INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

ESTIMATION OF COMBINING ABILITIES FOR EARLY MATURITY, YIELD AND OIL RELATED TRAITS IN SUNFLOWER (*Helianthus annuus L.*)

[1]Rizwana Qamar, [2]Hafeez Ahmad Sadaqat, [3]Amir Bibi & [4]Muhammad Hammad Nadeem Tahir
Department of Plant Breeding and Genetics, University of Agriculture Faisalabad 38040 Pakistan.

ABSTRACT
This research was organized in Department of Plant Breeding and Genetics, University of Agriculture Faisalabad to select the superior parents that would be used in the hybrid breeding program to minimize the life cycle duration and improvement in yield and oil related traits in sunflower. 10 genotypes keeping seven as lines and three as testers were crossed in line × tester scheme. Data were recorded for the traits like emergence percentage, days to fifty percent flowering, days to maturity, plant height, head diameter, 100 achene weight, achene yield per plant, oil contents, palmitic acid, oleic acid, linoleic acid and protein contents. Notable genetic differences were observed for all the studied traits through analysis of variance. Considerable genetic differences were observed for the interaction of lines and testers demonstrating the importance of specific combining ability effects. Variances due to specific combining abilities (SCA) are greater than the variances due to general combining abilities (GCA) displaying the nonadditive genetic effects for all traits. GCA effects demonstrate that the line G9 can be significantly used for producing high yielding early maturing hybrids. The line G100 with high negative GCA effects for plant height can be used to produce short stature genotypes. The line G2 can be used in the breeding program to improve the oil and oleic acid content whereas G65 for linoleic acid and protein contents. G9×G12 and G65×G12 was the cross combinations that demonstrate significant SCA effects for most of the traits studied.

KEYWORDS: GCA, SCA, Genetic Variation, Yield, Oil Contents, Oil Quality.

INTRODUCTION

Pakistan being an agricultural country, has great potential to become self-sufficient in food commodities but unfortunately it is far behind in fulfilling its requirement of food especially the oil which is the compulsory food element used in daily life. To fulfill its local demand of oil, government had to import oil worth billions of rupees which confers great loss to the national economy. It is direly needed to ameliorate this situation. There is need to enhance the potential of different conventional crops along with the introduction of nonconventional ones. Once sunflower was considered as nonconventional crop, introduced in 60's but now it becomes a leading source of edible oil in Pakistan as its production is 17% relative to the 13% of canola, rapeseeds and mustards (Govt. of Pakistan, 2013-14). Sunflower is one of the world's most important oilseed crops. It has more than 40% oil in its seed and has more concentration of polyunsaturated fatty acids (Aslam *et al.*, 2010). A good amount of vitamin E along with tocopherols and carotenoids are also present. Being light in taste its oil proved to be very good for the persons having cardiovascular diseases (Evert *et al.*, 1987). Sunflower has a great potential to be used as a major oilseed crop in Pakistan but its production is very low in comparison to its potential due to the cultivation of exotic hybrids. Hybrids are well known for their high yield and better stability (Kaya and Atakisi, 2014) in sunflower as compared to the open pollinated varieties. An exotic hybrid does not perform well in local climatic conditions and sometimes not suited for our cropping systems as they are not specifically bred for our local conditions. Its potential can be enhanced by the production of local hybrids as they will be more adapted to the local climate (Khokhar *et al.,* 2006). Global conditions are continuously changing, making it necessary to produce new hybrids that have higher genetic potential for seed and oil yield, early and uniform maturity and resistance to biotic and abiotic stresses so the major objective of sunflower breeding is to develop the high yielding early maturing hybrids with high oil quality and disease resistance (Dudhe, 2009). Estimation of combining ability is prerequisite for the selection of lines and inbreds to be used as parents in the hybrid breeding program. Heterotic performance of a hybrid combination depends upon combining abilities of its parents (Kadkol *et al.*, 1984). Thus, combining ability of parental lines is the ultimate factor determining future usefulness of the lines for hybrids and synthetics. The GCA and SCA provide an estimate for additive and non-additive gene actions, respectively (Sprague and Tatum, 1942). Large number of inbred lines can be evaluated for their general combining ability (GCA) and specific combining ability (SCA) by using the line x tester analysis (Kempthorne, 1957). Line x tester analysis not only gives the combining abilities of inbred lines but also demonstrates the type of gene action involved in the inheritance of plant traits.

