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LIMITS TO PARENTAL DIVERGENCE FOR THE OCCURENCE OF HETEROSIS IN SUNFLOWER (*Helianthus annuus* L.)

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SUMMARY

An investigation was carried out at the University of Agricultural Sciences, G.K.V.K. Campus, Bangalore, India, to determine the possible limits to parental divergence for the occurrence of heterosis in sunflower. Seven inbred lines were used to synthesize twenty-eight hybrids following diallel mating design. The magnitude of heterosis in these crosses and the magnitude of the divergence between the parents of the corresponding crosses were estimated. The study revealed sufficient evidence for the limits to the parental divergence to realize high frequency of heterotic crosses with high magnitude. Chances of occurrence of heterosis are higher when the parents are chosen to have their divergence between (m-s) and (m+s) compared with the crosses between the parents whose divergence fall outside this limit. The study also indicated a poor correspondence between the magnitude of heterosis and the genetic divergence.

Key words: Divergence, heterosis, limits.

INTRODUCTION

It is increasingly realized that crosses between divergent parents generally produce greater heterosis than those between the closely related ones as reported long time ago (Hays and Johnson, 1939). Of late several workers like Arunachalam and Bandyopadhyay (1980) in *Brassica campestris*, Srivastava and Arunachalam (1977) in *Triticale* and Arunachalam and Bandyopadhyay (1984) in ground nut and rapeseed have clarly established that there is a close correspondence between the magnitude of genetic divergence and heterosis. Further, Lokaprakash *et al.* (1995) in Rice and Ramesh (1996) in sesame have shown that parent should be diverse with respect to their general combining ability to realize high heterosis. However,

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Cress (1966) reported that heterosis is not found always when divergent parents are crossed *i.e.*, it does not necessarily follow the existence of a direct relationship between genetic divergence and heterosis throughout the entire range of diversity in the species. It seems logical to expect that in crosses of extremely divergent populations, the expression of heterosis may be limited by unharmonious gene combination in F_1 hybrids. At higher levels of genetic divergence, an increase in the divergence might be associated with a decrease in heterotic expression. It is therefore essential to explore the possible limits to parental divergence within which there are reasonably high chances for occurrence of heterosis. In view of this, the present investigation was carried out to determine the limits to parental divergence to realize high heterosis in sunflower.

MATERIALS AND METHOD

The material for the present investigation consisted of seven inbred lines/populations: 274, Tub, 85821, 10045, Morden, 27628 and Ly. These were crossed in a diallel mating desing to produce 28 hybrids which were evaluated along with their parents in randomized block desing with three replications during 1994-95 at the University of Agricultural Science, G.K.V.K. Campus, Bangalore. A recommended package of practices was followed to raise a good crop. Observations were recorded on five randomly selected plants in each entry and in each replication for plant height, stem diameter, head diameter, test weight, oil content, husk percent and seed yield per plant. The mean values of these five plants were used to estimate Mahalonbi's D^2 statistic (Rao, 1952) between the parents.

In order to determine the correspondence between parental divergence and heterosis (if any), rank correlation coefficient was computed between the magnitude of heterosis of the crosses and the genetic divergence between their corresponding parents.

The method proposed by Arunachalam and Bandyopadhyay (1984) was followed to delineate parental divergence in four divergent classes (DC). To take into account the variable magnitude of variation in parental divergence, the mean (m) and standard deviation (s) of the values of divergence were computed. The divergence classes were defined as follows:

DC1: $D^2 \geq (m+s)$

DC2: $D^2 < (m+s)$ and $\geq m$

DC3: $D^2 \geq (m-s)$ and $< m$

DC4: $D^2 < (m-s)$

For each cross, the divergence class to which the D^2 value between their parents belonged was established. The number of classes (n) falling in each divergence class, the percent of crosses showing significant heterosis in desirable direction (p) and the mean for each character over such crosses (x) were computed. Since in this process even a very low magnitude of heterosis which may not be of practical signif-

icance would get included, it was decided to set a norm for heterosis and obtain frequencies of crosses showing heterosis grater than or equal to the norm. The norm (k) was taken to be the mean heterosis of these crosses in desirable direction for that character. The percent of crosses (q) showing a heterosis value greater than or equal to k and the mean (y) for each character over such crosses were also worked out. In addition, maximum value of heterosis recorded in each divergence class for each character was noted.

