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PREDICTION OF HETEROSIS BASED ON GENETIC DIVERGENCE OF PARENTS THROUGH REGRESSION ANALYSIS IN SUNFLOWER (*Helianthus annuus* L.)

Mohan Rao, G*. Lakshmikantha Reddy, R.S. Kulkarni,
S. Ramesh, and S.S. Lalitha Reddy

Department of Genetics and Plant Breeding S. V. Agriculture College, Tirupati (ANGRAU), Andhra Pradesh, India
Department of Genetics and Plant Breeding UAS, GKVK, Bangalore, India

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SUMMARY

An investigation was carried out at the experimental plots of the Department of Genetics and Plant Breeding, Main Research Station, University of Agricultural Sciences, Hebbal, Bangalore, India to predict the level of heterosis based on genetic divergence through regression analysis in sunflower. One hundred and forty crosses involving 10 lines and 14 testers were affected and evaluated for ten quantitative traits. Better parent heterosis (BPH) of crosses was estimated and correlated with genetic divergence between parents as measured by Mahalanobi's D^2 statistic. The relationship between character-wise parental divergence and better parent heterosis only for five important characters *viz*., plant height, head diameter, seed yield, oil content and oil yield, was determined using linear regression and curvilinear regression of second degree. The estimates of better parent heterosis significantly regressed towards the genetic distance of the parents. However, it was not enough for successful prediction of heterosis through either linear or curvilinear regression of second degree as indicated from highly significant chi-square values for observed and predicted estimates of heterosis for all these characters.

Key words: genetic divergence, heterosis, regression, D^2 statistic, linear regression, curvilinear regression

INTRODUCTION

Sunflower, a highly cross-pollinated crop, is ideal for exploitation of heterosis. The discovery of cytoplasmic male sterility by Leclercq (1966) in France and fertility restoration by Kinman (1970) in USA provided the required breakthrough for

* Corresponding author: Phone: 911+ 080 3330153- Ext 286, Fax: 911+080 3636730, 3330277, 3636201, e-mail: a_m_rao2001@yahoo.com / amrao8@rediffmail.com

heterosis breeding. Concerted efforts were made in this direction, to develop and evaluate hybrids using different *cms* and fertility restorer lines. However, in pursuit of taking the program of hybrid sunflower to logical ends, choice of suitable parents through careful and critical evaluation of current material is of paramount importance. This is because *per se* performance of parents is not always a true indicator of its potential in hybrid combinations. There are several criteria by which a breeder can choose suitable parents for successful hybridization, of which the two important are (1) combining ability of parents and (ii) genetic diversity between the parents.

Most often, combining ability has been extensively used by plant breeders to select suitable parents for realizing high frequency of heterotic hybrids. However, genetic diversity of parents is equally important, as pointed by Hayes and Johnson (1939) for corn. More recently, Arunachalam and Bandyopadhyay (1980) in *Brassica campestris*, Srivastava and Arunachalam (1977) in *Triticale*, Arunachalam *et al*., (1984) in groundnut, Joshi *et al.*, (1997) in sunflower and Lalitha Reddy *et al*., (2000) in sesame have established that there is a close correspondence between the magnitude of genetic divergence and heterosis. However, Cress, (1966) reported that heterosis is not found to occur always when divergent parents are crossed. Dikshit and Swain (2000) also reported a lack of correspondence between parental diversity and heterosis in sesame. With this background, the present investigation was designed to elucidate the kind of relationship that exists between parental diversity and heterosis through regression analysis.

MATERIAL AND METHODS

Material for the experiment comprised of 10 cytoplasmic genetic male sterile (CGMS) lines *viz*., *cms* M1, *cms* M17, *cms* 86, *cms* 207, *cms* 234, *cms* 335, *cms* 336, *cms* 851, *cms* 852 and *cms* 853 and 14 fertility restorer lines (testers) *viz*., RHA C1, RHA C2, RHA 6D-1, MRHA-1, RHA M 17R, RHA 17, RHA 265, RHA 273, RHA 274, RHA 278, RHA 298, RHA 308, RHA 354 and RHA 856 which were procured from the Geneticist AICRP on sunflower UAS, GKVK, Bangalore.

