PHYSIOLOGICAL CHANGES ASSOCIATED WITH BREEDING FOR HIGHER YIELD OF SUNFLOWER IN ARGENTINA

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ABSTRACT:

In wheat and other important crops breeding for higher yield modified several physiological traits. The identification of traits which have undergone modifications can contribute to breeding programs. In the case of sunflower, only indirect evidence on the physiological changes produced by breeding is available.

The aim of our work is to identify some of the physiological traits modified by breeding sunflower in Argentina. Hybrids (5) and varieties (2) comprehending the 1965-1993 period were compared under near optimal field conditions at Buenos Aires. Pests and diseases were controlled. Among the genotypes, differences in phenology, leaf area index, biomass and yield were established. Higher yields were achieved through both increments in oil-corrected seasonal biomass production and in oil-corrected harvest index.

Key words: Physiological traits; breeding, sunflower, yield.

INTRODUCTION

Sunflower yield in Argentina increased from 768 kg per ha during 1969-79 to 1231 kg per ha in the eighties. Possible causes of this increase were the introduction of hybrids, tolerance to diseases, and the application of better management practices. In the near future agricultural management will have to consider the increased environmental costs of the activity, limiting the use of agrochemicals and other inputs. Thus, genetic gains should have to be higher than in the past to continue increasing grain and oil yields. The development of new selection criteria, based on the understanding of the physiological and morphological basis of yield determinants, will contribute to increase genetic gains. The aim of our work is to identify some of the physiological traits modified by breeding sunflower in Argentina. In this paper we present results from one year of experimentation; the second year is now in course.

MATERIAL AND METHODS

Plant material and conditions

Crops of two varieties (Guayacan and Pehuen, released in 1966 and 1968, respectively) and 5 hybrids (Contiflor 3, G100, Contiflor 15, ACA 884, and Paraiso 7, released in 1983, 1984, 1989, 1991 and 1993, respectively) were grown at Junín (34°33'S, 60°57'W) Argentina on a coarse sandy loam, on plots maintained near field capacity by supplementary irrigations. Crops were hand sown on 1 December 1994; plants emerged on 7 December. Population density varied among genotypes: 33.300 plants ha^{-1} for the varieties and the hybrids Contiflor 3, Contiflor 15 and Paraiso 7, and 40.000 plants ha^{-1} for hybrids G100 and ACA 884. The desired density was achieved by thinning. The treatments (cultivars) were in three complete randomized blocks. Individual plots had 6 (varieties) and 4 (hybrids) rows, 6 m long spaced at 0.70 m. Crops were fertilized at sowing with 60 kg ha^{-1} N (urea). Preventive applications with systemic fungicides were made at bud visible, anthesis and during grain filling every 15 days.

Phenology : Emergence, bud visible, first anthesis (50 % of inflorescences with 1-3 rows of anthesed florets), and full flowering (50 % of the inflorescences had eight rows of anthesed florets) were recorded. Evolution of grain filling and physiological maturity was evaluated through sampling grains from the periphery (excluding the outer two rows of grains) of 5 capitulae per plot 2 times a week until achievement of maximum grain weight.

Leaf area index : Leaf area per plant was determined by measuring maximum leaf width (Pereyra et al., 1982) of leaves in three plants per plot. Leaf area index was calculated as the product of leaf area per plant and population density.

Biomass determination : Biomass (stem, leaves, inflorescence and tap roots) was determined by harvests of bordered plants at anthesis and physiological maturity. All plants organs were dried at 70° C during 72 h prior to weighing. Grain yield (g m^{-2}) was registered.

Grain oil content was determined by nuclear magnetic resonance and allowance for synthesis costs of oil in grains was made as described by Hall et al. (1989) to obtain oil-corrected biomass values.

RESULTS AND DISCUSSION

Differences in time to flowering, though significant, were not greater than 7 days [thermal time (TT) = 171 °C day, Tb = 4 °C; Table 1]. Biomass at anthesis (BA) differed significantly among cultivars (Table 1); the differences were not associated to the year of cultivar release. Differences in BA between extreme cultivars were 360 g m^{-2} (Table 1). The relationship between BA and time to flowering (TF) explained 62 % of the data variability (BA=-12,48+0.37 TF, n=21). Possible causes of the differences in BA, other than time to flowering, are differences in leaf growth (and thus in interception of radiation) during the early stages of crop growth, and in radiation use efficiency (RUE) during the pre-anthesis period. Contiflor 3 has been found to have higher RUE during this period as compared with Contiflor 8 (Trápani et al. 1992).

Duration of grain filling period differed in only 2 days (TT=55 °C day, Tb = 4 °C) between varieties and hybrids, except in the hybrid G100 which reached physiological maturity in 25 days (Table 1).

Oil yield differed in 123 g m^{-2} between extreme cultivars (Table 1); the higher production was registered among the hybrids. Oil concentration markedly increased in comparing the oldest cultivar and the newest hybrid (Table 1).

Oil-corrected biomass at harvest differed significantly among cultivars: Guayacan and ACA 884, which had extreme values of this variable, differed by 33 %, in favour of the hybrid (Table 1). Possible causes of these results are: differences among the cultivars in leaf area duration and/or in post-anthesis EUR, and, to a lesser extent, in duration of the grain filling period.

Increments in oil-corrected biomass during post-anthesis is shown in Fig. 1. During this period crop growth was higher in the hybrids, except in Contiflor 3. Reduction in stem biomass during post-anthesis was significant in the varieties and Contiflor 3; the rest of the hybrids lost a small part of their stem biomass (Fig. 2).

Thus, in the varieties and Contiflor 3 redistribution of biomass was an important factor contributing to oil-corrected biomass yield. On the contrary, in the hybrids post-anthesis growth was the main factor under potential conditions (Figs. 1 and 2).

