http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan
Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 8 (5): 710-713, 2005
ISSN 1028-8880

Combining Ability Analysis in Sunflower (*Helianthus annuus* L.)

[1]Masood Jan, [2]Farhatullah, [2]Raziudin and [2]Ghulam Hassan
[1]Directorate General Research, [2]Department of Plant Breeding and Genetics,
NWFP Agricultural University, Peshawar, Pakistan

Abstract: For determination of good combiners for physiological heritable traits, a study on a 8x8 diallel fashion in sunflower was conducted during 2003 at NWFP Agricultural University Peshawar Pakistan. The extent of combining ability for days to 50% flowering, days to maturity, achene yield (kg ha^{-1}) and oil content was find out. The General Combining Ability (GCA), Specific Combining Ability (SCA) and Reciprocal Effects (RE) were significant for all the traits except days to maturity where RE were non-significant. The SCA effects were of greater magnitude than that of GCA effects, which showed high contribution of non-additive gene effects. The GCA:SCA ratio also revealed predominance of non-additive gene effects. Among the inbred lines TF-11, ARI and TF-4 were the best general combiners for all these traits. The best combiners for yield were ARI and GUL. The cross combination TF-335xARI was early in terms of days to 50% flowering and maturity. Generally the hybrids TF-4, TF-335, ARI and PESH performed well in nearly all parameters. Reciprocal crosses have higher potential than direct crosses for most of the traits. Both additive and non-additive variances were involved in the characterization of these physiological traits.

Key words: Sunflower, general combining ability, specific combing ability, additive and non-additive

INTRODUCTION

Recent research in biometrical genetics has resulted in the evolution of new and efficient technologies enabling the plant breeders to ascertain the nature of the gene action involved in the development of complex genetic characters. The diallel analysis for gene action developed by Hayman[1,2] and Jinks[3] have extensively been used to obtain precise information about the type of gene action involved in the expression of various complex characters like yield and yield components and to predict the performance of the progenies in the latter segregating generation studies on the nature of gene action from diallel crosses have shown preponderance of additive effects for yield and yield components although non-additive effects were also present in several cases[3].

The ability of an inbred to transmit desirable performance in its hybrid progenies is referred to as combining ability. Sprague and Tatum[4] further refined the idea into general and specific combining ability which have significant impact on evolution of inbred line. General Combining Ability (GCA) is the average performance of a particular inbred in a series of hybrid combinations, whereas, specific combining ability, refers to the performance of a combination of specific inbreds in a particular cross. The parental lines/genotypes are considered to be superior which prove as good donor and better combiner for desirable plant traits from breeding point of view. Breeding for various aspects needs the best combiners and desirable donors which could be helpful in evolving best hybrids/synthetics having high yield potential and good adopter for diversified agro-ecological zones. Present investigation was, therefore, set out to furnish information on combining ability in diallel cross experiment of selected inbreds in sunflower (*Helianthus annuus* L.) for various heritable traits under climatic conditions of Peshawar valley.

MATERIALS AND METHODS

The study was carried out at the research farms of NWFP Agricultural University Peshawar NWFP Pakistan during for three consecutive years i.e., 2001-2003. Five different sunflower selections from Tarnab Fertile (TF) lines viz., TF-1, TF-4, TF-7, TF-11 and TF-335 along with three hybrid cultivars viz., Gulshan-98, Aritar-93 and Peshawar-93 were included in the study. These TF-lines were selected from the crosses between North Dakota State University Fargo, USA materials and local genotypes of sunflowers. The hybrid cultivars Gulshan-98, Peshawar-93 and Aritar-93 were evolved by Pakistan Oilseed Development Board Tarnab, Peshawar.

Corresponding Author: Dr. Masood Jan, Directorate General Research, NWFP Agricultural University, Peshawar, Pakistan
E-mail: mrahim50@yahoo.com

These TF-lines and hybrid cultivars were selected for their variable characters i.e., days to 50% flowering, days to maturity, achene yield (kg ha^{-1}) and oil content (g kg^{-1}).