The divergence classes were ranked for their relative order of importance on the basis of the values of p, x, q and y separately. However, the relative order varied in each case and for each character. In order to come to a final conclusion jointly on the ranking based on p, x, q and y, a scoring process was adopted. A divergence class which gave the highest value of p was alloted score one, the next best score two and so on. Whenever there was a tie, the classes involved in the tie received the same score. The cores over p and x were added across all characters to obtain a final score for each divergence class. A similar procedure was adopted for q and y. It must be noted that the divergence class with the lowest final score will be the most desirable one with high frequency of heterotic classes and high average magnitude of average heterosis.

RESULTS AND DISCUSSION

It could be seen from Table 1 that the rank correlation coefficients between heterosis and genetic divergence were very low in magnitude and were not significant for any of the characters indicating a very poor correspondence between heterosis and genetic divergence.

Table 1: Rank correlation coefficient (r) between heterosis and genetic divergence

Sl.No.	Character	r
1.	Plant height	0.3000
2.	Stem diameter	0.0025
3.	Head diameter	0.1729
4.	Husk per cent	0.2039
5.	Test weight	0.1169
6.	Oil content	0.3182
7.	Yield per plant	0.2182

Table 2: Divergence classes as determined on the basis of mean (m) and standard deviation (s) of the D^2 values between the parents

DC1	$D^2 >$ or = 86.47
DC2	$D^2 <$ 86.47 and > or = 48.23
DC3	$D^2 >$ or = 9.99 and < 48.23
DC4	$D^2 <$ 9.99

The observations of Timothy (1963) that the heterosis need not be a measure of genetic divergence from his study of exotic stocks of maize would lend support to this finding. The absence of heterosis between the species of *Nicotiana* with genetically diverse genomes (Matzinger and Wernsman, 1967) would also conform with the present finding. A mutual cancellation of the components of heterosis would be an obvious explanation for the absence of heterosis, despite the parental divergence. However, Moll *et al.*, (1965) in maize, Bhupal Rao (1972) and Srivastava and Arunchalam (1977) in *Triticale* have reported a close correspondence between genetic divergence and heterosis.

Table 3: Proportion of crosses showing significant heterosis in the desirable direction and their average magnitude for four divergent classes in sunflower

DC	n	Plant height			Stem diameter			Head diameter			Test weight		
		p	x	t	p	x	t	p	x	t	p	x	t
1	3	100.00	137.25	29.74	66.66	2.21	41.21	100.00	15.44	61.17	33.33	4.03	21.38
2	4	75.00	133.52	25.60	100.00	2.06	74.38	100.00	16.39	87.35	75.00	3.96	48.29
3	4	75.00	120.31	35.19	100.00	1.95	32.33	50.00	13.84	64.23	25.00	5.09	1.61
4	10	90.00	132.49	82.46	100.00	2.08	90.43	70.00	15.44	85.00	40.00	4.46	21.30

Table 3: Continued

DC	n	Oil content			Husk percent			Seed yield/plant			Score
		p	x	t	p	x	t	p	x	t	
1	3	-	-	-	-	38.84	-13.75	66.66	27.47	184.85	21
2	4	-	-	-	100.00	34.92	-31.59	100.00	23.91	348.25	23
3	4	-	-	-	50.00	24.65	-23.75	50.00	21.97	137.79	38
4	10	10.00	32.20	8.61	60.00	36.67	-18.93	90.00	18.43	172.18	30

Table 4: Percent of crosses showing more than overall average heterosis and average magnitude given by those crosses for different characters in four divergent classes in sunflower

DC	n	Plant height		Head diameter		Stem diameter		Test weight		Oil content		Husk percent		Seed yield/plant		Score
		q	y	q	y	q	y	q	y	q	y	q	y	q	y	
1	3	66.66	141.06	100.00	16.85	100.00	2.22	100.00	4.03	-	-	100.00	38.29	100.00	34.41	24
2	4	50.00	139.56	25.00	19.53	100.00	2.39	50.00	4.48	-	-	56.66	35.52	100.00	34.74	27
3	4	75.00	126.77	25.00	15.73	75.00	2.01	100.00	5.09	-	-	100.00	29.56	50.00	35.93	29
4	10	90.00	150.94	57.00	16.45	50.00	2.25	75.00	4.70	100.00	35.30	50.00	38.49	44.44	28.39	29

The range of D^2 values was substantial in the present experiment justifying their arrangement in four divergence classes (Table 2).

