temperature response functions for sunflower grain growth were available at the time OILCROP-SUN was formulated. Functions for leaf responses were used as a substitute.
Approach: Plants were grown in controlled temperature glasshouses and embryo growth rates and durations determined.
Conclusions: Embryo growth rate (Fig. 4) and duration (Fig. 5) response functions were determined. The interaction betwen these variables resulted in continuous reductions of embryo size with temperatures above 20°C (Fig. 6). The cardinal temperatures (T_b, T_{opt}) for grain growth duration (-1°C and 34°C) were rather different to those for leaves (4°C and 24°C). Reference: Chimenti et al., 2000, Field Crops Research (in press).





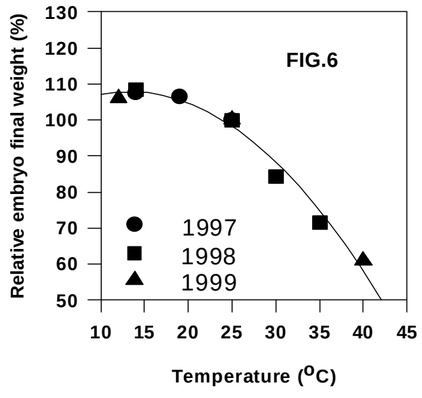


Figure 4. Relationship between embryo-growth rate and temperature for grains from the peripheral position of the capitulum.

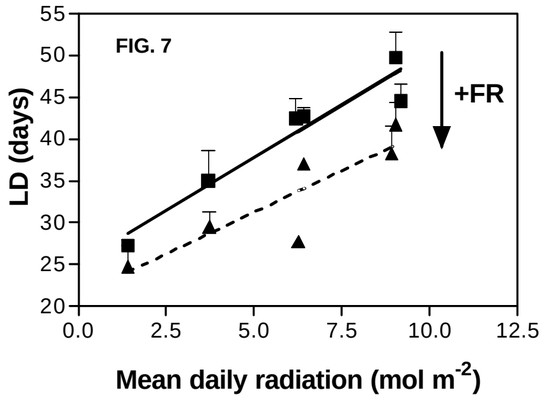
Figure 5. Relationship between the reciprocal of embryo-growth duration and temperature for grains from the peripheral and intermediate position of the capitulum.

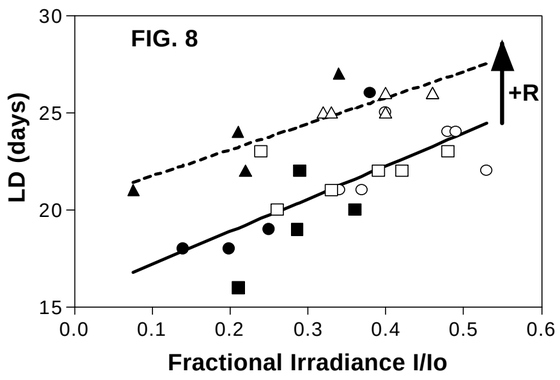
Figure 6. Relationship between relative embryo final weight (25°C final embryo weight = 100%) and temperature for grains from the peripheral position of the capitulum.

CASE 3.

Control of pre-anthesis leaf senescence

Problem: Crops that generate high (> 4) LAI´s before anthesis begin to senesce so that LAI is actually falling before anthesis. This does not occur in sparser canopies. What rôle does light [intensity and quality] play in this process?.
Approach: Experiments involving variations in shading, enrichment with red (R) and far red (FR) light and crop density (D) were used to test the hypothesis that light [intensity and quality] modulates basal leaf senescece in sunflower.
Conclusions: Leaf duration (LD) (time between maximum leaf area and 20% initial chlorophyll content) is dependent on daily PAR receipt and is shortened by enrichment with FR (Fig. 7) and extended by enrichment with R (Fig. 8). Experiments with tobacco lines overexpressing Phytochrome A confirmed the rôle of phytochrome in controlling leaf senescence (data not shown). Specific leaf nitrogen of basal sunflower leaves relates more strongly with mean daily R/FR (Fig. 9) than with mean daily PAR (data not shown).
References: Rousseaux et al., Physiol. Plant. 96: 217-224, 1996; Plant Cell Environ. 20: 1551-8, 1997; Crop Sci. 39: 1093-1100,1999; Physiol. Plant. 110: 000-000, 2000.





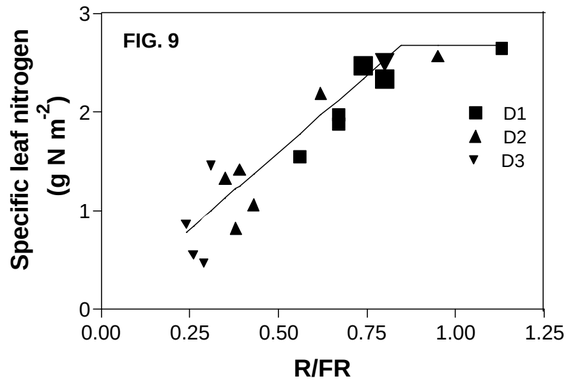


Fig. 7 . Leaf duration (days after full expansion) as a function of mean daily incident PAR for leaves of isolated plants without (squares) or with (triangles) FR enrichment.