To develop inbred lines, the materials were selfed for four generations and selections were made in each generation for various parameters. The main purpose of the inbred line development was to bring homozygosity in these lines and cultivars for further study. These inbred lines were re-named as TF-1, TF-4, TF-7, TF-11, TF-335, GUL, ARI and PESH.

All the genetic materials (inbred lines) were crossed in 8x8 diallel fashion. To produce enough F_0 seeds, the crossings were made for three consecutive years. The F_0 seed was harvested separately from each cross at maturity.

Hybrid seeds (F_1) of 56 crosses along with their eight parents were tested in an experiment in a Randomized Complete Block Design with three replications. In all the experiments sowing was done by dibbling 3 seeds per hill that was latter thinned to one plant per hill. Each row was 4 m long. Plant to plant and row-to-row distance was kept 25 and 60 cm, respectively.

Data on physiological parameters were subjected to analysis of variance technique to confirm the presence of genetic variability for various traits in F_1 generation. The data on F_1 hybrid and parental lines thus collected were subjected to combining ability analysis using procedures outlined by Griffing Method 1, Model 11[5].

RESULTS AND DISCUSSION

Genotypic differences were found significant ($p<0.01$) for days to 50% flowering, days to maturity, achene yield (kg ha^{-1}) and oil content (g kg^{-1}) in F_1 generation (Table 1). This confirms the presence of variability in the genetic materials. The significant differences among genotypes allowed the data to proceed further.

Mean squares for generally combining ability and specific combining ability were significant ($p<0.01$) for all characters, indicating the importance of additive and non-additive genetic variance for these characters. The mean squares for reciprocal effects were also significant ($p<0.01$) for all characters except for days to maturity (Table 2). The results indicated that non-additive gene effects were more important for the control of these characters. Radhika *et al.*[6] along with significant role of cytoplasmic inheritance.

Table 1: Mean squares for days to 50% flowering, days to maturity, achene yield (kg ha^{-1}) and oil content (g kg^{-1}) in F_1 generation of diallel cross in sunflower

Traits	Genotypes	Error
Days to 50% flowering	31.52**	61.609
Days to maturity	29.35**	9.70
Yield (kg ha^{-1})	69892.68**	4.74
Oil content (g kg^{-1})	40.84**	7.04

** = Significant at 1% level of significance

Table 2: Mean squares due to general combining ability, specific combining ability and reciprocal effects for various characters in 8x8 diallel cross combinations in sunflower

Traits	GCA (7)	SCA (28)	Reciprocal (28)	Error (126)
Days to 50% flowering	41.040**	8.275**	5.103**	0.199
Days to maturity	33.56**	10.26**	3.36ns	3.230
Yield (kg ha^{-1}).	30999.36**	19241.020**	25428.65**	1.580
Oil content (g kg^{-1})	8.79**	12.80**	15.63**	2.350

** = Significant at 1% level of significance

The variance components given in Table 3 were estimated to determine precisely the importance of additive and dominance components in the control of characters under study. High SCA effects were observed for these characters. These results indicated higher non-additive effect for these characters. Ratio of GCA:SCA for all these characters is much smaller than one, showing that non-additive gene effect had a predominant role in inheritance of these characters. The achene yield (kg ha^{-1}) and oil content with high reciprocal effects indicated the involvement of cytoplasmic inheritance along with non-additive gene effects in the control of these characters. Gangappa *et al.*[7] reported that achene yield was under the control of both additive and non-additive gene actions with the latter predominating. Both additive and non-additive gene effects equally contributed for the inheritance of days to flowering. This can also be confirmed from GCA:SCA ratio, which is very close to 0.50. Similar findings were reported by Kumar *et al.*[8] who mentioned high SCA for all these traits.

Days to 50% flowering: All the inbred lines showed significant GCA effects for days to 50% flowering. The parent TF-11 with highest negative GCA effect (-2.943) has the potential to be a good combiner for earliness; followed by inbred line ARI with GCA effect (-1.318). The TF-7 has the highest positive GCA effect (1.828), which could be late due to late flowering (Table 4).