Each of the 10 *cms* lines were crossed with 14 restorer lines at the experimental plots of the Department of Genetics and Plant Breeding, University of Agricultural Sciences, Hebbal, Bangalore during summer 1998 and the 140 hybrids along with their 24 parents were evaluated during *rabi* 1998, summer 1999 and *kharif* 1999 for eight quantitative traits *viz*, days to 50% flowering, plant height, stem diameter, head diameter, test weight, seed yield, oil content and oil yield. The experiment was laid out in RBD with three replications. Each entry was sown in five rows of 3.0 meters length with a spacing of 60 × 30 cm. All the recommended agronomic practices were followed for raising a healthy crop. The observations were

recorded on 10 randomly selected plants of each genotype. The mean values computed over three seasons and replications were used for the estimation of better parent heterosis (BPH) as suggested by Turner (1953) and Hayes *et al.* (1955).

The relationship between character-wise parental divergence (as measured by Mahalanobi's D^2 statistic) and better parent heterosis were determined using linear regression and curvilinear regression of second degree. The analysis of variance for both linear and curvilinear regression was also carried out.

Chi-square test was carried out to determine whether the experimental data fit well either linear regression or second degree regression equation using observed and predicted estimates of heterosis.

RESULTS AND DISCUSSION

In order to assess the existence of relationship if any between the estimate of heterosis of the crosses and genetic divergence of their respective parents as measured by D^2 statistic, correlation coefficients between heterosis and character-wise D^2 of the parents for selected characters only *viz*., plant height, head diameter, seed yield, oil content and oil yield, were estimated and the results are presented in Table 1.

Table 1: Correlation between heterobeltiosis and genetic divergence between the parents

Parameters	Plant Height	Head Diameter	Seed Yield	Oil Content	Oil Yield
Correlation coefficient	0.608**	0.681**	0.195*	0.758**	0.270**
Coeffecient of determination	0.37**	0.463*	0.038	0.575**	0.073

Table 1 indicated the presence of significant correlations for all the characters. However, the correlations were positive and strong enough only for plant height, head diameter and oil content, suggesting that increased genetic distance between the parents resulted in increased manifestation of heterosis of their crosses for these three characters. However, coefficients of determination indicated that only 37, 46 and 58% of the variation in the estimates of heterobeltiosis for these three characters, respectively, could be explained as due to the genetic distance of the parents. Thus, the observed heterobeltiosis could be explained only to a certain extent through the genetic distance of the parents. This finding was further strengthened by the analysis of variance for regression (Tables 2 and 3) of first and second degree, respectively.

Although the estimates of heterosis significantly regressed towards the genetic distance of the parents, it was not enough for confident prediction of heterosis through either linear or curvilinear regression of second degree as indicated from the highly significant chi-square values for the observed and predicted estimates of heterosis for all these characters. Thus, it might be concluded that although there existed a positive relationship between genetic distance of the parents and heterobeltiosis for characters such as plant height, head diameter, seed yield, oil content

Table 2: Analysis of variance for linear regression of heterobeltiosis on genetic divergence between the parents in sunflower

Source	df	Plant Height	Head Diameter	Seed Yield	Oil Content	Oil Yield
Regression	1	2722 **	6587 **	1257	5481.5**	7522
Deviation from regression	138	124.2	174	6240	80.39	10223
Chi-sqare value	-	57164**	2347.3**	3663.5**	2895.4**	32889**
Linear regression equation	-	Y=21.43-0.47x	Y=42.43-0.6x	Y=109.2+0.28x	Y=8.11-.03x	Y=141.9-0.21x

Table 3: Analysis of variance for second degree regression of heterobeltiosis on genetic divergence between the parents in sunflower

