HELIA, **19**, Nr. 25, p.p. 111-118, (1996) UDC 631.527.5:633.854.78

EXPRESSION OF HETEROSIS IN SINGLE-, DOUBLE- AND THREE-WAY CROSS HYBRIDS OF SUNFLOWER (*Helianthus annuus* L.)

H.S. Gill and M.S. Punia

Oilseeds Section, Dept. of Plant Breeding, CCS Haryana Agricultural University, Hisar - 125 004, India

Received: October 27, 1996.
Accepted: November 30, 1996.

SUMMARY

A comparative study on heterosis was conducted on nine single, eighteen double, and eighteen three-way cross hybrids for six characters viz., maturity (days), head diameter (cm) 100-seed weight (g), number of seeds per head, seed yield per plant (g) and oil content (%). The results of the study revealed that single cross hybrids were best for head diameter, number of seeds per head, and seed yield per plant. The double cross hybrids were superior for earliness and 100-seed weight. The three-way cross hybrids were inferior to single and double-cross hybrids in exploiting heterosis.

Key words: Sunflower, heterosis, single-cross, double-cross, three-way cross.

INTRODUCTION

Sunflower being a cross pollinated crop, it provides an opportunity for developing new and superior hybrids through the use of heterosis breeding. Commercial cultivation of hybrid sunflower started in 1969 in France and in 1972 in Romania. The practical use of heterosis in sunflower became possible only after a source of cytoplasmic male sterility was identified by Leclercq (1969). Development of the first sunflower hybrid based on cytoplasmic male sterility in the early 1970's intensified the interest of farmers in growing this crop with sunflower yield potential increasing markedly. The heterosis for seed yield and its component traits in single-cross hybrids have been reported in sunflower (Anaschencko *et al.*, 1975; Voskoboinik, 1977; Chaudhary and Anand, 1984; Cruz, 1986 and Naik *et al.*, 1988). However, the present study deals with the expression of heterosis not only in single crosses, but also in the double- and three-way cross hybrids of sunflower.

MATERIALS AND METHODS

The experimental material consisted of 9 single crosses, 18 double crosses, and 18 three-way cross hybrids, their 15 parents, and three standard checks viz., APSH-11, MSFH-8 and EC68415 (Table 1). All the 63 genotypes/hybrids were grown in 2 rows of 3 m length with spacing 60x30 cm in a randomized block design with three replications at the experimental farm of Department of Plant Breeding, CCS Haryana Agricultural University, Hisar, during the years 1992-93. All F_1 hybrids written on the left hand side (Table 1) have been used as female parents for making double- and three-way cross hybrids. Male sterility in these F_1's has been induced by the application of gibberellic acid (GA_3) as gameticide @ 0.2% at the time of opening of flower. Data were recorded on the following characters viz., maturity (days), head diameter (cm), 100-seed weight (g), number of seeds per head, seed yield per plant (g) and oil content (%). Data were analysed as per the standard procedure and heterosis was calculated as follows :

(i) Per cent heterosis over better parent (BP) = $\frac{F_1 - BP}{BP} \times 100$

(ii) Per cent heterosis over best check (BC) = $\frac{F_1 - BC}{BC} \times 100$

Table 1: Single-cross, double-cross and three-way cross hybrids utilized in this experiment

Single-cross hybrids
CMS 300A x RHA 298; CMS 300A x RHA 272; CMS 300A x RHA 273;
CMS 336A x RHA 857; CMS 336A x RHA 856; CMS 336A x RHA 274;
CMS 336A x RHA 271; CMS 336A x RHA 296; CMS 7-1Ax RHA 297