MATERIAL & METHODS

The study was conducted in the research area of Department of Plant Breeding and Genetics, University of Agriculture Faisalabad. Ten parental lines (G53, A26, G12, G57, G65, G2, G9, G93, G100 and G7) were sown according to randomized complete block design in crossing block. These lines were crossed in line x tester scheme to get 21 F_1 hybrids. The F_1 seeds of 21 crosses and their parents were planted in the field during February 2012, following a randomized complete block design in triplicate. The seeds were sown in rows keeping 30 cm plant to plant and 75cm row to row distance. In both growing seasons all the agronomic and cultural practices were performed uniformly from sowing till harvest.

Analysis of variance technique will be used after collecting the data on early maturity, yield and oil related traits as demonstrated by (Steel *et al.,* 1997) to study the level of significance between F_1 hybrids and their parents and then subjected to the analysis of general and specific combining abilities (Kempthorne, 1957).

RESULTS & DISCUSSION

Considerable genetic variation is observed in all traits including emergence percentage, days to fifty percent flowering, days to maturity, plant height, head diameter, 100 achene weight, Achene yield per plant, oil contents, palmitic acid, oleic acid, linoleic acid and protein contents as reported by the significant mean square values (Table 1). Existence of resemblances and dissimilarities among the present genotypes can be efficiently used in breeding program to develop new varieties and hybrids (Razzaq *et al.,* 2014). Parents and crosses also revealed significant differences for all the observed traits demonstrating the presence of wider genetic difference among the parents and crosses. Parents vs crosses demonstrate notable genetic differences for all traits except days to maturity and head diameter. These results suggest the presence of heterosis among the crosses (Devi *et al.,* 2005)]. So these lines may play valuable role in the development of new hybrids. Lines and testers revealed non significant genetic differences for all traits indicating the similarities among the lines and testers. Significant genetic differences were observed for line x tester demonstrating the considerable contribution of SCA effects towards the variation among crosses. Reported results are in accordance with the observed results of (Andarkhor *et al.,* 2012; Chandra *et al.,* 2011; Shankar *et al.,* 2007). The variances due to SCA are greater than the variances due to GCA and GCA/SCA ratio is also less than one (Table 2) indicating the presence of non-additive type of gene action for all the traits under study (Chandra *et al.,* 2011; Devi *et al.,* 2005). Percentage contribution of lines are greater than testers for all the traits whereas the contribution of their interaction is greater than the lines for the traits including days to fifty percent flowering, days to maturity, plant height, head diameter, oil contents, palmitic acid, oleic acid and linoleic acid.

TABLE 1. Mean Squares from Analysis of Variance of Early Maturity, Yield and Oil Related Traits in Sunflower

				SOV					
Traits	Rep	Genotype	Parents (P)	Crosses (C)	P vs C	Lines (L)	Testers (T)	L×T	Error
DF	2	30	9	20	1	6	2	12	60
EM%	0.62	128.4**	223.0**	91.5 **	13.2 **	153.8	50.3	67.3 **	1.32
DTFF	0.78	94.08 **	21.04 **	80.79 **	1017.1**	107.48	86.11	66.56 **	1.08
DTM	3.8	41.7**	39.7**	44.6**	0.4	59.4	29.7	39.7**	0.24
PH	25.6	1625.7**	1567.9**	1700.6**	649.0 **	2530.8	849.9	1427.3**	33.4
HD	1.2	70.1**	29.5**	91.8**	1.48	148.3	11.7	77.0**	1.71
100AW	0.01	1.05**	1.12**	1.06**	0.13 *	1.79	0.15	0.85**	0.03
AY/P	0.4	188.1**	189.1**	196.4**	13.0 *	387.8	309.7	81.9 **	2.76
OC	0.01	6.75**	3.08**	7.68**	21.1**	7.06	4.94	8.46**	0.017
PA	0.01	0.69**	0.93**	0.59**	0.45**	0.38	0.06	0.79**	0.001
OA	0.01	91.44**	117.3**	78.97**	107.9**	88	90.62	72.51**	0.001
LA	0.01	54.9**	72.5**	49.7**	1.30**	38.7	70.8	51.7**	0.001
PC	0.01	3.44**	2.76**	3.60**	6.52**	6.46	2.04	2.43**	0.001

TABLE 2. Genetic Variance Components in 21 F_1 Hybrids for Early Maturity, Oil and Yield Related Traits.