Source	df	Plant Height	Head Diameter	Seed Yield	Oil Content	Oil Yield
Regression	2	1397 **	3300 **	3932	2936 **	29930
Deviation from regression	137	124.5	175.9	6237	78.12	99160
Chi-sqare value	-	6429.36**	8625.32**	64779**	2895.4**	9013.7**
Regression equation of second degree	-	$Y=22.15-0.65x+0.01x^2$	$Y=42.29-0.63x+0.00x^2$	$Y=103.87+1.59x-.03x^2$	$Y=9.54-0.04x+0.00x^2$	$Y=156.1-1.64x+.01x^2$

* Significant at 0.05 Level
** Signifcant at 0.01 Level
$Y=D^2$ Statistic between the parents
X=Heterobeltiosis for the character

and oil yield, the relationship was not strong enough for regression of heterosis on genetic distance to confidently predict the level of heterosis based on a given value of genetic distance between the parents. Maier *et al.* (1992) and Dhillon *et al.* (1993) observed that RFLP-based genetic distance did not help in predicting heterosis in corn. Conversely, Dias and Kageyama (1997) observed that genetic distance was linearly related to average performance of hybrids in cacao.

Thus, the present study indicated that the variation in parental diversity explains partially (if not completely) the variation in the magnitude of heterosis in sunflower. Therefore, it is suggested that reliance should also be placed on the genetic distance apart from combining ability while selecting the parents for hybridization in order to realize high frequency of heterotic hybrids.

CONCLUSIONS

Although there existed a positive relationship between genetic distance of the parents and heterobeltiosis for characters such as plant height, head diameter, seed yield, oil content and oil yield, the relationship was not strong enough for regression of heterosis on genetic distance to confidently predict the level of heterosis based on a given value of genetic distance between the parents.

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REFERENCES

Arunachalam, V. and Bandyopadhyay, A., 1980. Are "Multiple cross-Multiple pollen hybrids" an answer for productive populations in *Brassica campestris* variety brown sarson? Theor. and Appl. Genet. 54: 203-207.

Arunachalam, V., Bandyopadhyay, A., Nigam, S.N. and Gibbons, R.W., 1984, Heterosis in relation to genetic divergence and specific combining ability in groundnut (*Arachis hypogaea* L.). Euphytica 33: 33-39.

Cress, C.E., 1966. Heterosis of the hybrid related to gene frequency differences between two populations. Genetics 53**:** 269-274.

Dhillon, B.S., Maier, B.J., Pollmer, W.G., Herrman, R.G. and Melchinger, A.E., 1993. Relationship of RFLP among European maize inbreds with ear dry matter yield of their hybrids. Maydica 38: 245-248.

Dias, L.A. D. and Kageyama, 1997. Multivariate genetic divergence and hybrid performance of cacao (*Theobromae cacao* L.). Brazilian J. Genet. 20: 62-70.

Dixit, U.N. and Swain, D., 2000. Genetic divergence and heterosis in sesame. Indian J. Genet. 60: 213-219.
Hayes, H.K., Immer, F.R. and Smith, F.C., 1955. Methods of Plant Breeding. MC Graw Hill New York.
Hayes, H.K. and Johnson, I.J., 1939. The breeding of improved selfed lines of corn. J. Amer. Soc. Agron. 31 : 710-724.
Joshi, S.S., Ramesh, S., Gangappa, E., Jagannath, D.P. and Chikkadevaiah, 1997. Limits to parental divergence for the occurrence of heterosis in sunflower (*Helianthus annuus* L.). Helia 20: 95-100.
Kinman, M.L., 1970. New developments in the USDA and state experiment station sunflower breeding programme. Proceedings of 4th International Sunflower Conference, Memphis, Tennessee, 188-189.
Lalitha Reddy, S.S., Sheriff, R.A., Ramesh, S. and Mohan Rao, A., 2000. Exploring possible limits to parental divergence for the occurrence of heterosis in sesame (*Sesamum indicum* L.). Crop Res. 19: 305-309.
Leclercq, P., 1966. An utilizable male sterile line for the production of hybrid sunflower. Ann. Amelior. Planta. 76: 135-139.
Maier, J.B., Albracht, E., Melchinger, Elisbeth, Brunaxlans Jung, Hartwig, H.G. and Reinhold, G.H. 1992. Genetic diversity for RFLP's in European maize inbreds - I. Relation to performance of flint x dent crosses for forage traits. Crop Sci. 32: 895-902.
Srivastava, P.S. L. and Arunachalam, V., 1977. Heterosis as a function of divergence in *Triticale*. Der Pflazenzuchtung 78: 269-275.
Turner, T.H. (Jr), 1953. A study of heterosis in upland cotton - I Yield of hybrids compared with varieties. Agron. J. 45: 484-486.

