Pak. J. Bot., 39(6): 2009-2015, 2007.

GENETIC DIVERGENCE AND PATH COEFFICIENT ANALYSIS FOR SEED YIELD TRAITS IN SUNFLOWER (*HELIANTHUS ANNUUS* L.) HYBRIDS

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Abstract

Twenty sunflower hybrids were evaluated for various parameters under field conditions to estimate genetic parameters, correlation coefficient, path analysis and linkage distance. Analysis of variance and mean performance for yield and its components revealed significant differences among all the genotypes for all the characters. Results revealed highly significant differences among all the hybrids. Days to maturity had positive correlation with head diameter but negative association with seed yield. However, seed yield had highly positive genotypic correlation with oil contents but non significant with 100 seed weight. Oil contents had negative association with days to flower initiation, completion and plant height but significantly positive correlation with seed yield. The direct effects of days to flower initiation, plant height and head diameter were positive while remaining characters exhibited negative direct effects. The highest direct effect was exhibited by days to flower initiation and plant height. Head diameter had also positive direct effect on seed yield. Cluster diagram using Ward's method revealed three clusters at 50% linkage distance. Results revealed that the hybrids in cluster II, were short duration, high yielding more 100 seed weight and oil contents percentage. Therefore, it is suggested that these hybrids could be exploited under wide range of environments for better out come.

Introduction

Sunflower (*Helianthus annuus* L.) belongs to the family Compositae. In the present changing agriculture scenario and water constraint, area under sunflower has been increased significantly, especially in Sindh, since 2003 (Anon., 2005-06). Sunflower hybrids grown in the country contain from 39 to 52% oil in the seed and still have better yield potential. Sunflower seed was the third largest source of vegetable oil worldwide, following cottonseed and soybean. In Pakistan, sunflower is a second important source of vegetable after cottonseed. Sunflower oil is generally considered a premium oil because of its light color, high level of unsaturated fatty acids and lack of linolenic acid, bland flavor and high smoke points. The primary fatty acids in the oil are oleic and linoleic (typically 90% unsaturated fatty acids), with the remainder consisting of palmitic and stearic saturated fatty acids. Sunflower was introduced during early sixties in Pakistan as oilseed crop but the area remained stagnant since 2003 and after this it increased rapidly in the country (Fig. 1).

Knowledge of genetic parameters is essential for understanding and their manipulation in any crop improvement programme. Seed yield in sunflower is a quantitative character and dependent on its own component characters. Such interdependence of contributory characters, as well as the characters of economic importance often misleads and thus makes correlation coefficient by and large unreliable during selection (Dewey & Lu, 1959), particularly in crop like sunflower, which is highly cross pollinated and heterozygous and envisages enormous variability in succeeding generation. Earlier in sunflower, Punia & Gill, 1994; Anwar-ul-haq *et al*., (2005); Shankar *et al*., (2006) and Farratullah *et al*., (2006)

applied path coefficient by partitioning the genotypic correlations into direct and indirect effects of the traits. Moreover, other researchers (Arshad *et al*., 2004 & 2006; Ghafoor & Ahmad, 2005) have used these techniques along with diversity study for investigating genetic parameters. Keeping in view the importance of this technique, the present study was planned to investigate the genetic divergence, correlation coefficient and path analysis for seed yield traits to identify the best genotypes on the basis of result for future exploitation.

Materials and Methods

Twenty sunflower hybrids of diverse origin were grown in a Randomized Complete Design (RCBD) with four replications during the year 2006 at the National Agricultural Research Center (NARC), Islamabad, Pakistan. The hybrids were grown in 4 rows of 5m lengths with row-to-row and plant-to-plant spacing of 75 and 25cm apart, respectively. Sowing was done manually on ridges by dibbling 2-3 seeds per hill to a depth of 2 to 3 cm to maintain optimum plant population. All other recommended cultural practices were adopted for healthy crop growth during whole season. Optimum fertilizers (120 kg/ha nitrogen, 60 kg/ha phosphorus and potassium each) were applied to exploit potential of the hybrids. After emergence of seedlings, thinning was done to achieve the optimum plant population. Ten randomly sampled plants were used for recording data viz., days to flower initiation, completion and maturity, plant height (cm), head diameter (cm), 100 seed weight, oil content percentage and seed yield per plot and then converted to kg ha^{-1}. The oil content of the oven-dried seeds was determined by nuclear magnetic resonance (NMR).