Table 3: Estimates of component of variance for various characters in diallel cross combinations in sunflower

Traits	GCA	SCA	Recip.	Error	Total	Additive	Non-additive	GCA/SCA ratio
Days to 50% flowering	2.057	4.534	2.452	0.199	9.242	4.113	4.534	0.454
Days to maturity (No.)	1.460	3.940	0.060	3.230	8.690	2.930	3.940	0.371
Yield (kg ha^{-1})	755.990	10801.090	12713.530	1.580	24272.200	1511.980	10801.090	0.070
Oil content (g kg^{-1})	-0.240	5.870	6.640	2.350	14.620	-0.480	5.870	-0.040

Table 4: Estimates of GCA effects for various characters in diallel cross combinations in sunflower

Inbred lines	Days to 50% flowering (No.)	Days to maturity (No.)	Achene yield (kg ha^{-1})	Oil content (g kg^{-1})
TF-1	0.849**	0.802	-11.028**	-1.067**
TF-4	0.557**	1.198**	5.670**	1.184**
TF-7	1.828**	1.677**	-17.748**	0.068
TF-11	-2.943**	-2.448**	-70.021**	0.209
TF-335	1.578**	1.115**	-8.621**	-0.611**
GUL	0.245**	-0.344	40.522**	0.107
ARI	-1.318**	-1.469	78.571**	-0.604**
PESH	1.667**	-0.5318*	-17.346**	0.714**
SE (gi)	0.011	0.177	0.086	0.128
SE (gi-gj)	0.025	0.404	0.197	0.293

*, ** = Significant at 5 and 1% level of significance, respectively

Table 5: Estimates of specific combining ability effects for various characters in diallel cross combinations in sunflower

Characters crosses	Days to 50% flowering (No.)	Days to maturity (No.)	Yield (kg ha^{-1})	Oil content (g kg^{-1})
TF-1xTF-4	0.547**	0.281	12.191**	3.760**
TF-1xTF-7	0.943**	2.469	30.542**	-1.190
TF-1xTF-11	-0.620**	-2.573	41.486**	0.570
TF-1xTF-335	0.193**	2.531	-3.335**	-1.380
TF-1xGUL	0.360**	-0.344	-83.607**	-0.270
TF-1xARI	-0.078	-1.052	84.195**	-1.450
TF-1xPESH	-3.099**	-4.323**	19.778**	0.570
TF-4xTF-7	0.734**	1.573	-84.484**	-0.860
TF-4xTF-11	-1.828**	-1.969	85.271**	1.840
TF-4xTF-335	0.318**	-0.198	-118.460**	-1.220
TF-4xGUL	2.651**	0.760	43.062**	1.933
TF-4xARI	-1.786**	-1.115	53.942**	-2.760**
TF-4xPESH	-3.641**	-2.219	55.914**	2.810**
TF-7xTF-11	0.734**	-0.781	52.672**	1.310
TF-7xTF-335	0.214*	-0.510	31.440**	-0.220
TF-7xGUL	-2.953**	-4.052**	69.620**	-0.380
TF-7xARI	0.109	0.073	-60.086**	2.750**
TF-7xPESH	1.422**	0.635	48.053**	1.100
TF-11xTF-335	0.651**	1.781	48.545**	-0.670
TF-11xGUL	2.151**	1.740	45.069**	4.570**
TF-11xARI	-0.120	0.031	51.075**	-4.110**
TF-11xPESH	2.035**	3.260*	-378.230	-3.660
TF-335xGUL	-1.036	-1.323	39.837**	1.540
TF-335xARI	-3.973**	-4.365**	7.788**	1.000
TF-335xPESH	0.339**	-0.969	114.538**	0.130
GULxARI	0.526**	2.594	-57.356**	1.880**
GULxPESH	-1.662**	-0.344	46.006**	-1.350
ARIxPESH	0.568**	0.281	3.512**	-1.500
SE(Sij)	0.080	1.263	0.620	0.920
SE(Sij-Sik)	0.170	2.829	1.380	2.050
SE(Sij-ski)	0.150	2.425	1.190	1.760

*, ** = Significant at 5 and 1% level of significance, respectively

The hybrid TF-335xARI was the earliest for flowering (SCA -3.973) followed by hybrid TF-4xPESH with -3.641 SCA effects. The crosses TF-4xGUL and TF-11xGUL were poor combiners for earliness, with high positive SCA effects i.e., 2.651 and 2.151, respectively (Table 5).

