GROWTH ANALYSIS OF SUNFLOWER

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Summary

A growth analysis study on the effects of two contrasting environments on the yield of field grown sunflower (Helianthus annuus L) cultivated in Campinas, São Paulo State, Brazil, was undertaken.

Accumulation of dry matter, NAR, RGR, LAI, LAD, LAR were determined in two diferent seasons of cultivation, in a randomized experimental design with 5 replications. Higher values for those parameters were obtained in the wet season.

Although total seed weight in the wet season was higher, the difference between seed yield of wet and dry season was only about 400 kg/ha probably due to the excess of rain and cloudy days during flowering period in the wet season, leading to an increase of empty seeds and decrease in photosynthetic level. The plant grown in the dry season was much more efficient because it allocated less for growing, concentrating the efforts in seed yield.

The earlier leaf senescence observed in the dry season was responsible for the greater decrease in NAR.

Both LAI and LAD gave higher values in the wet season, at flowering.

Regression analysis showed good fit to all parameters studied, except for NAR in the dry season.

Introduction

The study of sunflower physiology in Brazil is practically inexistant, although this culture has a great potential (Sichmann et al. 1970) in our conditions and its cultivation since long time is concentrated mainly in the small and medium seize properties (Ungaro, 1982).

It is expected that the pattern of plant growth vary between tropical and temperate regions due to the differences in seasonal variation and climatic factors such as temperature and light energy intercepted.

The sunflower in Brazil has been mainly cultivated in the dry season, following the main crop, although the cultivation in the wet season is also possible, and gives better seed production.

The present study is a contribution for the better understanding of the comportment and development of this culture, with the compairison of two seasons, very different in their climatic conditions.

In recent years, growth analysis studies of Helianthus annuus L have been conducted by Warren Wilson (1967), Robelin (1967), Rajan et al (1973), Eze (1973), Blanchet et al (1982; 1982 b), Merrien et al (1983), concluded that exist complex interations between light and temperature effects on NAR, LAR, RGR and leaf area; sunflower has a relatively high NAR, TDM; LAI and LAD are factors of medium importance in seed production; the leaf survival in the filling period largely influence the seed production.

Materials and Methods

The experiment was conducted under field conditions at Campinas, São Paulo State, Brazil, during the year of 1983/84, with Helianthus annuus cv. IAC-Anhandy (obtained by mass stratificated selection in Peredovick variety), in two planting dates: 11 October 1983 (wet season) and 30 March 1984 (dry season).

It was applied 400 kg/ha of the formulae 4-20-20 (N-P-K) at sowing and 100 kg/ha of amonium sulphate 35 days after emergency. The seedlings were hand thinned to stablish a final stand of 60 000 plants/ha. In the dry season treatment, to the basic formulae was added 1,0 kg of boron.

The samples were collected each 7 days, starting in the first true leaves pair stage (± 7 days after emergency), untill the physiological maturity of the seeds (± 90 days after emergency). At each sampling date, 5 samples of 5 plants each (0,80 m^2 of area per sample) were collected at random. These plants were separeted into leaves, stem and capitulum, and fresh weight and stem lenght were recorded.

The leaf area was estimated by punching out leaf discs of known area randomly, including the midrib, as described in the work of Eze (1973).

The dry weight was determined after drying the samples in a temperature of 60°C untill constant weight.

The following parameters were weekly determined in the two planting seasons: total dry matter (TDM); leaf dry matter (LDM), stem dry matter (SDM), capitulum dry matter (CDM), seed dry matter, leaf area index (LAI), relative growth rate (RGR), net assimilation rate (NAR), leaf area rate (LAR) and leaf area duration (LAD). They were obtained according to Buttery (1969) and Eze (1973).

Regression analysis were used in the results interpretation, according to Nichols and Calder (1973).

Results

The montly mean values of temperature and rainfall during the two growing seasons are shown in Table 1. There were only slight differences in temperature between the two seasons, except for the end of plant cycle in the dry season. The rainfall at flowering period was too high in the wet season and inexistant in the dry season.

The duration of vegetative period was practically the same for both seasons.