Double-cross hybrids
[(CMS 336A x RHA 857) x (CMS 300A x RHA 298); (CMS 336A x RHA 856) x (CMS 300A x RHA 298); (CMS 336A x RHA 274) x (CMS 300A x RHA 298); (CMS 336A x RHA 271) x (CMS 300A x RHA 298); (CMS 336A x RHA 296) x (CMS 300A x RHA 298); (CMS 7-1A x RHA 297) x (CMS 300A x RHA 298); (CMS 336A x RHA 857) x (CMS 300A x RHA 272); (CMS 336A x RHA 856) x (CMS 300A x RHA 272); (CMS 336A x RHA 274) x (CMS 300A x RHA 272); (CMS 336A x RHA 271) x (CMS 300A x RHA 272); (CMS 336A x RHA 296) x (CMS 300A x RHA 272); (CMS 7-1A x RHA 297) x (CMS 300A x RHA 272); (CMS 336A x RHA 857) x (CMS 300A x RHA 273); (CMS 336A x RHA 856) x (CMS 300A x RHA 273); (CMS 336A x RHA 274) x (CMS 300A x RHA 273); (CMS 336A x RHA 271) x (CMS 300A x RHA 273); (CMS 336A x RHA 296) x (CMS 300A x RHA 273); (CMS 7-1A x RHA 297) x (CMS 300A x RHA 273)]

Three-way cross hybrids
[(CMS 336A x RHA 857) x IB2; (CMS 336A x RHA 856) x IB2; (CMS 336A x RHA 274) x IB2; (CMS 336A x RHA 271) x IB2; (CMS 336A x RHA 296) x IB2; (CMS 7-1A x RHA 297) x IB2; (CMS 336A x RHA 857) x IB28; (CMS 336A x RHA 856) x IB28; (CMS 336A x RHA 274) x IB 28; (CMS 336A x RHA 271) x IB28; (CMS 336A x RHA 296) x IB28; (CMS 7-1A x RHA 297) x IB28; (CMS 336A x RHA 857) x IB 43; (CMS 336A x RHA 856) x IB 43; (CMS 336A x RHA 274) x IB43; (CMS 336A x RHA 271) x IB43; (CMS 336A x RHA 296) x IB43; (CMS 7-1A x RHA 297) x IB43)].

Parental lines
Cytoplasmic male sterile lines : CMS 300A, CMS 336A, CMS 7-1A;
Inbred lines : IB2, IB28, IB43;
Restorer lines : RHA 271, RHA 272, RHA 273, RHA 274, RHA 296, RHA 297, RHA 298, RHA 856 and RHA 857

RESULTS AND DISCUSSION

Estimation of heterosis in the single-cross, double-cross, and three-way cross hybrids for the six characters studied is presented in Tables 2, 3 and 4, respectively, and a comparison among the three types of hybrids is presented in Table 5. Comparison of heterosis revealed that for days to maturity the double-cross hybrid (CMS 336A x RHA 271) x (CMS 300A x RHA 272) was found to be significantly superior over the better parent (CMS 300A), but the superiority over the best check (EC 68415C) was not significant (Table 4). The single- and three-way cross hybrids were not able to express significant heterosis for earliness in maturity.