From Tables 3 and 4 it is very clear that the divergence class DC1 is superior over the other three classes as far as the occurrence of high percent of heterotic crosses with high magnitude was concerned *i.e.*, in order to get a high freqency of heterotic crosses with high magnitude, the parental divergence should be between (m+s) and (m-s). This means that parents should be extremely divergent to realize high freqency of heterosis. Arunachalam *et al.*, (1984) observed the occurrence of high freqency of heterotic crosses in the lowest divergence class (DC4), which is something unusual. However, Srivastava and Arunachalam (1977) and Aruanchalam and Bandyopadhyay (1984) have clearly identified the superiority of DC2 over the other classes.

The present study provides sufficient evidence for the limits of the parental divergence to realize high frequency of heterotic crosses with high magnitude in sunflower. As reported by several workers in different crops, the limits to parental divergence exists in sunflower also. In the present study chances of occurence of high frequency of heterotic crosses with high magnitude of heterosis are higher when the parents were chosen to have their divergence between (m-s) and (m+s) as compared with the crosses between the parents whose divergence fall outside this limit.

CONCLUSION

There need not always be any correspondence between the magnitude of heterosis and the magnitude of genetic divergence. Further, limits to parental divergence does exist for the occurrence of high heterosis in sunflower and the divergence should be between (m-s) and (m+s) to realize hybrids with reasonably high magnitude of heterosis.

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LÍMITES DE LA DIVERGENCIA DE PARENTALES PARA LA INCIDENCIA DE HETEROSIS EN GIRASOL (*Helianthus annuus* L.)

RESUMEN

Se llevó a cabo una investigación en la Universidad de Ciencias Agrarias , G. K.V. K. , campus de Bangalore, India para determinar los posibles límites de la divergencia parental para la incidencia de heterosis en girasol. Siete líneas puras fueron utilizadas para sintetizar veinte ocho híbridos a partir de un dialelo. La magnitud de heterosis de estos cruces y la magnitud de divergencia entre los padres de los correspondientes cruces fueron estimados. El estudio reveló suficiente evidencia para los límites de la divergencia parental para realizer la alta frecuencia de cruces heteróticos con alta magnitud. Las posibilidades de ocurrencia de heterosis y más cuando los padres fueron escogidos por tener divergencia entre (m-s) y (m+s) en comparación con los cruces entre los padres cuya divergencia cayó fuera de estos límites. El estudio también indicó una pobre correspondencia entre la magnitud de heterosis y la divergencia genética.

LIMITES DE LA DIVERGENCE PARENTALE ET HÉTÉROSIS CHEZ LE TOURNESOL (*Helianthus annuus* L.)

RÉSUMÉ

Une étude a été réalisée à L'université des Sciences Agricoles, G.K.V.K Campus Bangalore, Indie; pour déterminer les limites de la divergence entre les parents pour la manifestation de l'hétérosis chez le tournesol. Sept lignées fixées ont été utilisées pour fabriquer vingt huit hybrides, selon un dispositif diallèle. L'importance de la variation de l'hétérosis et de la divergence entre les parents des croisements correspondants a été estimée. L'étude révèle avec suffisamment d'évidence les limites de la divergence parentale dans la réalisation de fréquences élevées de croisements hétérotiques à forte variation. Les chances de manifestation de l' hétérosis vent plus élevées lorsque les parents vent choisis pour une divergence entre (m-s) et (m+s) par rapport aux croisements entre parents dont la divergence excède ces limites. L'étude montre aussi une faible correspondence entre l'importance de l'hétérosis et la divergence génétique.