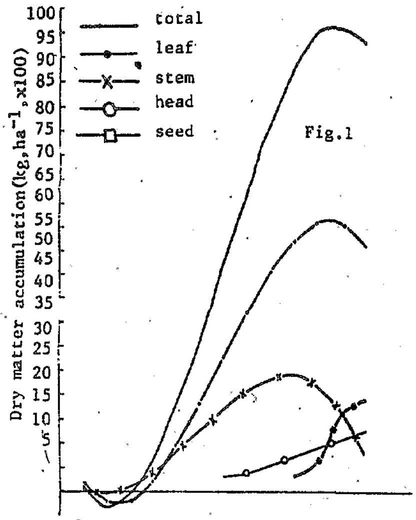
In the wet season, the total dry matter, leaf dry matter and stem dry matter was twice the obtained in the dry season (Figures 1 and 2). The ratio seed production/TDM was 0,19 in the dry season and 0,29 in the wet season. There was a high rate of dry matter accumulation in the vegetative phase which, in the beggining of the seed filling period, decreased in both seasons. The leaf dry matter reached the maximum value at flowering period. The stem dry matter reached the maximum value at the end of flowering period. The head dry matter continued to increase untill near the physiological maturity. The final plant height was 2.05 m in the wet season and 1.35 m in the dry season.

In the dry season, the absence of rain after the beggining of the flowering period (Table 1) resulted in premature leaf senescence.

The NAR and RGR were maximum at the beggining of vegetative period, decreasing after 22 days from emergency (Figures 3 and 4). In the wet season, decreases in the NAR values occurred in a slower rate, but starts much earlier than in the dry season. In the dry season there was a rapid decrease in NAR values after flowering period. Almost the same pattern can be seen for relative growth rate.

The LAI and LAD on the wet season plants was consistently higher than the dry season plants (Figures 5 and 6).

The LAR for the wet season treatment was above 2,0 at the beggining of the



TDM
$Y = 1385.0 - 1674.3x + 461.72x^2 - 21.99x^3; r^2 = 0.98$

LDM
$Y = 278.2 - 447.65x + 157.04x^2 - 9.15x^3; \quad r^2 = 0.92$

SDM
$Y = 1217.1 - 1320.8x + 331.15x^2 - 15.88x^3; r^2 = 0.99$

HDM
$Y = 253.0 + 68.28x + 13.03x^2$

Fig.1. Distribution of dry matter in wet season.

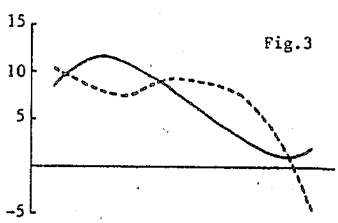


Fig.3. Net assimilation rate in wet and dry season

Wet season
$Y = 5.306 + 4.241x - 0.873x^3 + 0.041x^3; r^2 = 0.70$

Dry season
$Y = 13.595 - 3.63x + 0.786x^2 - 0.051x^3; r^2 = 0.43$

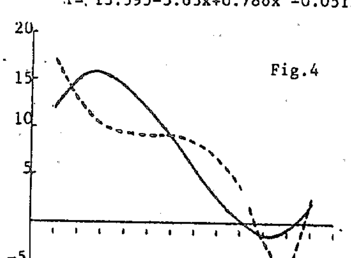


Fig.4. Relative growth rate in wet and dry season

Wet season
$Y = 6.991 + 7.11x - 1.62x^2 + 0.083x^3; \quad r^2 = 0.92$

Dry season
$Y = 24.014 - 8.41x + 1.58x^2 - 0.099x^3; r^2 = 0.81$

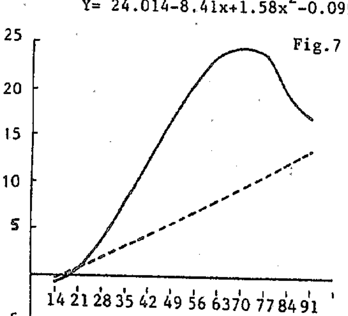
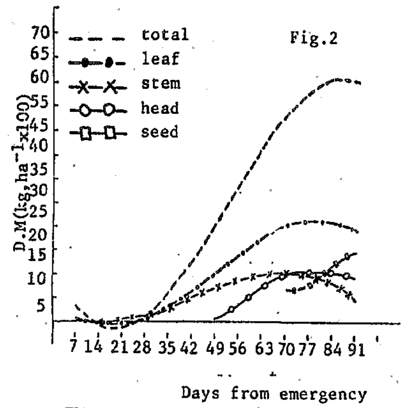


Fig.7. The change in the leaf area duration with time, in both seasons.