Table 2: Estimation of heterosis in single-cross hybrids of sunflower

Cross	Maturity (days)		Head diameter (cm)		100-seed wt. (g)		No. of seeds/ head		Seeds yield/plant (g)		Oil content (%)	
	over		over		over		over		over		over	
	†	‡	†	‡	†	‡	†	‡	†	‡	†	‡
CMS300A x RHA 298	-1.06	2.19	2.33	1.73	3.82	4.26	6.67	13.66	15.07	14.74	2.96	2.09
CMS300A x RHA 272	-1.06	2.19	-5.81	-6.35	-11.00	-17.94	-8.55	-2.55	-16.85	-17.05	-0.92	-3.37
CMS300A x RHA 273	10.00**	8.79**	19.18**	18.50**	7.65	0.74	8.20	15.30	5.03	4.77	0.39	2.08
CMS336Ax RHA 857	7.60**	8.79**	26.48**	35.26**	15.47	6.47	26.44**	38.80**	35.43**	51.79**	-0.15	0.45
CMS336A x RHA 856	8.88**	7.69**	26.48**	35.26**	14.83	5.88	0.50	9.28	3.20	15.67	5.28	4.03
CMS336A x RHA 274	4.39**	4.39**	-1.08	5.78	-16.46	-18.67	11.22	20.95	-9.13	1.84	-1.76	-0.30
CMS336A x RHA 271	-1.06	3.29*	-58.92**	-56.07**	-16.46	-19.11	-6.26	1.82	-50.76**	-44.81**	-4.11	-1.49
CMS336A x RHA 296	4.39**	4.39**	-26.48**	-21.38**	-0.63	-6.91	-4.52	3.82	-11.40	-0.88	2.02	4.47
CMS7-1 x RHA 297	2.17	3.29*	10.27**	23.70**	5.90	0	8.88	-12.93	26.96	-0.22	-5.21	-2.38
SE±	1.36		0.58		0.56		70.5		5.01		1.19	

* Significant at 5%
** Significant at 1%
† Better parent
‡ Best check

For head diameter, the single-cross hybrids viz., CMS 336A x RHA 856, CMS 336A x RHA 857, and CMS 300A x RHA 273 produced significant heterotic vigour over their respective better parent and the best check, EC 68415C (Table 2). None of the double- cross hybrids were able to exhibit significant heterosis, whereas, two three-way cross hybrids, (CMS 336A x RHA 856) x IB28 and (CMS336A x RHA296) x IB43 produced significant heterosis (Table 4) but not to the level as expressed by the single-cross hybrids. For 100-seed weight, none of the single- and three-way cross hybrids were able to express significant heterosis. Only one double-cross hybrid, (CMS 336A x RHA 856) x (CMS 300A x RHA

Table 3: Estimation of heterosis in double-cross hybrids of sunflower

Cross	Maturity (days)		Head diameter (cm)		100-seed wt. (g)		No. of seeds/head		Seeds yield/plant (g)		Oil content (%)	
	over		over		over		over		over		over	
	†	‡	†	‡	†	‡	†	‡	†	‡	†	‡
CMS 336AxRHA 857 x CMS300AxRHA298	2.22	-2.19	-8.1**	-1.73	-0.30	-2.94	-0.81	11.66	4.08	2.72	-5.69	1.34
CMS336AxRHA856xCMS300AxRHA298	-3.26*	1.09	-5.94	0.68	16.31*	13.24*	-8.36	3.15	1.52	13.00	-5.83	1.19
CMS336AxRHA274xCMS300AxRHA298	-2.19	-2.19	-3.78	2.89	11.78	8.82*	3.83	16.76	18.59	32.92*	-14.02**	-4.62
CMS336AxRHA271xCMS300AxRHA298	0	3.29*	-13.51	-7.51	-20.69*	-22.80*	-22.49	-12.75	-39.95**	-32.70	-8.88**	2.08
CMS336AxRHA296 xCMS300AxRHA298	2.19	2.19	-8.60**	2.31	6.95	4.12	1.45	14.57	12.14	25.69	-4.86	2.24
CMS7-1AxRHA297xCMS300AxRHA298	4.35**	5.49**	-2.90	-3.40	-5.44	10.59	24.75	-15.30	-20.74	-20.94	-3.33	3.61
CMS336AxRHA857xCMS300AxRHA272	5.43**	6.59**	2.70	9.83**	-4.38	-6.91	4.47	17.49	3.52	16.03	7.27*	7.91*
CMS336AxRHA856xCMS300AxRHA272	0	-1.09	-12.97**	6.93	4.68	1.91	-11.00	0.12	-5.58	5.82	6.64	5.37
CMS336AxRHA274xCMS300AxRHA272	2.19	2.19	-10.27**	-4.04	-21.90**	-23.97	-8.90	2.55	-27.91*	-19.20	-14.85**	-13.58**
CMS336AxRHA271xCMS300AxRHA272	-5.32**	-2.19	-23.24**	-17.91**	-3.47	-6.03	-30.42*	-21.67	-30.15	-21.71	3.92	6.72
CMS336AxRHA296xCMS300AxRHA272	2.19	2.19	-20.34**	-20.80**	1.66	-1.03	-18.28	-8.01	-24.27*	-15.12	1.18	12.09
CMS7-1AxRHA297xCMS300AxRHA272	2.17	3.29**	0.58	0	8.08	13.09	-12.78	-1.82	-10.23	-10.95	-2.90	0
CMS336AxRHA857xCMS300AxRHA273	2.22	1.09	-13.51**	7.51*	-5.59	-6.61	-3.93	8.56	-7.63	3.83	2.37	2.98
CMS336AxRHA856xCMS300AxRHA273	5.55**	4.39**	22.70	-17.34	-4.38	-6.91	-30.10	-21.31	-32.30**	-24.12	-3.92	-5.07
CMS336AxRHA274xCMS300AXRHA273	3.33**	2.19	-8.10**	-1.73	-17.82*	-20.00	-9.55	-1.64	-26.20*	-17.27	2.94	4.48
CMS336AxRHA271xCMS300AxRHA273	5.55**	4.39	-7.02*	0.57	-2.72	-5.29	11.39	3.64	-7.36	3.93	-6.40	-3.83
CMS336AxRHA296xCMS300AxRHA273	5.55**	4.39	-8.10**	-1.73	-7.15	-12.20	-30.31*	-24.23	-33.30*	-25.34	-5.92	-5.07
CMS7-1AxRHA297xCMS300AxRHA273	5.55**	4.39	0.58	1.15	-4.38	-6.91	-37.09**	-32.97*	-39.00**	-32.11**	-11.01**	-8.36*
SE±	1.36		0.58		0.56		70.5		5.01		1.19	

