A PHYSIOLOGICAL AND GENETICAL STUDY OF EARLINESS IN SUNFLOWER

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SUMMARY

The increased area of sunflower grown in Northern France has led to a requirement for varieties with shorter vegetative cycles. Since 1985, physiological and genetical studies have been undertaken to obtain a better understanding of earliness at maturity. The stages of development of hybrids obtained from a factorial cross of 5 male steriles and 5 restorers were observed. No characteristic before flowering permitted prediction of humidity at harvest, the criterion best correlated as the duration between flowering and physiological maturity. A genetical analysis showed that, concerning humidity at harvest, the behaviour of a hybrid cannot be predicted from those of its parents. However, a factorial analysis on the hybrids showed that the additive parental effects were significant and much more important than interactions. Earliness at harvest is thus a characteristic, like yield, for which it is necessary to determine the general combining ability of parental lines to forecast the behaviour of hybrids.

INTRODUCTION

The area of sunflowers grown in France has been multiplied by 30 in the last 10 years. Adaptation of the crop to more northern zones has led to two importants problems : firstly the plant must complete its vegetation cycle under conditions of lower temperetures ; secondly the risk of end-of-cycle diseases (Sclerotinia, Botrytis) is increased when there is rain in summer or early autumn. These problems should be resolved by the breeding of earlier sunflower varieties.

Up to the present, there have been few agrophysiological or genetical studies on earliness in sunflower comparable with those on maize (Verdier, 1983), a species in which the range of earliness is much greater than in sunflower. For this reason, in 1985, work was started in sunflower at Clermont-Ferrand. This paper reports a search for criteria permitting prediction of humidity at harvest and studies of the heredity of earliness.

MATERIALS AND METHODS

A - Sunflower genotypes

A factorial cross was made between 5 female parents (all with cytoplasmic male sterility) : BL, CD, CG, CX, NG and 5 restorers : PB2, PRS1, PRS6, RHA274, ZN41, giving 25 hybrids. The 5 male parents (R) were early compared with the 5 female parents (B) which were relatively late. The male fertile forms of the female parents were used for observations of inbred lines.

B - Trial plans

The trials were in randomised block designs. They were made up in 1986 of 15 genotypes for the parents, 30 genotypes for the hybrids and in 1987, of respectively 19 and 27 genotypes per trial. In 1986 there were 2 repetitions, each in 2 locations, in 1987 there were 3 repetitions in 1 location.

C - Observations

The durations of different developmental stages were obtained. These stages have been described by Robinson et al. (1971). In 1986 : emergence appearance of flower bud (E1 for the CETIOM, R1 for Schneiter et al. (1981)), flowering (defined as the ligular florets perpendicular to the capitulum face). In 1987 physiological maturity was also observed (yellow capitulum with brown bracts). For any genotype, a physiological stage is reached when 50 p. cent of the plants show the characteristic.

D - Biometric measurements

Leaf number and area, stem height and base diameter, capitulum diameter, seed yield (/ha), 1000 seed weight, number of seeds per plant and humidity at harvest were determined. Oil content was measured by N.M.R. (Brucker, Mini Spec 10) (Gradlund and Zimmerman, 1975).

E - Analyses

The correlation matrices for the characters were obtained to determine which observation was best correlated with humidity at harvest. In 1986, one matrix included 17 varieties with 1 repetition and a second 14 variables with 4 repetitions. In 1987, there were 13 variables and 3 repetitions.

Heredity was estimated for humidity at harvest and number of days from emergence to flower bud appearance by mean parent-hybrid covariance (Falconer, 1972 ; Segala et al., 1980 ; Piquemal et Mouret, 1982 ; Robert et al., 1987). A regression coefficient for mean parent-hybrid equaling 1 definies strict additivity. The linear regression between per se value of inbred lines and the means of their hybrids indicates the possibility of selection on the per se value for the character considered. It is a second estimation of heritability. Factorial analyses of variance determined the parental effects (general combining ability : G.C.A.) and interaction effects (specific combining ability : S.C.A.).

RESULTS

A - Biometric observations

The factor most closely correlated with humidity at harvest was the duration flowering-physiological maturity ($r = 0.640^{**}$), others of interest were duration emergence-flowering (1986 : $r = 0.408^{*}$; 1987 : $r = 0.540^{**}$) and duration emergence-appearance of flower bud (1986 : $r = 0.413^{*}$; 1987 : $r = 0.418^{*}$). In 1987, the phases emergence-flowering and flowering-physiological maturity were not correlated. It thus appears difficult to predict humidity at harvest from criteria of the development cycle before flowering. The two correlation coefficients that are significant are not very high. It appears that the phases before and after flowering are independant, at least for the genotypes discussed here.

B - Genetical analysis

1 - The mean parent-hybrid and inbred per se value -G.C.A. regressions are described in Table 1.