Genetic parameters, correlation coefficients (phenotypic, genotypic and environmental) were computed according to the method suggested by Singh & Chaudhary (1979). The significance of genotypic correlation coefficients was tested with the help of standard errors as suggested by Reeve & Rao (1981). Path coefficient was worked out by the methods used by Dewey & Lu (1959). Cluster diagram using WARD's method was also made from the mean of the hybrids (Sneath & Sokal, 1973).

Results and Discussion

The results regarding the analysis of variance along with other statistics for eight characters are presented in Table 1. Significant differences were observed for flower initiation, completion and maturity. Insignificant differences for replications revealed high acceptance of the result due to negligible influence of environments. Similarly, low pattern was observed for variation where differences between genotypic and phenotypic variance for most of the characters indicated little environmental effects. High heritability was observed for days to flower initiation, completion and plant height while the characters having low heritability was observed for head diameter and seed yield, that indicated the need to build strong breeding programme to develop diverse inbred lines for hybrid development.

Correlation coefficient study: The genotypic correlation coefficients were higher as compared to phenotypic in most of the characters indicating high reliability of the results (Table 2). Days to maturity of the hybrids had positive and significant correlations with days to flower initiation and flower completion. However, negative genotypic association of days to flowering (initiation and completion) and maturity with seed yield, 100 seed weight and % oil contents was observed and suggested to be broken through various breeding techniques. There is need to develop inbred lines for short duration high yielding sunflower hybrids to fit in various cropping systems (Anwar *et al*., 2005).

Table 1. Characters mean and analysis of variance for yield and its related components in 20 sunflower hybrids.

Hybrid	Origin	Source	DFI	DFI	DM	PH	HD	SY (Kg ha^{-1})	100 S W	OC %
Mehran-II	Pakistan	ARI, Tando Jam, Sindh	54	65	100	192.5	16.9	1802	5.30	32.81
Helios-250	Bolivia	-do-	60	68	103	127.3	17.5	1576	5.32	38.41
Helios-251	Bolivia	-do-	49	56	98	111.8	16.6	1995	5.28	39.07
Helios-360	Bolivia	Global Commodities	50	57	98	115.7	16.8	2072	5.47	43.29
ZR-123	Argentina	Hammad & Co	53	60	100	142.7	15.3	1955	4.57	42.62
Hysun-38	Australia	ICI-Pakistan Seeds	54	60	99	155.5	16.4	2294	4.78	36.53
Hysun-33	Australia	-do-	59	63	98	156.8	15.5	2223	5.85	39.46
SF-187	USA	Monsanto Pakistan Seeds	54	58	96	126.6	16.5	2367	4.91	40.63
Parsun-1	Pakistan	NARC, Islamabad	50	59	98	130.6	15.9	1709	5.25	39.66
Parsun-2	Pakistan	NARC, Islamabad	49	58	96	142.3	15.5	2010	6.30	38.61
63 A 82	USA	-do-	49	56	97	130.6	16.3	2221	4.70	44.14
63 A 90	USA	Pioneer Seeds	49	55	94	114.3	15.3	2457	5.26	41.66
64 A 93	USA	-do-	58	62	100	166.5	17.1	1982	5.70	35.93
Nusun-636	USA	Rajby Int., Karachi	49	57	96	139.0	18.3	2079	7.13	45.00
Nusun-658	USA	-do-	50	57	97	121.3	17.9	2161	5.76	44.38
Nusun-665	USA	-do-	47	55	98	128.8	16.8	2226	5.26	45.09
Nusun-5101	USA	-do-	49	56	97	132.3	15.5	2622	5.84	45.47
NK-S-278	USA	Syngenta Pak.	52	57	98	148.1	16.5	2573	5.80	40.12
NSH-160	Yugoslavia	Trade Channels	51	57	97	125.3	15.4	2350	5.54	42.18
S-3503	India	-do-	51	57	95	130.2	15.2	2341	6.09	42.17
F. ratio (V)			14.53**	22.57**	7.49**	16.88 **	1.90*	2.91**	3.51**	8.84**
F. ratio (R)			2.017^{ns}	4.348**	3.673*	2.057^{ns}	4.033*	0.798^{ns}	0.107^{ns}	0.062^{ns}
Standard error			0.932	0.742	0.689	4.759	0.656	160.197	0.318	1.14
C D 1			2.637	2.099	1.948	13.462	1.857	453.106	0.9	3.225
C D 2			3.507	2.791	2.59	17.904	2.469	602.631	1.197	4.29
Genotypic variance			11.764	11.879	3.079	359.764	0.391	49193.32	0.254	10.207
Phenotypic variance			15.241	14.081	4.975	450.373	2.114	151845.7	0.66	15.409
Heritability			0.772	0.844	0.619	0.799	0.185	0.324	0.386	0.662