* Significant at 5%, ** Significant at 1%, † Better parent, ‡ Best check

Table 4: Estimation of heterosis in three-way cross hybrids of sunflower

Cross	Maturity (days)		Head diameter (cm)		100-seed wt. (g)		No. of seeds/head		Seeds yield/plant (g)		Oil content (%)	
	over		over		over		over	over	over			
	†	‡	†	‡	†	‡	†	‡	†	‡	†	‡
CMS336AxRHA857xIB2	2.17	3.29*	-1.66	5.30	-1.66	-4.26	-15.41	-8.01	-11.05	-0.30	1.78	2.39
CMS336AxRHA856xIB2	4.44**	3.29*	2.70	9.82**	-4.83	-7.35	-38.26**	-32.97	-34.17**	-26.21	-2.42	3.58
CMS336AxRHA274xIB2	4.39**	4.39**	-8.10**	-1.73	-17.67	-19.85**	13.06	-5.46	-42.74	-35.81**	-4.41	-2.98
CMS336AxRHA271xIB2	-1.06	3.29*	-18.91**	-13.29	3.78	1.03	3.85	12.93	5.36	18.10	-6.10	-3.58
CMS336AxRHA296xIB2	5.49**	5.49**	-4.32	-2.31	-12.99**	-15.29	-32.16	-26.23	-41.99	-34.98	5.32	6.27
CMS7-1AxRHA297xIB2	3.26*	4.39**	2.90	-2.31	3.25	-1.91	29.46	-1.27	28.16	0.70	-2.32	0.59
CMS336AxRHA857xIB28	2.17	3.29*	-12.43**	-6.35	-3.25	1.76	-17.25	-9.83	-17.70	-4.22	0	0.59
CMS336AxRHA856xIB28	7.77**	6.59**	11.35**	19.07**	1.95	7.35	1.34	10.20	5.90	23.66	-1.35	-2.53
CMS336AxRHA274xIB28	2.19	2.19	20.00**	-14.45**	-10.06	5.29	-17.25	-9.83	-24.06	-11.61	-3.23	1.73
CMS336AxRHA274xIB28	1.06	4.39**	-32.97**	-28.32**	-21.78*	-17.65	-6.53	15.84	-14.41	-0.38	-3.34	-0.75
CMS336AxRHA296xIB28	3.29**	3.29*	-6.46	0	-6.84	1.91	-4.86	3.46	-9.41	5.43	-13.04	-12.53
CMS7-1AxRHA297xIB28	3.26*	4.39**	5.23	-4.62	-14.52*	-10.00	-7.19	-1.27	-24.06	-11.61	1.47	1.49
CMS336AxRHA857xIB43	2.17	3.29**	-15.67**	-9.82**	3.32	0.58	-7.52	2.91	-28.16*	-19.48	2.96	1.99
CMS336AxRHA856xIB43	-2.22	-3.29	-15.13**	-9.25**	7.25	4.41	-21.76	11.11	-32.03**	-30.81	0	1.20
CMS336AxRHA274xIB43	3.29*	3.29*	-10.27**	-4.04	13.54	7.35	13.42	26.23**	7.56	0.56	-4.11	-2.68
CMS336AxRHA271xIB43	0	4.39**	-3.24	3.46	-2.72	-5.29	17.51	30.78**	4.72	17.38	0.29	2.98
CMS336AxRHA296xIB43	4.37**	4.39**	15.13**	23.12**	-2.72	-5.29	3.27	14.93	2.04	14.37	-5.18	-2.98
CMS7-1AxRHA857xIB43	6.52**	-7.69**	-10.27**	-4.04	-25.34	-29.41	-30.43	-22.58	-35.56**	-30.03*	-7.97**	-5.22
SE±	1.36		0.58		0.56		70.05		5.01		1.19	