Table 1 - Values of the significant regressions between parental lines and their hybrids.

	Mean parent -hybrid		per se value(B) -GCA(B)		per se value(R) -GCA(R)	
	R	r	R	r	R	r
a - 1986 data						
Humidity at harvest	-	0.256 NS	-	0.371 NS	-	0.328 NS
Duration Emergence-flower bud	0.505	0.651 **	-	0.683 NS	-	0.131 NS
b - 1987 data						
Humidity at harvest	0.291	0.430 *	0.143	0.927 **	-	0.266 NS
Duration Emergence-flower bud	0.620	0.483 **	0.235	0.894 *	-	0.571 NS

R = regression coefficient r = correlation coefficient

a - Humidity at harvest

In 1986 there was no significant regression between parents and hybrids. In 1987 the mean parent-hybrid regression was significant but the regression coefficient was low (0.291). The per se inbred female lines - GCA females was significant.

b - Duration emergence-flower bud appearance.

In both years the mean parent hybrid regression was significant with similar heritabilities (51 and 62 p. cent). In 1986 the inbred-GCA regression was not significant, in 1987 it was significant, but with a low regression coefficient (R = 0.235).

2 - Factorial analyses

2.a - Humidity at harvest

The results for hybrids and mean parental effects are given in Table 2.

Genotype differences are highly significant. While the restorer parents show significant effects, none appear for the female parents, probably due to the fact that their G.C.A. do not differ significantly. Certain interactions are significant.

2.b - Number of days emergence-flower bud appearance

The results for hybrids and mean parental effects are given in Table 3.

Genotypic effects are highly significant. As for humidity at harvest the effect of restorer parents is much greater (x 6) than that of female parent, which in nevertheless significant. There are no significant interactions.

Table 2 - Parental effects concerning humidity at harvest (p. cent water content of clean seed)

B \ R	PRS1	RHA274	PB2	PRS6	ZN41	$\bar{x}$
BL	8.82	6.67	6.51	9.01	6.69	7.54
CD	10.89	9.58	6.34	10.04	7.54	8.87
CX	10.91	10.22	8.55	10.63	7.59	9.58
GC	8.90	7.58	6.64	9.75	6.69	7.72
NG	11.01	7.47	6.85	12.92	6.96	9.04
$\bar{x}$	9.99	8.30	6.98	10.47	7.09	

F genotype : 12.04 **
F Restorers : 4.99 **
F B lines : 1.44 NS
F interaction : 0.33 NS

l.s.d. hybrids 5 % : 1.62
l.s.d. parents 5 % : 2.05

Table 3 - Parental effects concerning the duration emergence-flower bud appearance (number of days)

B \ R	PRS1	RHA274	PB2	PRS6	ZN41	$\bar{x}$
BL	48.70	47.00	44.30	49.00	49.30	47.66
CD	49.00	50.00	44.30	40.00	49.30	48.32
CX	45.70	50.70	47.00	50.00	49.70	48.54
GC	45.70	49.00	42.00	49.30	49.00	47.00
NG	44.30	47.00	42.00	49.30	49.00	46.32
$\bar{x}$	46.68	48.66	43.92	49.38	49.26	

F genotype : 8.07 **
F1 R : 28.03 **
F1 B : 4.45 **
F interaction : 1.87 NS

l.s.d. hybrids 5 % : 2.30
l.s.d. parents 5 % : 1.24

DISCUSSION

Humidity at harvest appears to have a low heritability. In 1986, there was no correlation between mean-parent and hybrid (Chervet, 1988). In 1987, heritability was estimated at 29 p. cent. The regression between female inbred lines - female G.C.A. was either not significant or significant with a weak regression coefficient ($R = 0.143$) whilst for the restorer parents, no significant relation appeared. Thus it seems difficult to predict the value of a hybrid from its parents. However, general combining ability appears more important than specific combining ability in the factorial analyses. Additive genes thus appear to be involved in the determination of earliness at harvest.

In contrast with the first character, the duration between emergence and appearance of the flower bud appears much more heritable, 51 p. cent in 1986, 62 p. cent in 1987. In 1987, the per se value of female inbred lines describes their G.C.A. S.C.A. effects are quite weak for this character. Gene with additive effects should be predominant.

In conclusion, it appears difficult to predict the earliness at harvest of a sunflower hybrid from any other character except its physiological maturity, which is measured very late in the vegetation cycle. Concerning the forecast of the behaviour of a hybrid, it is not possible to observe only the parental lines, but estimations of general combining ability provide useful information. In contrast, the first phase of vegetation, from emergence to flower bud appearance, has much higher heritability, the behaviour of inbred lines often indicating the behaviour of their hybrids. It may be considered that fewer factors are involved in this phase than in earliness at harvest which is the sum of all the factors involved in the duration of the vegetative cycle.

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