COMBINING ABILITY OF SUNFLOWER (Helianthus annus C.) LINES AND COMPARSION AMONG PARENT LINES AND HYBRIDS.

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(SPANISH SUMMARY)

En agosto de 1990 se sembró un experimento con 45 híbridos de girasol, sus progenitores: 9 líneas (R) restauradoras y 5 líneas (B) isogénicas de la línea estéril citoplásmica y 8 testigos (híbridos y variedades). Se usó un diseño experimental de bloques al azar con 4 repeticiones. La prueba se estableció en el Campo Experimental de Río Bravo del Instituto Nacional de Investigaciones Forestales y Agropecuarias de Tamaulipas, México (CERIB-INIFAP-TAM). Los objetivos fueron: a) evaluar la aptitud combinatoria de las líneas; b) comparar el comportamiento entre líneas Per-se, y la (ACG) y c) observar diferencias entre híbridos experimentales y comerciales. Para rendimiento de grano se observaron efectos de no aditividad y para contenido de aceite los efectos fueron principalmente aditivos. No hubo correlación entre líneas Per-se y la ACG para rendimiento de grano. Para contenido de aceite se obtuvo una correlación alta y significativa, donde las hembras mostraron mayor asociación. Diez híbridos experimentales superaron al promedio de testigos en el rendimiento de grano y 23 en el contenido de aceite.

ABSTRACT

In August of 1990 it was planted an experiment with 45 hybrids of sunflower, their progenitors nine restorer lines (R), five isogenic lines (B) of the cytoplasmic male sterility and eight controls (hybrids and varieties) were included.

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It was used an experimental design of randomized complete blocks with four repetitions. The experiment was conducted in the Campo Experimental Rio Bravo of the Institute Nacional de Investigaciones Forestales y Agropecuarias de Tamaulipas, México (CERIB INIFAP-TAM). The objectives were: a) To evaluate the combining ability of the lines; b) To compare the behaviour among Per-se lines and the GCA and c) To observe differences among experimental and comercial hybrids. The variable grain yield showed effects of non-additive while oil content showed additives. There was not correlation among lines Per-se and the GCA for grain yield. The contain of oil was higly correlated and significative, where the females showed superior association. Ten experimental hybrids overcome the average of the controls in the grain yield and 23 in the content of oil.

INTRODUCTION

The sunflower commercial production in México initially (1969-70), needed the utilization of open pollinated varieties. Later on 1978, the hybrids that were used some 3 years before, in the commercial production of the USA, were also employed in México

In the Central área of the Mexican State of Tamaulipas, 2 sunflower hybrids from the States: Saffola 304 and PAG-100 had big acceptance. This fact created the need to try to produce our own sunflower hybrids and seeds, for local use and as good or better than the introduced on the basis of better adaptation and consecuent, higher yields on grain and seed oil content.

For this purpose, it was necessary the formation of parent lines and identification of materials with agronomic and identification of materials with agronomic and physiologic characteristics more adecuated to the regional environment and according with the local grower needs.

The lines selection by means of sigle crossing is hard and laborious and when the number of lines is high, the job is harder. The testing of lines Per-se has given good results on corn and sorghum crops, some work has been done on this direction to determine the agronomic characteristics that are more reliable to consider it at the line selection for this type of test.

The objectives of this experiment were: a) To evaluate the combining ability of lines in their hybrid combinations; b) To compare the behavoir among the line Per-se and the General Combining Ability (GCA); c) To observe the differences among the commercial and experimental hybrids.

REVIEW OF LITERATURE

Allard (1960) and Brawer (1969) define the general combining ability as the mean behavoir of a line on its hybrid combination; the same definition that was made by gprague and Tatum (1942) who added that specific combining ability (SCA) represents the deviations of some better or worst crosses compared with the average of the parent lines, indicating that the GCA is due to additive genetic effects and the SCA is an effect of dominance or ephystasis.

Griffing (1956) mentiones that generally combine the lines with higher GCA and are selected those of higher SCA directly estimated by the hybrid behavior. Lonnquist (1968) indicates that the GCA can be estimated for any character but for cereals is mainly applicated to the grain yield.

For corn, several methods have been utilized to estimate the GCA. Lonnquist and Linsay (1964) mentione the half-breeds test; Griffing (1956) suggest the use of dialelic crosses and Marquez (1985) and Gonzalez (1987) the lines test.

