THE CRITICAL PERIOD FOR THE EFFECT OF INTERCEPTED SOLAR RADIATION ON SUNFLOWER OIL CONCENTRATION DOES NOT DEPEND ON GRAIN FILLING DURATION

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Introduction and Objective

Oil content depends on weight per seed and oil concentration, both defined during the grain filling period. The expression of oil yield components are determined by genetic factors and are greatly affected by environmental and growth conditions.

Intercepted solar radiation per plant (ISR) during the grain filling period (R6 to R9) largely determines weight per seed and oil concentration in sunflower grains. Aguirrezábal et al. (2003) found a critical period from 250 ºC to 450ºC day after flowering (°C DAF, base temperature : 6 ºC) during which a reduction of ISR accounted for most of this effect in the Dekalb G-100 traditional hybrid.

The main objective of this work was to determine whether the critical period for the effect of the ISR on sunflower oil concentration is different in two traditional hybrids with different grain-filling stage durations.

Materials y Methods

Two experiments were conducted at the Unidad Integrada Balcarce (INTA-FCA, UNMdP), Argentina (37°45′ S, 58°18′ W) during 2007-2009.

Two traditional sunflower hybrids with different growing cycle length were evaluated: ACA 885 (intermediate-long cycle) and DEKALB 3820 (DK 3820, intermediate-short cycle). The experiments were designed in split-plot with three replicates. The hybrids were assigned to main plots and treatments to subplots.

Treatments were applied to modify ISR during either, the whole grain filling period (from the end of flowering to physiological maturity, R6-PM) or short periods (A, B, C, D) according to the scheme (Figure 1 A). The treatments were 80% shading, and thinning of 50% of the original plant density and untreated control (Figure 1A). In experiment achieved during 2007-2008 season, two additional treatments were applied during R6-PM: 50% shading (50%) and 80% shading plus 50% thinning (Sh-Th).

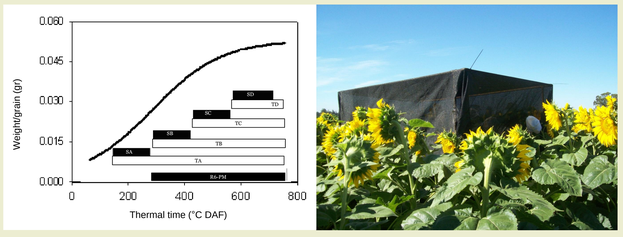

Fig. 1: A) Treatments duration (80% Shadings: SA, SB, SC, SD, SR6-PM. Thinning: TA, TB, TC, TD). B) Image of a shading structure.

Differences among treatments were detected by analysis of variance (ANOVA) and Tukey test ($P \leq 0.05$) of data means.

The ISR accumulated from R6 to PM and for 100°C day segments after flowering was related to the oil concentration by fitting an exponential rise to maximum equation to experimental data (Eq. 1.)

$$x = yo + a\,(1\text{-}e^{-b*ISR}) \qquad \textbf{Equation 1}$$

The critical period for the effect was defined by those 100°C day segments where r² for the fitting was higher than the one obtained with ISR accumulated during R6-PM.