DFI: Days to flower initiation; **DFC:** Days to flower completion; **DM:** Days to Maturity; **PH:** Plant height (cm); **HD:** Head diameter (cm); **SY:** Seed yield (Kg ha^{-1}); **100SW;** 100 Seed weight (g)**; OC%:** Oil content %

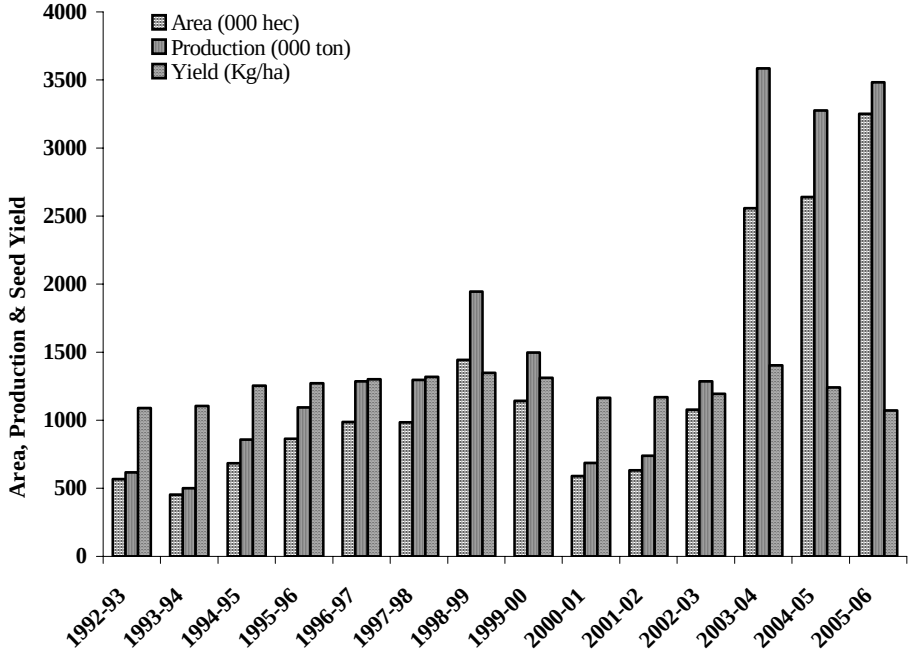

Fig. 1. Area, production and seed yield of sunflower in Pakistan.

Table 2. Genotypic (*rG*), phenotypic (*rP*) and environmental (*rE*) correlation coefficients among 7 characters in 20 sunflower hybrids.

Variable		DFI	DFC	DM	PH	HD	SY (Kg ha^{-1})	100 SW
DFC	*rG*	0.89**						
	rP	0.86**						
	rE	0.74 **						
DM	*rG*	0.71 **	0.83**					
	rP	0.53*	0.61**					
	rE	0.13	0.06					
PH	*rG*	0.52 *	0.61**	0.43				
	rP	0.45*	0.55*	0.33				
	rE	0.17	0.27	0.01				
HD	*rG*	0.12	0.30	0.60 **	0.04			
	rP	0.13	0.17	0.16	0.13			
	rE	0.19	0.14	-0.07	0.30			
SY (Kg ha^{-1})	*rG*	-0.42	-0.8**	-0.75**	-0.31	-0.66**		
	rP	-0.30	-0.42	-0.45 *	-0.04	-0.15		
	rE	-0.24	-0.01	-0.23	0.34	0.02		
100 SW	*rG*	-0.18	-0.14	-0.41	0.05	0.46 *	0.01	
	rP	-0.13	-0.12	-0.21	0.07	0.07	0.18	
	rE	-0.08	-0.12	-0.02	0.11	-0.08	0.27	
OC%	*rG*	-0.66**	-0.76**	-0.53*	-0.74**	-0.02	0.45 *	026
	rP	-0.51 *	-0.55 *	-0.37	-0.54 *	-0.03	0.44 *	0.07
	rE	-0.15	0.09	-0.08	-0.03	-0.05	0.50 *	-0.13