With sorghum, has been common the use of dialelic crosses on one way (direct single crosses) as shown by Finker et al (1976) Singhania y Rao (1975) made comparsions between the lines test Per se with their GCA Mendoza (1988) conclude that the yield of the lines Per se is a good initial criteria for eliminate, parent lines of hybrid sorghums.

For sunflower, itis necessary to know the heterosis manifestation so as the important agronomic characteristic correlations between the parent lines and their hybrids in order to have an adecuated model for the hybrid development and improvement that will have better attributes. Miller et al (1982) indicate that the selection could be more effective during the formation and selfings processes if some knowlodge of the combining ability and the line response, were also known.

Kloczowski (1972) mentiones that general correlation test have shown that the traits that contribute for a good plant development are associated with high yields.

Russell (1953) observed a positive and significative correlation with the seed oil content in percent, plant height, days to flowering and tolerance to rust between the parent lines and their hybrids, however, he did not find correlation for grain yield between the line and its correspondent GCA Kovacik et al (1980) indicate that the number and weight on the aquenes, the plant height, the head diameter and the stem diameter have correlated well with the lines grain yields.

Skoric (1982) found that F_1 hybrids shown a greater correlation for grain yields and seed oil content with the female than with male lines, while Miller et al (1982) when no correlation was obtained definitively between the grain yield of the female line and its crosses, indicate that the selection for grain yield would be based on the response of the lines in their crosses better than the line itself results.

MATERIALS AND METHODS

The experiment was conducted at the Rio Bravo ARS (CERIB-INIFAP-SARH) Northern the Mexican State of Tamaulipas, which is located 26°of the North Latitude and 98° West Longitude.

The altitude is of 38 meters ASL and the climate is extreme dry: B5, (h') hw" (e) with annual average temperature of 26°Celsius.

There were evaluated 67 genotypes: 5 mantaining lines (B) counter part of the (A) cytoplasmic sterile, 9 restorer lines (R), 45 hybrids from the cross of the lines included in this experiment, 5 commercial hybrids and 3 open polinated vorieties as checks.

The 5 (B) lines and their isogenic sterile and 8 of the restorer lines were obtained in the Rio Bravo ARS and it was included in this group, the RHA-273 line introduced from the USA, so as the checks: PAG 100, Saffola 304 and 317 and Pioneer 6420 and 6320 and the Rib-77, Sereno and TPM open pollinated varieties.

On August of 1990, these materials were sown under randomized complete blocks experimental design and with 4 replications. The experimental plot were of 3 rows of 3m of lenght the plant population was of 50,000 per hectare. The experiment was conducted under irrigation conditions, giving one irrigation before sowing and 3 more auxiliary, at 30,55 and 75 days after seeding. Ten plants with complete competence were harvested and the considered variables, were: grain yields (kg/ha), oilseed content (% on dry matter basis and by means of Nuclear Magnetic Resonance: NMR), the weight of 100 seeds (gr), head diameter (cm), plant height (cm), days to flowering (50%) and days to physiological maturity.

To separate the effects among treatments, the sum of squares was divided for crosses, parent lines and checks according with the design: Line X Tester. This design permits to estimate the combining ability of the lines and their crosses same as the Genetic Design II of North Carolina, where the mean sguares separate males and females (GCA) and their interaction (ECA.)

To use the information obtained by means of the behavior Per-se of the lines and its association with the correspondent GCA in the included variables, the correlations were made considering separately the male lines group (R) the one of female lines (B) and both no matter if (B) or (R).

RESULTS AND DISCUSSION

The statistical analysis shown a highly significative difference for treatments and for all the considered characteristics for which reason it was made the treatments partition (of parent lines, crosses and checks), where were observed that the parent lines obtained a statistical difference highly significative same as the crosses in the whole of characteristics included in the test. At the same time the checks among them, showed similar values except for grain yields and head diameter that were not significative (Table 1).

TABLE 1.- ANALYSIS OF VARIANCE FOR THE CHARACTERISTICS: GRAIN YIELD (GY), SEED OIL CONTENT (0%), WEIGHT OF 100 SEEDS (W 100 S), HEAD DIAMETER (HD), PLANT HEIGHT (PH) DAYS TO FLOWERING 50% (DF) AND DAYS TO PHYSIOLOGIC MATURITY (DFM). RIO BRAVO, TAM. MEX ARS-INIFAP-SARH.