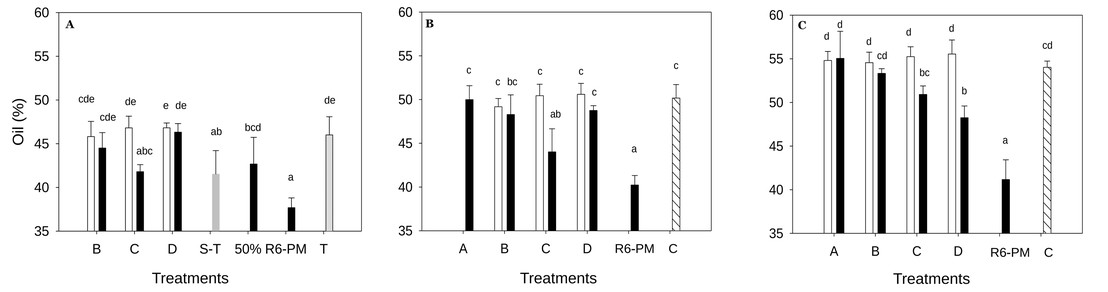

Figure 2: Treatment effect on oil concentration. A) ACA885, 2007-2008; B) ACA885, 2008-2009; C) DK3820. ■ shadings; □ thinning; ■ shading and thinning (Sh-Th). Bars indicate standard error. For each experiment, means with the same letter are not significantly different (Tukey, $p \leq 0.05$).

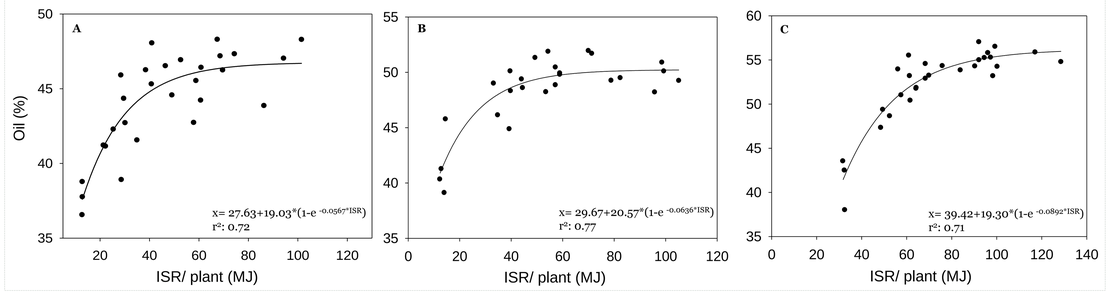

Figure 3. Relationship between oil concentration and ISR accumulate from R6 to PM. The continuous line represents the fitting of the equation 1 to the experimental data. A) ACA 2007-2008 r²= 0.76, B) ACA 2008-2009 r²= 0.77, C) DK3820 r²= 0.71.

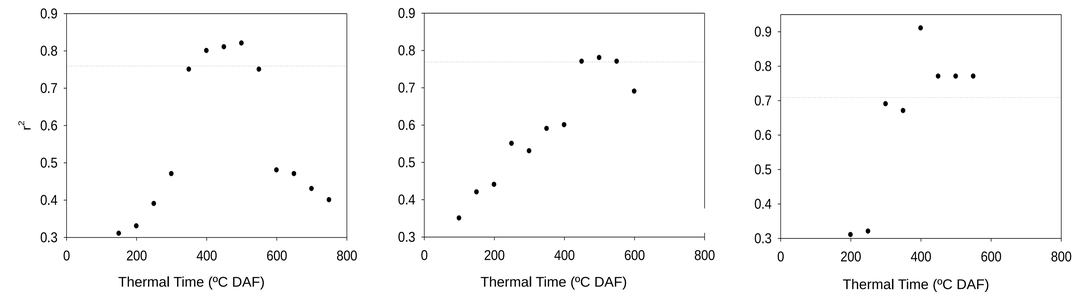

Figure 4: Determination coefficient (r²) vs. thermal time after flowering. r² was obtained for each 100ºC day by fitting equation 1 to the relationship between oil concentration and ISR accumulated during the corresponding period. r² values are plotted as a function of the beginning of the 100ºC days segment. A) ACA 2007-2008, B) ACA 2008-2009, C) DK3820. The dotted line represents the threshold defined by r² values obtained in Figure 3.