DFI: Days to flower initiation; **DFC:** Days to flower completion; **DM:** Days to Maturity; **PH:** Plant height (cm); **HD:** Head diameter (cm); **SY:** Seed yield (Kg ha^{-1}); **100SW;** 100 Seed weight (g)**; OC%:** Oil content %

Table 3. Direct (highlighted) and indirect effects of 8 traits on seed yield in sunflower.

Variables	DFI	DFC	DM	PH	HD	100 SW	OC%	Seed Yield
DFI	**1.68**	-2.19	-0.29	0.17	0.03	0.05	0.14	-0.42
DFC	1.50	**-2.45**	-0.34	0.21	0.07	0.04	0.16	-0.81
DM	1.19	-2.04	**-0.40**	0.15	0.14	0.10	0.11	-0.75
PH	0.88	-1.50	-0.18	**0.34**	0.01	-0.012	0.15	-0.31
HD	0.21	-0.75	-0.24	0.01	**0.24**	-0.12	0.01	-0.66
100 SW	-0.31	0.34	.1679	0.02	0.11	**-0.26**	-0.05	0.02
OC%	-1.11	1.88	0.21	-0.25	-0.01	-0.07	**-0.20**	0.45

DFI: Days to flower initiation; **DFC:** Days to flower completion; **DM:** Days to maturity; **PH:** Plant height (cm); **HD:** Head diameter (cm); **SY:** Seed yield (Kg ha^{-1}); **100SW;** 100 Seed weight (g)**; OC%:** Oil content %

Table 4. Mean and standard deviation of three clusters with number of hybrids for eight variables.

Variables	Cluster-I (6)	Cluster-II (11)	Cluster-III (3)
Days to flowering initiation	53.67 ± 3.01	49.36 ± 1.12	57.33 ± 3.06
Days to flower completion	59.50 ± 2.07	56.45 ± 0.93	65.00 ± 3.00
Days to maturity	98.17 ± 1.33	96.64 ± 1.29	101.00 ± 1.73
Plant height (cm)	143.38 ± 12.61	126.5 ± 9.93	162.1 ± 32.82
Head diameter (cm)	16.02 ± 0.53	16.3 ± 1.07	17.2 ± 0.31
Seed yield (ton ha^{-1})	2.19 ± 0.31	2.23 ± 0.20	1.79 ± 0.20
100 Seed weight (g)	5.19 ± 0.54	5.69 ± 0.65	5.44 ± 0.23
Oil content %age	39.84 ± 1.98	42.82 ± 2.35	35.72 ± 2.81