Wet Season
$y = 29.356 - 209.1x + 136.64x^2 - 9.255x^3; r^2 = 0.97$

Dry Season
$y = 97.323 + 81.73x + 5.265x^2 - 0.167x^3; \quad r^2 = 0.96$



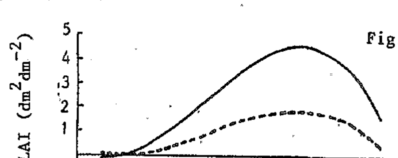
TDM
$Y = 1110.6 - 1087.5x + 254.53x^2 - 11.356x^3; r^2 = 0.98$

LDM
$Y = 182.57 - 216.25x + 68.33x^2 - 3.83x^3; \quad r^2 = 0.89$

SDM
$Y = 507.01 - 530.93x + 130.98x^2 - 6.27x^3; \quad r^2 = 0.94$

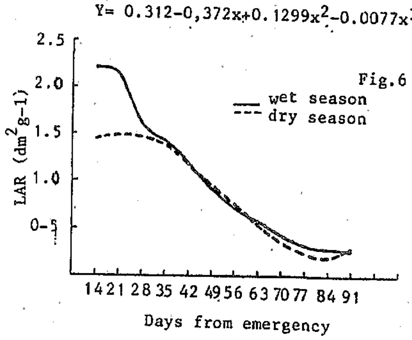
HDM
$Y = -386.73 + 526.29x - 48.39x^2$

Fig.2. Distribution of dry matter accumulation in dry season.



Wet season
$Y = 0.233 - 0,572x - 0.259x^2 - .016x^3; \quad r^2 = 0.89$

Dry season
$Y = 0.312 - 0,372x + 0.1299x^2 - 0.0077x^3; r^2 = 0.93$



Wet season
$Y = 2.556 - 0.336x + 0.009x^2 + 0.0003x^3; \quad r^2 = 0.98$

Dry season
$Y = 1.222 + 0.263x - 0.073x^2 + 0.0037x^3; \quad r^2 = 0.90$

Fig.5. The change in the leaf area index with time in both seasons.

Fig.6. The change in the leaf area ratio with time in both seasons.

Table 1. Meteorological data for the two growing seasons.

	max. temp. (°C)	min. temp. (°C)	rain (mm)
Oct.	26.5	16.5	90.1
Nov.	28.5	17.3	140.2
Dec.	27.5	18.8	277.1
Jan.	30.8	19.3	187.7
Feb.	32.6	20.0	36.1
Mar.	29.9	18.7	80.6
Apr.	26.9	16.9	152.6
Mai.	27.2	15.8	56.0
Jun.	26.2	13.0	0.0
Jul.	26.4	13.4	0.0

OBS: The mounth assinaled correspond to the flowering period.

season while in dry season treatment, LAR remained below 1.5. After 15 days, LAR was practically the same for both treatments (Figure 7).

Regression analysis showed good fit to all parameters studied, except for NAR in the dry season.

Discussion

The duration of vegetative period was practically the same for both seasons , which agrees with the results obtained by Yegappan et al.(1980). Although TDM in the wet season was twice the obtained in the dry season, and the LAI was more than twice, the seed yield did not followed this proportion, due probably to the excess of rain and cloudy days during the flowering period, resulting in lack of polinization and to the increase in photosynthetic level.Puech et al.(1975)found that sunflower grown at 60% of normal insolation suffered 36% reduction of yield if the shadding was limited to only 27 days during flowering period and seed development. In our experiment we had 23 cloudy days during the flowering period.