Variation Factor	FD	GY	0%	W100S	HD	PH	DF	DFM
Parent Lines	13	0.36**	31.8**	14.31**	33.5**	39788**	90.4**	9.0**
Crosses	44	0.22**	17.0**	2.44**	4.59**	1098**	13.2**	8.6**
Check	7	0.09	27.9**	1.13**	3.29	979**	59.3**	17.4**
GCA MALES	8	0.52**	31.3**	8.08**	13.0 **	0.28**	41.5**	18.3**
GCA FEMALES	4	0.08	20.0**	4.01**	5.75**	0.46**	6.75	10.3**
Females X Males (SCA)	32	0.16**	4.22**	0.84**	2.34	0.02**	6.97**	6.0**
Error	198	0.046	2.12	0.38	1.65	63	2.82	2.94

Estimating the GCA of the parent lines, was observed that the male lines manifested a statistical difference highly significative in all the cases, while for the female ones the obtained values were highly significative on five of the characteristics and only for the grain yield and days to flowering were not observed any statistical differences.

The interaction Females X Males that indicate the varianza due to the specific combining ability (SCA) where were obtained highly significative differences on six characteristics but the head diameter that was nos significative.

The grain yields so as days to flowering and days to physiologic maturity shown non-additive genic action effects. The seed oil content shown an effect of genic action additive mainly but with some non-additive effect. For the weight of 100 seed and for the plant height the effects of additive and non-additive geni action were equally important, while for head diameter, additive effects were observed.

Related with grain yields these results coincide with the ones obtained by Tyagi (1988) and Dominguez and Miller (1988) and they are different than the results observed by Anaschenko (1974) and Miller et al (1980) for seed oil content that coincide with the conclutions of Putt (1966) who mentioned the existence of a very high aditive component, while Russell 1953 concluded that seed oil content is determined by the genes action partially dominant and Fick (1975 and Abdel Hamid (1988) that observed aditive effects equally important.

At table 2 the correlation coefficients obtained are detailed, betwen the behavoir Per-se of the lines and the GCA on 7 agronomic characters.

The correlations between the yield of the Per-se lines (no matter if B or R) and the GCA was positive and not significative while the parent lines correlated separately (females and males) shown negative and low values so as not significative. For seed

TABLE 2. CORRELATIONS BETWEEN THE Per-se BEHAVIOUR AND THE GCA OF THE LINES. RIO BRAVO TAM. MEXICO ARS-INIFAP-SARH 1990.

Characteristics	Correlations		
	Combined	Females (B)	Males
Grain Yields	0.24	-0.12	-0.19
Seed Oil Content	0.80**	0.98**	0.43
Weight of 100 Seeds	-0.05	0.76	-0.01
Head Diameter	0.19	0.45	0.13
Plant Height	0.96**	0.97**	0.83**
Days to Flowering (50%)	0.54*	0.71	0.83**
Days to Physiologic Maturity	0.29	0.80	0.32

(B) Mantaining Lines.- Isogenic Lines (A) Citoplasmic Sterile.

oil content it was detected in the whole lines, a positive and highly significant correlation and same as in the female lines group, the male lines group has low and non-significant correlatio For plant height the correlation coeficients were high and positiv so as significative wholly taken and for each one group of parent lines. The weight of 100 seeds and the head diameter, the group of male lines shown a low and negative correlation, but in the other hand the female lines had higher values but not significant. The days to flowering the whole group of lines shown a positive and significative association, however, this coefficient was greater for the male group than for the female one. For days to physiologic maturity the index observed was positive and significative, just for the female lines group.

The correlation coefficients obtained for grain yields do not show that the behavoir of the lines Per-se and for this character

do not permit to make a good selection. Similar results were found by Miller et al (1982) and these were different than the indicated by Skorik (1982) who obtained a significative correlation for grain yields. These same researchers coincide on their results in conection with the oil seed content and point out that the F_1 hybrids gave a greater correlation with the mother lines, what was observed in the test now being presented.