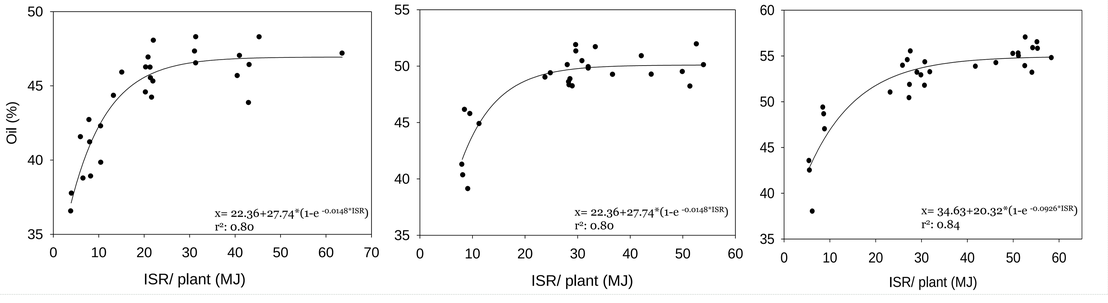

Figure 5: Oil concentration as a function of ISR accumulated during the critical periods. The continuous line represents the fitting of equation 1 to the experimental data. A) ACA885 2007-2008 (r²= 0.83), B) ACA885 2008-2009 (r² =0.80), C) DK3820 (r²= 0.84)

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Results

80% Shading treatment from R6 to PM for ACA885, during 2007-2008 and 2008-2009 reduced 10% ($p \leq 0.05$) the oil concentration compared to control plants. Among short treatments, only SC showed a significant effect on oil concentration (Fig. 2 B and C). For DK3820, R6-PM and SD treatments significantly decreased oil concentration (13 and 7% respectively, compared to control plants; Fig. 2 C).

Relationship between ISR and oil concentration

Oil concentration increased with ISR accumulated from R6 to PM up to a maximum. The determination coefficients obtained by fitting equation 1 to experimental data were considered as threshold values to determine the critical period for each hybrid (Figure 3). Figure 4 shows the r² obtained for the relationship between oil concentration and ISR accumulated in 100°C day periods as a function of the beginning of the period.

The critical periods for ACA885 were 450 to 650°C DAF and 400 to 600°C DAF (for 2008-2009 and 2007-2008 season, respectively); and, 400 to 650 °C DAF for DK3820.

The correlation between oil concentration and ISR accumulated only during the critical period improve considerably compared with the fitting obtained considering the ISR accumulated between R6 and PM in all hybrids.

Comparison of critical periods

The maximum differences between the critical periods length for both hybrids was 50°C day. No correlation between the duration of the critical period and grain filling duration was observed (Figure 7). The period when oil concentration is more sensitive to ISR variation for all hybrids is placed in the second half of the grain-filling period (51-71%, ACA885 2007-2008; 61-89% ACA885 2008-2009 and 59-96% for DK3820.)

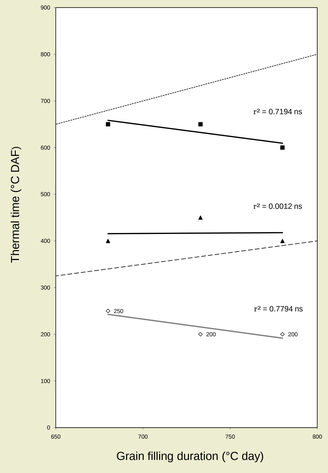

Figure 6: Correlations between the duration of R6-PM and: the beginning (rhombs), the end (squares) and the duration of the critical period (triangles) for the effect of the ISR on the oil concentration established for ACA (2007-2008 and 2008-2009) and DK3820. Dashed line: 50% grain filling; dotted line: physiological maturity. ns: no significant regression.

Conclusions

-The critical period is not related to the duration of the flowering-physiological maturity stage.

-Final oil concentration in the grain of traditional hybrids is strongly modified by ISR accumulated in a critical period of 200ºC day during the second half of grain filling period.

-This results may help to explain differences in oil concentration of sunflower crops grown under relatively potential conditions

-The information here obtained could be incorporated to sunflower oil yield models to improve their performance and contribute to understand the effects of environmental conditions and management practices on sunflower oil yield.

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