The ratio seed production/TDM is not high (0.3 to 0.4) appearing to indicate a defect in the assimilators translocation to the seeds (Blanchet et al. , 1982) . We found lower ratio in the wet season and greater one in the dry season. Kesteloot et al.(1978) found that there was a visible relation between vigour and productivity. Otherwise, Blanchet et al.(1982) suggest that maybe a short stem should be preferable, because it also requires assimilates for its development. Probably the good seed production obtained in the dry season of this experiment could be explained, also, by the lower growth of the stems , leaving relatively more for the formation of other plant parts. The comparison between total dry matter accumulation in both seasons lead us to believe that the plant development in the dry season was much more efficient for seed production because it allocate less for growing and development, concentrating the efforts in the reproductive organs.

At the beggining of the seed filling period , the total dry matter accumulation rate decreases due to two reasons: A9 the photosyntates are transformed mainly in oil and protein, which requires a great use of energy due to respiration; b) in sunflower there is an early ageing of the foliar apparatus which becomes less active at the onset of flowering (Rawson and Constable, 1980; Blanchet and Merrien, 1981). In this experiment, we observed that the dry matter accumulation rate decreased after flowering, sometimes becoming negative, in spite of a high LAI as found by Blanchet et al.(1982).

Blanchet et al.(1982) observed that both stem and leaf reached the maximum amount of assimilates at flowering ; after this period, should occur a small decrease probably due to the transfer to the seeds. In our experiment we suppose That it happened in the same way for the leaves; otherwise, the stem continued to accumulate a little longer than the leaves. The head dry matter continued to increase untill near the physiological maturity (end of the experiment).

According to Williams (1946), drougt conditions may be expected to depress NAR value on any basis. Otherwise, Merrien et al.(1981) stated that water deficity is much more important to leaf area than to its assimilation activity.High water deficit results in an earlier leaf senescence, beggining in the older leaves, leading to a net assimilation rate decrease (Merrien et al., 1981b) , but the activity of the upper leaves is capable of making up for the lack of the lower ones(Vrebalov, 1972; Rodrigues Pareira, 1974). In the present paper, the results obtained for NAR in the dry season agree with Merrien et al.(1981b). Although the drought condition occurred from the end of flowering to the end of plant cycle , even after 15 days of drought the NAR was high ($0.12 g.dm^{-2} day^{-1}$); after that, it decreased to negative values, corresponding to a period in which we observed a premature leaf senescence. The rapid decrease of NAR values observed in the last two weeks of the dry season experiment could be explained also by lower leaf assimilation activity after flowering, since, in the wet season, NAR values also decreased after flowering.

Although many authors pointed out the influence of temperature in the NAR (Heath and Gregory, 1938; Williams, 1946; Warren Wilson, 1966; Hodgson, 1967) we suppose that in our experiment there was no influence of this component between the two seasons, since the mean temperature had only small differences through out the seasons. An exception was observed at the final stage of the dry season, when the mean temperature was above 20°C. Reviewing those experiments showing the influence of temperature in NAR we observed that when the mean temperature was less than 20°C the variation in NAR between the experiments was greater.

Sunflower shows a high photosyntetic capacity during the vegetative phase; after the flowering, this performancy tends to be attenuated (Blanchet and Merrien, 1981). This can be observed by the analysis of the studied parameters in both seasons. Much of the decline occurred in NAR and RGR in the wet season treatment can be attributed to a rise in self-shadding (increasing LAI). Several factors, besides self-shadding, may be expected to decrease net photosynthesis, such as the increase in seed formation (Howell, 1962) and senescence of the leaves themselves (Buttery, 1969).

The difference in LAR values between wet and dry season could be explained by the lack of water stress in the wet season plants, allowing them to a fully leaf expansion. After 28 days from emergency, total dry matter variation was proportional to the leaf area variation, because both seasons showed almost the same LAR values. The LAI in the wet season was much higher than in the dry season plants resulting in a consistently higher LAD in the wet season.

Conclusions

1. The plant developed in the dry season was much more efficient than the plant developed in the wet season.

2. At the beggining of the seed filling period, the TDM accumulation decreases.

3. The decrease in NAR after flowering in the dry season was due, mainly, to the earlier leaf senescence and less temperature.

4. After 28 days from emergency, the TDM variation was proportional to the leaf area variation.

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