To observe a high correlation between lines Per-se and the GCA on both parent line groups, referring to the plant height, it indicates that there was a close association with the hybrid plant developed height. The negative values observed for the male lines group for the traits: weight of 100 seeds and head diameter so as for grain yield as was expected and given the characteristics of the plants of these lines (branched, small heads and seeds. For days to flowering, the male lines group expresed a greater influence in the flowering of the respective hybrids while for physiologic maturity, the female ones shown a greater association.

TABLE 3.- GRAIN YIELDS (kg/ha) OF HYBRIDS FORMED WITH LINES HIGH OR LOW YIELDING Per-se. RIO BRAVO TAM. MEXICO ARS-INIFAP-SARH 1990.

	HIGH YIELD Per-se					LOW YIELDS Per-se			
FEMALE LINES	MALE LINES ♂				FEMALE LINES	MALE LINES ♂			
♀	838	SARH	Z-37	Z-28	♀	S-44	273	S-7-8	S-59
CM3	1754	1340	2044	1936	285	1655	1845	2111	1698
VI	2038	1753	1739	2076	386	1859	1962	1731	2240
		X= 1835					X= 1888		

X General Mean= 1670 kg/ha

To identify the Per-se lines with higher grain yields, so as the ones with the lowest yields, two groups were formed, each one with two females and four males. The yields of the hybrids formed with these lines are detailed on table 3, where observed

that the average yield of 1835 kg/ha of the high yielding group, was a little lower than the average yield (1888 kg/ha) given by the low yield lines group.

For the first group, when the female lines were common parent lines, formed 14 hybrids with yields that were equal or greater than the average mean (45 hybrids) that was of 1670 kg/ha The males in this group formed 16 hybrids. In the second group (low yields Per-se) the females and the males when functioning as commun parents created 15 and 17 hybrids respectively with same or higher yields to the general mean. This situation confirms that on sunflower, the lines Per-se selection for grain yields is not a correct practice to follow.

Considering the Per-se lines with relation to the seed oil content, were selected two female lines and three male ones with higher seed oil content whose hybrids reached an average of 46.5%- while the same number of female and male lines with the lowest seed oil parentages, their hybrid combinations reported an average of 40.6% which is lower than the general mean of 43.1% (Table 4). The two female lines with the highest seed oil content when working as common parent lines, give 17 hybrids with same or higher content than the general mean, while the females with the lowest content on oil seed only give 4 hybrids. In the case of the males with greater seed oil content attained 10 hybrids against 8 hybrids that were possible with the three males with the lowest seed oil content.

Doing the selection for this character on the basis of the high or low GCA of the parent lines, for the first case there were selected two females and three males which hybrid combinations gave an average of 47.1 % for the seed oil content.

The case of the parent lines with low GCA were the same that reported the lowest content Per-se. The parent lines with high GCA in commun intervention gave 17 hybrids for the female case and 12 for the male ones.

TABLE 4.- OIL PERCENTAGE OF HIBRIDS FORMED WITH PARENT LINES OF HIGH OR LOW CONTENT Per-se (UPPER PART) AND WITH HIGH OR LOW (GCA) (LOWER PART) RIO BRAVO, TAM. MEXICO ARS-INIFAP-1990.

	HIGH CONTENT Per-se				LOW CONTENT Per-se		
FEMALE LINES	MALE LINES ♂			FEMALE LINES	MALE LINES ♂		
♀	S-59	273	S-44	♀	SARH	Z-37	Z-28
285	45.7	46.1	47.6	VI	41.0	39.8	42.8
386	46.0	47.0	46.0	CM3	39.6	38.5	41.6
	X = 46.5				X = 40.6		

	HIGH GCA				LOW GCA		
FEMALE LINES	MALE LINES ♂			FEMALE LINES	MALE LINES ♂		
♀	838	S-7-8	273	♀	Z-37	SARH	Z-28
386	47.6	48.8	47.0	CM3	38.5	39.6	41.6
285	46.2	47.0	46.1	VI	39.8	41.0	42.8
	X = 47.1				X= 40.6		

These results show that the lines selection Per-se for high seed oil content is effective mainly on female lines, where there are less risks to eliminate lines with low oil content that can report a good GCA, while in the case of the males, the risks are higher. This can be taken in accouot when some of the male lines with low seed oil content would have another important trait for its improvement.