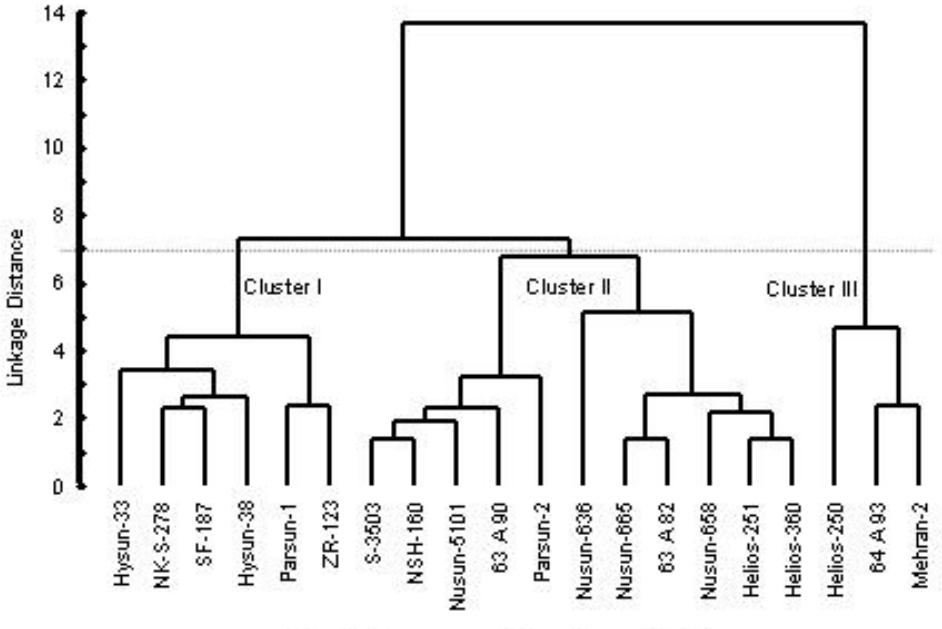

Fig. 2. Phenogram of 20 sunflower hybrids.

Seed yield had significant positive correlations with oil contents. These results support the earlier finding of Shankar *et al*., (2006) and Farratullah *et al*., (2006). Hundred seed weight had significant positive genotypic correlation with head diameter.

Contrary to this Alba *et al*., (1979) reported a negative correlation between seed yield and head diameter but similar correlation for 100 seed weight. Oil contents had negative association with days to flower initiation, completion and plant height. Due to negative association of important agronomic traits such as days to maturity, plant height and seed yield, sunflower acreage is affected because planting or harvesting of major crops, such as cotton and rice. Therefore, there is a need to make efforts for the development of inbred lines where to recombine genes of early maturity, short height and higher yield potential through various breeding and biotechnology techniques, to adjust this crop in the existing cropping systems.

Path coefficient study: Genotypic correlation were partitioned into direct and indirect effects through various yield contributing characters to investigate the selection criteria in sunflower breeding (Table 3). The direct effects of days to flower initiation, plant height and head diameter were positive while the remaining characters exhibited negative direct effects in this study. The highest direct effect (1.68) was exhibited by days to flower initiation, followed by plant height (0.34). Beside this, head diameter had also positive direct effect (0.24) on seed yield. Earlier, Farratullah *et al*., (2006) reported similar findings in sunflower. Madhavilatha *et al*., (2004) and Arshad *et al*., (2004) also observed similar results in their studies conducted on sunflower and chickpea. The results of present study suggests that days to flower initiation, plant height and head diameter are the main seed yield components. Moreover, Singh & Labana, (1990); Visic, (1991) and Marinkovic, (1992) also reported similar results in their study conducted on sunflower. While concluding the results of present study, the characters viz. days to flower initiation and plant height should get due attention in sunflower breeding programmes along with head diameter and 100 seed weight which indirectly contribute to seed yield and oil contents.

Cluster diagram based on Euclidean dissimilarity using Ward's method revealed three clusters at 50% linkage distance (Fig. 2). Cluster analyses indicate the extent of genetic diversity and that is of practical use in plant breeding (Sultana *et al*., 2006). There were 6 genotypes in cluster I, 11 in cluster II while cluster III consisted 3 of genotypes. There was no clear indication of any relationship on the basis of their origin. However, It is evident from the results that the hybrids (S-636, NSH-160, Nusun-658, Nusun-5101, 63 A 90, Parsun-2, Nusun-636, Nusun-665, 63 A 82, Nusun-658, Helios-251 and Helios-360) in the cluster II were short duration, high in seed yield, 100 seed weight and oil contents percentage in the present study. Moreover, these hybrids were shortest in height (126.5 cm) as compared to hybrids falls in clusters I and III. Therefore, these hybrids could be tested under wider range of environments before their recommendations for general cultivation keeping in view the real potential of hybrids.

Acknowledgement

The authors are highly grateful to Dr. Akbar Shah Mohmand PSO/coordinator oil seed Program, NARC for their financial and moral support. Thanks are also extended to Dr. Abdul Ghafoor, Senior Scientific Officer, PGRP, NARC, Islamabad for analysis and editing of this manuscript.

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(Received for publication 5 June 2007)