* Significant at 5%, ** Significant at 1%, † Better parent, ‡ Best check

298) was found to be significantly superior over the better parent (CMS 300A) and the best check EC 68415C (Table 3).

The single-cross hybrid CMS 336A x RHA 857 was found to be significantly superior over the better parent (CMS 336A) and the best check (EC 68415C) for number of seeds per head and seed yield per plant (Table 2). None of the hybrids among the double- and three- way crosses produced significant heterosis. For oil content, only one double-cross hybrid, (CMS 336A x RHA 857) x (CMS 300A x RHA 272), produced significant heterotic vigour (Table 3).

Table 5: A comparison of heterosis among single-, double- and three-way cross hybrids of sunflower

Character		Single-cross hybrids	Double-cross hybrids	Three-way cross hybrids
Maturity (days)	†	-1.06-10.00	-5.32-5.55	-2.22-7.77
	‡	2.19-8.79	-2.19-6.59	-3.29-7.69
Head diameter (cm)	†	-58.92-26.48	-23.24-2.70	-32.97-15.13
	‡	-56.07-35.26	-20.80-9.83	-28.32-2312
100-seed weight (g)	†	-16.46-15.47	-21.9-16.3	-25.34-13.64
	‡	-19.11-6.47	-23.7-13.24	-29.41-7.35
Number of seeds/ head	†	-8.35-26.44	-37.09-11.39	-38.26-23.46
	‡	-12.93-38.8	-32.97-17.49	-32.97-30.78
Seed yield/plant (g)	†	-50.76-35.43	-39.95-18.59	-42.74-28.16
	‡	-44.81-51.79	-32.7-32.92	-35.81-23.36
Oil content (%)	†	-5.21-5.28	-14.85-7.27	-13.04-5.32
	‡	-3.37-4.47	-13.85-7.91	-12.53-6.27

† Better parent, ‡ Best check

From the study of comparisons (Table 5), it is concluded that single- cross hybrids were best in exploiting heterosis for head diameter, number of seeds per head, and seed yield per plant as compared with double- and three-way cross hybrids. The double-cross hybrids were superior for days to maturity, 100-seed weight, and oil content. Although heterosis has also been expressed by three-way cross hybrids for the characters studied, it was less as compared with single- and double -cross hybrids. Contrary to these results, Bounnit *et al.* (1978) and Vranceanu and Stoenescu (1979) reported that double-cross and three-way cross hybrids were similar to single-cross hybrids in seed yield and oil content.