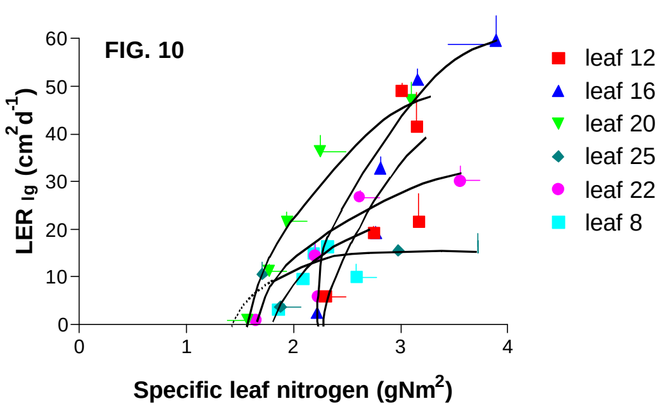
Fig. 8. Leaf duration (days after full expansion) as a function of mean daily fractional radiation measured 197 °Cd after full expansion in basal leaves of a canopy for leaves exposed to additional R (triangles), additional green (circles [equivalent dose of PAR to R]) and controls (squares).
Full symbols: Exp. 1 - empty symbols: Exp. 2

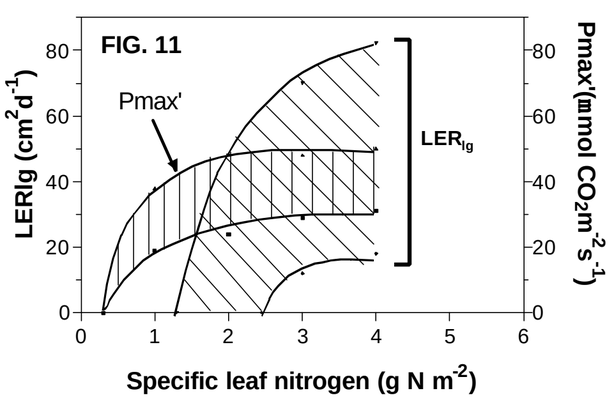
Fig. 9. Specific leaf nitrogen /mean daily R/FR relationship for basal leaves in canopies of varying density.

CASE 4.

Nitrogen effects on leaf expansion

Problem: The effects of nitrogen on sunflower leaf photosynthesis had been described, but its effects on sunflower leaf expansion had not been studied in great detail.
Approach: Experiments involving variations in nitrogen supply or reciprocal exchanges between high and low levels of N were used to examine expansion of leaves at various levels of insertion and the effects of N on cell division (before and after leaf emergence) and expansion.
Conclusions: Leaf expansion rates in the quasi-linear phase of growth varied between levels of leaf insertion and with specific leaf nitrogen (SLN) (Fig. 10). The threshold SLN for leaf expansion was considerably greater than that of maximum photosynthesis, rather closer to the SLN at which Pmax saturates (Fig. 11). Changes between levels of N availability at various stages of the growth of emerged leaves did not produce significant changes in cell division if the changeover ocurred later than 10% of final leaf size, cell expansion continued to respond to changeovers until the leaf had achieved at least 60% of its final size (data not shown). N availability did, however, produce important changes (by a factor of ca. x2) in cell number per leaf primordium at the stage of leaf appearance (Fig. 12). References: Trápani and Hall, Plant Soil 184: 331-40, 1996; Trápani et al., Ann. Bot. 84: 599-606, 1999.





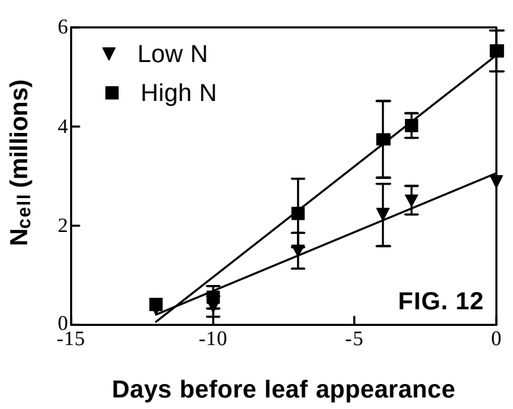


Fig. 10 Leaf expansion rate during the quasi-linear growth phase (LER_{lg}) as a function of SLN for selected target leaves L8 through L25. Curves fitted by eye.

Fig. 11 Diagram of envelopes for relationships of Pmax' and LER_{lg} with specific leaf nitrogen for leaves of different positions and N supply levels. Curves fitted by eye to outlying individual data points for each variable.

Fig. 12 Dynamics of cell number (N_{cell}) in unemerged leaves 9 of hydroponically grown sunflower plants under high (•) and low (–) nitrogen supply.