In case of R-effects the highest negative reciprocal effects (-3.17) was recorded for cross ARIxTF-7 showing that this hybrid is also a good combiner for early flowering. However, cross TF-335xTF-7 is late because it has positive reciprocal effect (8.500) (Table 6).

Table 6: Estimates of reciprocal effects for various characters in diallel cross combinations in sunflower

Inbred lines	Days to 50% flowering (No.)	Days to maturity (No.)	Achene yield (kg ha^{-1})	Oil content (g kg^{-1})
TF-4xF-1	-1.500**	-0.67	-36.270**	5.030**
TF-7xTF-1	-0.830**	-0.33	-1.300	-2.070
TF-7xTF-4	-1.330**	-0.50	-26.630**	-4.180**
TF-11xTF1	2.500**	1.83	-96.970**	-1.340
TF-11xTF-4	1.000**	0.50	6.850**	1.420
TF-11xTF-7	-0.500**	1.83	62.500**	3.130*
TF-335xTF-1	-1.500**	2.50	-13.720**	3.380**
TF-335xTF-4	6.500**	0.83	20.520**	2.900
TF-335xTF-7	8.500**	1.33	-51.000**	2.580*
TF-335xTF-11	0.500**	-0.50	43.830**	-0.530
GULxTF-1	-0.670**	0.50	-61.520**	-6.890**
GULxTF-4	-1.330**	2.33	24.180**	-0.350
GULxTF-7	-1.000**	1.00	58.670**	1.050
GULxTF-11	1.670**	0.00	-21.500**	1.340
GULxTF-335	-1.000**	-1.17	-6.330**	-1.390
ARIxTF-1	-1.000**	-0.33	64.670**	-0.840
ARIxTF-4	2.330**	0.33	58.220**	-0.780
ARIxTF-7	-3.170**	-1.00	-73.330**	0.430
ARIxTF-11	-0.170	0.17	-11.220**	1.180
ARIxTF-335	-0.500**	-1.00	-12.330**	-2.180
ARIxGUL	0.670**	1.83	18.330**	-3.210*
PESHxTF-1	2.170**	2.00	-72.330**	-3.940**
PESHxTF-4	3.000**	2.50	-35.050**	0.460
PESHxTF-7	1.330**	0.50	-7.880**	2.500*
PESHxTF-11	-2.830**	-2.00	-553.330**	-0.002
PESHxTF-335	1.330**	-0.33	-19.500**	2.440*
PESHxGUL	-0.330**	0.50	-1.460	-4.920**
PESHxARI	1.670**	-1.30	-18.000**	-2.940*
SE (rij)[a]	0.100	1.62	0.790	1.170
SE (ri-rij)[b]	0.200	3.23	1.580	2.350

*, ** = Significant at 5 and 1% level of significance, respectively

Days to maturity: Five inbred lines TF-4, TF-7, TF-11, TF-335 and PESH showed significant GCA effects. The highest negative GCA effect was demonstrated by inbred line TF-11 (-2.448) followed by ARI (-1.469). It means that TF-11 and ARI are good combiners for early maturity in sunflower (Table 4).

In case of SCA, effects for days to maturity is significantly negative for three F_1 hybrids viz., TF-1xPESH (-4.323), TF-7xGUL (-4.052) and TF-335xARI (-4.365). The negative SCA effects show that these hybrids are of short duration and may be maturing earlier. The R-effects for days to maturity are negligible (Table 5).

Achene yield (kg ha^{-1}): All the inbred lines viz., TF-1, TF-4, TF-7, TF-11, TF-335, GUL, ARI and PESH depicted significant GCA effects for achene yield. The inbred line ARI is a good combiner with the highest positive significant GCA effect (78.570), followed by inbred line GUL with 40.522 GCA effect. The inbred line TF-11 was a poor combiner for the trait (Table 4). The cross combination TF-335xPESH with the SCA effect (114.538), is the best combiner followed by hybrid TF-4XTF-11 (85.271) (Table 5). These two crosses are good combiners for achene yield. The highest negative SCA effect (-378.230) was depicted by TF-11xPESH followed by TF-4xTF-335 with -118.46 SCA effect and were found poor combiners for the character.