From these results it is evident that for seed yield and its component characters, single-cross hybrids are more suitable for exploiting heterosis to the maximum level as compared with double- and three-way cross hybrids. The single-cross hybrid CMS 336A x RHA 857 was excellent for yield and its components. This cross can be exploited in the future breeding programmes for the production of superior hybrids for increasing the production and productivity of sunflower.

REFERENCES

Anaschenko, A.V., Rozhkova, V.T., and Milleva, T.V. 1975. The results of study of heterosis in sunflower. *Genetike i Selektsii* 55(1): 134-142.

Bounnit, B., Stoenescu, F.M., and Filipescu, H. 1978. Heterosis of oil content and quality in sunflower seed. *Applicata* 10(5): 511-525.

Chaudhary, S.K., and Anand, I.J. 1984. Heterosis and inbreeding depression in sunflower. *Crop Improvement.* 11(1): 15-19.

Cruz, Q.D. Dela. 1986. Heterosis and combining ability for yield and yield components in sunflower. *Philip. J. Crop Sci.* 11(3): 171-174.

Leclercq, P., 1969. Une sterilite male cytoplasmique chez le tournesol. *Ann. Amelior, Plant,* 19: 99-106.

Naik, N.M., Pawar, B.B., and Dumbre, A.D. 1988. Heterosis in sunflower. *J. Maharashtra Agric. University,* 13(1): 39-42.

Voskoboinik, L.A. 1977. Breeding sunflower for heterosis in Bulgaria. *Referativnyl Zhurnal.* 7: 65: 464.

Vranceanu, A.V., and Stoenescu, F.M. 1979. Expression of heterosis in single, three way and double sunflower hybrids. *Fundulea* 44: 29-36.

EXPRESION DE LA HETEROSIS EN HÌBRIDOS SIMPLES, DOBLES Y TRES VIAS DE GIRASOL (*Helianthus annuus* L.)

RESUMEN

Un estudio comparativo sobre heterosis fue conducido en nueve hibridos simples diez y ocho dobles y diez y ocho tres vias para seis caracteres, medurez (dias), diámetro del capítulo (cms), peso de 100 semillas (g), número de semillas po capítulo, rendimiento por planta (g) y contenido en aceite (%). Los resultados del estudio revelaron que los hìbridos simples fueron los mejores para el diámetro del capítulo, número de semillas por capítulo y rendimiento de semilla por planta. Los híbridos dobles fueron superiores para precocidad y peso de 100 semillas. Los híbridos tres vias fueron inferiores a los híbridos simples y dobles en el aprovechamiento de la heterosis.

EXPRESSION DE L'HÉTÉROSIS DANS DES HYBRIDES SIMPLES, DOBLES ET TROIS VOIES DE TOURNESOL (*Helianthus annuus* L.)

RÉSUMÉ

Une étude comparative sur l'hétérosis a été conduite sur neuf hybrides simples, dix huit hybrides doubles et dix huit hybrides trois voies pour six caractéres ie, maturité (jours), diamétre du capitule (cm), poids de 100 grains (g), nombre de graines par capitule, rendement en grains par plante (g) et teneur en huile (%). Les résultats de l'étude révélent que les hybrides simples étaient meilleurs pour le diamétre du capitule, le nombre de graines par capitule, et le rendement en grains par plante. Les hybrides doubles sont supérieurs pour la précocité et le poids de 100 grains. Les hybrides trois voies sont inférieurs aux hybrides simples et doubles pour l'exploitation de l'hétérosis.