Another of the objectivies of the experiment was to compare the experimental and commercial hybrids, the last ones as checks, in order to have a better appreciation on the possibilities of

the experimental materials. On the Table 5 are summarized the averages obtained between the parent lines and their hybrids and between these and the checks (commercial hybrids), among the traits considered in the same Table.

The B lines shown a high difference in comparsion with the (R)lines, on the grain yields, plant height, head diameter and on the weight of 100 seed, due mainly to the phenotypic traits of the lines plants (R). The grain yields on the (R) lines was obtained considering all the heads of each plant. Another important difference of this group was its greater earliness compared with the(B)lines one.

TABLE 5.- AVERAGES OBTAINED FOR THE (B) AND (R) LINES; THEIR CROSSES (A X R) AND COMMERCIAL HYBRIDS (CHECKS) IN THEIR AGRONOMIC QUALITIES. RIO BRAVO, TAM. MEXICO ARS OF INIFAP-SARH (1990)

GENOTYPES	CHARACTERISTICS							
	No.	GY	SOC%	PH	HD	W100S	DF	DPM
B* Lines (A)	5	1277	40.7	110	14.0	5.82	68	96
R Lines	9	745	42.7	89	8.3	2.33	61	93
A X R Hybrids	45	1837	44.0	136	14.7	5.48	60	93
Checks	5	2041	44.3	133	15.0	6.92	64	96

* Isogenic of the A line, citoplasmic sterile.

The B lines shown also low grain yields althought this was due mostly to the homocygosis effect (S4-S6) of the lines themselves. The V1 and CM_3 lines wich averages on the seed oil content were the lowest with 38.2 and 35.6%, respectively and influenced the low average of the females group; however, they obtained the highest grain yields with 1332 and 1507 kg/ha.

The heterosys effect was observed on the experimental hybrids for grain yields, seed oil content, plant height and for the head diameter. Comparing the experimental and commercial hybrids (checks) it was observed that in the two main traits (grain

yields and seed oil content), the checks were better than the experimental hybrids, considering the averages; althought three of them were higher in grain yields than the best check that was Saffola 317 that give 2181 kg/ha and 10 experimental hybrids that overpassed the average of the checks (of 2041 kg/ha). Related with the oilseed content the experimental hybrids shown a superiority on the checks althought 18 hybrids were much better than the check Saffola 304 that reported an average of 45.1% and 23 of them were better than the checks average that was of 44.3%. Among the open pollinated varieties, the outstanding ones were: Sereno in grain yield with 2063 kg/ha and an oil seed content of 41.6 % and the cultivar TPM, in the seed oil content of 46.1% and the grain yields of 1824 kg/ha. At the Table 6 is found the data of grain yields and oil content of the seed so as kg of oil obtained from 5 experimental hybrids compared with the 3 best commercial hybrids (checks).

TABLE 6.- GRAIN AND OIL YIELDS (kg/ha) IN THE BEST 5 EXPERIMENTAL HYBRIDS AND CHECKS. RIO BRAVO, TAM. MEXICO APS 1990.

GENOTYPES	YIELDS (kg/ha)	
	GRAIN	OIL
Experimental Hybrids		
CM3 X 273	2313	918
386 X S-49	2240	1024
486 X S-7-8	2192	980
285 X S-7-8	2111	992
285 X S-10	2102	940
Checks		
Saffola 317	2181	973
Saffola 304	2171	979
PAG-100	2121	891

CONCLUSIONS

The grain yields shown non-additive genic action effect and same effects were observed for days to flowering and days to

physiologic maturity. The oil content in the seeds manifested mainly additive genic action effects. For the 100 seed weight and plant height the additive and non-aditive genic action effects were equally important and the head diameter shown the aditivity effects.

There was not correlation between the behavoir of the lines Per-se and the GCA for the grain yield. The conjunct correlation between the lines Per-se and the GCA was positive and significative for oil content in the seed, plant height and days to flowering, however, for parent lines group the behavoir of the female lines shown higher association than the males ones for seed oil content and days to pysiologic maturity while than the males group gave greater association for days to flowering. Both groups of parent lines correlated high and significatively, for plant height.

There were observed heterosys effects in the experimental hybrids for grain yields and seed oil content. Ten experimental hybrids had higher than the check average of grain yields and 23 for the seed oil content. (LQV/ olem, 4292)

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