Oil corrected harvest index (HI_c) differed significantly among the cultivars, with the varieties and Contiflor 3 showing the lowest HI_c values and the hybrids, the highest (Table 1).

Taken together our results indicate that increments in oil-corrected biomass at harvest and HI_c were achieved through breeding. In wheat breeding for higher yields brought about mainly increments in harvest index while total biomass increments were minor (Slafer et al., 1992).

It is worth noting that although hybrids G100 and ACA 884 showed similar yields, they differed greatly in leaf area index at anthesis (Table 1), leaf area duration (data not shown) and, to a lesser extent, in cycle (Table 1). Redistribution of biomass during the post-anthesis period was similar in these cultivars (Fig. 2). These data suggest that G100 may have higher post-anthesis EUR under potential conditions. Determination of pre and post-anthesis EUR and duration of leaf area of the cultivars are the next steps to take. These data will contribute to elucidate the possible ways by which modern cultivars reach their higher yields.

CONCLUSIONS

Breeding for higher yields in Argentina modified physiological traits in sunflower. This was obtained by different ways.

Higher yields were achieved through both increments in oil-corrected seasonal biomass production and in oil-corrected harvest index. None of the cultivars examined synthesized all possible advantageous traits which might maximize yields. Thus, space for improving genetic gains apparently exists, although, caution must be exercised due to possible negative interactions.

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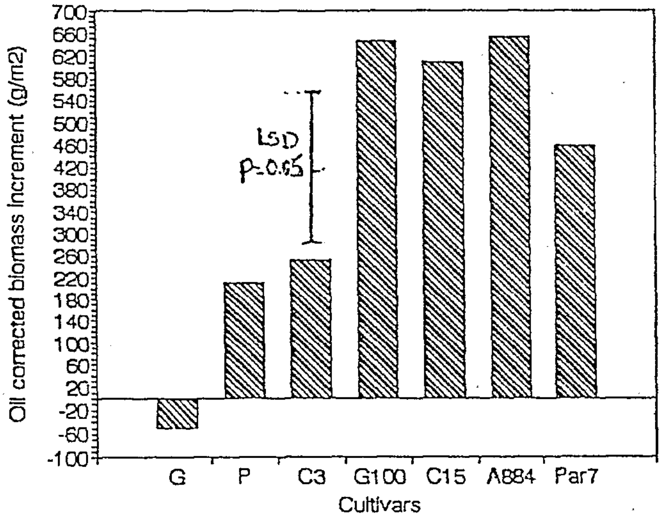

Figure 1. Increments in biomass, corrected by oil content, during the post-anthesis period of cultivars Pehuen (P), Guayacán (G), Contiflor 3 (C3), G100, Contiflor 15 (C15), ACA 884 (A884), and Paraiso 7 (P7).

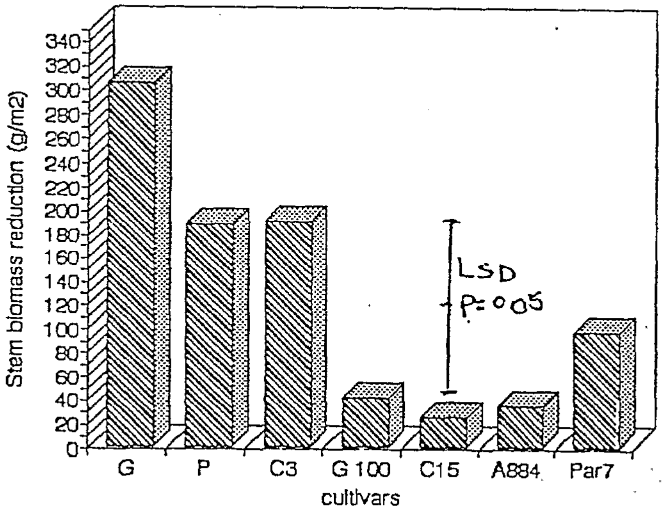

Figure 2: Reduction in stem biomass during the post-anthesis period in the cultivars Pehuen (P), Guayacán (G), Contiflor 3 (C3), G100, Contiflor 15 (C15), ACA 884 (A884), and Paraiso 7 (P7).

Table 1: Duration of phenological phases: emergence-physiological maturity (E-PM) and emergence-first anthesis (E-FA), duration of grain filling period (DGF) in thermal time units (Tb=4°C) and days; leaf area index at anthesis (IAF_{max}); biomass at anthesis BA. Biomass at physiological maturity (BH_c) and harvest index (HI_c) corrected by oil content; grain-oil yield and oil concentration.

Cultivar Variables	Guayacan 1966	Pehuen 1969	Contiflor 3 1983	G100 1984	Contiflor 15 1989	ACA 884 1991	Paraiso 7 1993	LSD (p=0.05)
E-PM(°C d)	1974	1828	1817	1701	1891	1822	1824	26.9
E-FA(°C d)	197	1157	1144	1026	1088	1088	1053	51.7
(days)	64	62	61	54	58	58	56	
DGF(°C d)	563	499	533	552	614	606	618	--
(days)	34	30	31	25	36	36	35	
LAI_{max}	3.4	3.0	3.6	2.5	2.2	4.6	2.4	0.7
BA ($g.m^{-2}$)	1157	1029	1115	796	830	1001	797	166
BH_c ($g\ m^{-2}$)	1107	1239	1368	1443	1416	1653	1256	160
ΔSW($g\ m^{-2}$)	303	187	189	33	50	40	95	146
Oil yield ($g\ m^{-2}$)	108	150	176	221	201	231	197	34
HI_c	0.35	0.42	0.43	0.51	0.46	0.47	0.51	0.034
Oil (%)	44	48	44	52	51	49	52	3.9