PREDICCIÓN DE HETEROSIS SOBRE LA BASE DE LA DIVERGENCIA GENÉTICA DE LOS PROGENITORES MEDIANTE EL ANÁLISIS DE REGRESIÓN DE GIRASOL [*Helianthus annuus* L.]

RESUMEN

La investigación fue realizada en las parcelas experimentales del Instituto de Genética y Selección de Plantas de la Estación de Investigaciones Principal de la Universidad de Ciencias Agrícolas de Hebal, Bangalor, La India, con el objetivo de prever el nivel de heterosis a base de la divergencia genética determinada mediante el análisis de regresión de girasol. Diez características cuantitativas fueron evaluadas en 140 cruzamientos de 10 líneas y 14 testers. La heterosis del mejor progenitor (BPH) de estos cruzamientos fue evaluado y puesto en correlación con la divergencia genética de los progenitores, medida por la estadística D^2 de Mahalanobis. La relación entre la divergencia de los progenitores, vinculada por características, y la heterosis del mejor progenitor, fue determinada por la regresión lineal y la regresión curvilineal de segundo grado para cinco características importantes, la altura de la planta, el diámetro del capítulo, el rendimiento de semilla, el contenido de aceite y el rendimiento de aceite. Los valores del heterosis del mejor progenitor evaluados, significativamente se acercaban a la distancia genética de ambos progenitores. Pero, esto no era suficiente para una previsión exitosa de heterosis, sea por regresión lineal, sea por regresión curvilineal de segundo grado, tal como demostraron las altamente significantes valores "hi-cuadrado" para los valores de heterosis determinados y previstos, para las características investigadas.

PRÉVISION DE L'HÉTÉROSIS SELON LA DIVERGENCE GÉNÉTIQUE DES GÉNITEURS PAR L'ANALYSE DE RÉGRESSION DU TOURNESOL (*Helianthus annuus* L.)

RÉSUMÉ

Une recherche a été effectuée sur les parcelles expérimentales du Département de génétique et de culture des plantes, Station de recherches principale, à l'Université des sciences de l'agriculture, Hjebbal, Bangalore, en Inde pour prévoir le niveau d'hétérosis basé sur la divergence génétique par l'analyse de régression du tournesol. Dix caractéristiques quantitatives ont été évaluées pour 140 croisements de 10 lignes et 14 testeurs. L'hétérosis du meilleur géniteur (BPH) de ces croisements a été évalué et placé en corrélation avec la divergence génétique des géniteurs mesurée par la statistique Mahalanobi D^2. La relation entre la divergence des géniteurs liés au point de vue des caractéristiques et l'hétérosis du meilleur géniteur a été déterminée par la régression linéaire et curvilinéaire du second degré pour cinq caractéristiques importantes, la hauteur de la plante, le diamètre de la tête, le rendement d'huile, le contenu d'huile et le rendement d'huile. Les estimations de valeurs d'hétérosis du meilleur géniteur se sont approchés de manière significative de la distance génétique des deux parents. Cependant, comme l'ont montré les valeurs hautement significatives "chi-carré" pour les estimations observées et prévues de l'hétorésosis pour toutes les caractéristiques, cela n'est pas suffisant pour la prévision réussie d'hétérosis, qu'il soit linéaire ou curvilinaire, par la régression du second degré.