The maximum significant R-effect (64.67) was shown by cross combination ARIxTF-1, followed by cross combination TF-11xTF-7 with R-effects of 62.50. These crosses may also be selected for yield (Table 6).

Oil content (g kg^{-1}): For oil content two inbred lines viz., TF-4 and PESH showed significant positive GCA effects while three inbred lines TF-1, TF-335 and ARI had significant negative GCA effects. The inbred line TF-4 was a good combiner with the highest positive GCA effect (1.184), followed by PESH with GCA effect of 0.714. Similarly, TF-1 was a poor combiner with the maximum negative GCA effect (-1.067) (Table 1).

Five cross combinations TF-1xTF-4, TF-4xPESH, TF-7xARI, TF-11xGUL and GULxARI displayed significantly positive SCA effects. The highest positive SCA effect (4.57) was expressed by F_1 hybrid TF-11xGUL showing that it is a good combiner for oil content, followed by TF-1xTF-4 (3.760). The cross combination TF-11xARI is a poor combiner for oil content having maximum significant negative SCA effect (-4.110) (Table 5). The R-effects are highly significant (5.030) for cross combination TF-4xTF-1 followed by TF-335xTF-1 with reciprocal effect of 3.38 (Table 6).

The inferences drawn from the results described in the above paragraph elucidated that variable number of crosses for different parameters expressed positive SCA effects. A comparison of cross involving negative SCA effect for days to flowering also showed that TF-335xARI also exhibited negative SCA for days to maturity. It confirms that this hybrid is early maturing further explain the role and positive correlation of days to flowering and maturity. The idea can further be strengthened by recording positive GCA for both characters in case of hybrids TF-7 which is late. For yield (kg ha^{-1}) the cross combinations TF-335xPESH and TF-4xTF-11 were good combiners. Cross combination TF-11xGUL was the best combiner for oil content. All these crosses were obtained by the combinations of high x low or low x high general combiners. This might be due to the interaction of dominant alleles from good combiner and recessive alleles from poor combiner. All these combinations having maximum SCA effects for days to 50% flowering and days to maturity had at least one parent with high GCA. However, for achene yield and oil content, the case was totally different. The Reciprocal effect was totally different from that of the specific combining ability effects. These results were contradictory to that of Liu *et al.*[9] who found at least one parent with high GCA for all combinations with high seed or oil yield. These differences might be due to the different genetic materials in the experiments.

REFERENCES

1. Hayman, B.I., 1954. The theory and analysis of diallel crosses I. Genetics, 39: 789-809.
2. Hayman, B.I., 1954. The analysis of variance of diallel tables. Biometrics, 10: 235-244.
3. Jinks, J.L., 1956. The F_2 and Backcross generations from a set of diallel crosses. Heredity, 10: 1-30.
4. Sprague, G.F. and L.A. Tatum, 1942. General vs Specific combining ability in single cross of corn. J. Am. Soc. Agron., 34: 923-932.
5. Griffing, B., 1956. Concept of general and specific combining ability in relation to diallel crossing system. Aust. J. Biol., 9: 463-493.
6. Radhika, P., K. Jagadeshwar and P.S. Sharma, 1999. Genetic analysis of seed yield and certain physiological parameters in sunflower. J. Res. ANGRAU., pp: 5-17.
7. Gangappa, E., K.M. Channakrishnaiah, S. Thakur and S. Ramesh, 1997. Genetic architecture of yield and its attributes in sunflower (*Helianthus annuus* L.). Helia, 20: 85-93.
8. Kumar, A.A., M. Ganesh and P. Janila, 1998. Combining ability analysis for yield and yield contributing characters in sunflower (*Helianthus annuus* L.). Ann. Agric. Res., 19: 437-440.
9. Liu, T.G., Ya-Wang, T.G. Liu and Y. Wang, 1996. A study of the combining ability of sterile and restorer lines of oilseed sunflower (*Helianthus annuus* L.). Ningxia J. Agri. For. Sci. Technol., 6: 24-27.