Genetic components	EM (%)	DTFF	DTM	PH	HD	100 AW	AY/P	OC	PA	OA	LA	PC
Vgca	4.6	3.56	1.75	73.0	3.95	0.04	14.4	0.18	.004	2.93	1.4	0.19
Vsca	22	21.8	13.1	464	25.1	0.27	26.3	2.81	0.26	24.1	17.2	0.81
Vgca/Vsca	0.2	0.16	0.13	0.15	0.15	0.14	0.54	0.06	0.015	0.12	0.08	0.23
%of testers	5.49	10.65	6.66	4.99	1.28	1.28	15.76	6.42	0.98	11.47	10.82	5.68
%of lines	50.04	39.91	39.95	44.64	48.42	50.26	59.21	27.54	19.01	33.34	31.0	53.79
% of LxT	44.11	49.44	53.39	50.37	50.3	48.26	25.03	66.02	80.0	55.09	58.17	40.51

General combining ability effects has been presented (Table 3). The line G9 had the highest significant value for emergence percentage (4.6) and highest significant negative values for days to fifty percent flowering (-4.0) and days to maturity (-3.1) so this line can be used in the breeding program for producing early maturing genotypes. The line G100 had the highest significant negative value for plant height (-23.3). To overcome the problem of lodging this line can make a considerable contribution. For yield traits, the line G9 had the highest significant value for head diameter (5.9), 100 achene weight (0.54) and achene yield per plant (13.3). Production of sunflower can be enhanced by adding the line G9 in the breeding program. The line G2 had highest significant value for oil contents (1.2) (Andarkhor *et al.*, 2012; Ghaffari *et al.*, 2011; Khan *et al.*, 2008). For palmitic acid the line G2 had the highest significant negative value (-0.3). For oleic acid the line G2 had the highest significant value (4.4). The line G65 had the highest values for linoleic acid (2.6). Generally the oil that contains more concentration of oleic acid and linoleic acid and less concentration of palmitic acid considers best for edible purpose. So the line G2 can be used in the breeding program to improve the oleic acid content and G65 for linoleic acid contents. The line G65 had the highest value for protein content (1.1).

TABLE 3. Results for General Combining Ability of 10 Parental Lines for Early Maturity, Yield and Oil Related Traits

Parents	Lines								Testers		
	G57	G65	G2	G9	G93	G100	G7	G53	A26	G12	G57
EM%	1.0*	3.4**	-6.9**	4.6**	-0.08	-4.0**	1.9**	0.3	-0.4	1.7*	-1.2*
DTFF	0.7	1.7**	-3.7**	-4.0**	5.6**	1.6**	-1.9**	0.4	1.5*	0.7	-2.3*
DTM	-2.8**	0.7**	-1.2**	-3.1	2.5**	-2.8**	3.7**	0.1	1.3**	-0.8*	-0.5*
PH	14**	-3.2	-10**	28.1**	-1.4	-23.3**	-3.3	1.9	7.1**	-2.1	-4.9**
HD	3.6**	-0.5	-2.1**	5.9**	-0.29	-6.7**	0.1	0.4	-0.6**	0.8	-0.2*
100AW	0.2**	0.2**	-0.30**	0.54**	0.07	-0.82**	0.02	0.06	-0.04	0.1	-0.05
AY/P	8.3**	-0.5	-2.1**	13.3**	-11.2**	11.8*	-2.8**	0.5	-1.9*	-1.5	3.4*
OC	0.6**	0.8**	1.2**	-0.5**	-0.9**	-0.7**	-0.4**	0.04	0.4**	0.08	-0.5**
PA	0.3**	-0.1**	-0.3**	0.07**	0.1**	-0.2**	-0.0**	<.01	0.05*	-0.01	-0.04*
OA	0.1**	-4.9**	4.4**	1.3**	.04**	1.8**	-2.9**	<.01	2.2**	-1.8**	-0.3**
LA	1.8**	2.6**	0.2**	-1.7**	-3.4**	0.2**	0.1**	<.09	1.6**	-1.9**	0.3**
PC	-0.3**	1.1**	<-.01*	-1.1**	0.8**	-0.7**	0.3**	<.01	-0.3*	0.0**	0.2*

TABLE 4. Results for Specific Combining Abilities in 21 F_1 Crosses for Early Maturity, Yield and Oil Related Traits

Crosses	EM%	DTFF	DTM	PH	HD	100AW	AY/P	OC	PA	OA	LA	PC
G57×G53	-3.34**	-4.06**	-5.69**	12.4**	-2.30**	-4.25**	5.72**	0.86**	0.11**	-0.67**	-36.1**	-18.5**
G57×A26	7.83**	1.60*	5.30**	-8.30*	-0.20	0.07	-5.01**	0.90**	-0.31**	2.82**	-5.03**	-0.80**
G57×G12	-2.36**	1.74**	-1.79**	-13.4**	-4.37**	0.47**	-0.26	-1.76**	0.20**	-2.15**	2.72**	0.37**
G65×G53	4.53**	1.93**	3.63**	9.63**	-5.51**	-0.44**	3.71**	-1.46**	-0.35**	-0.90**	-1.09**	0.23
G65×A26	-4.84**	4.98**	-0.17	6.33	0.38	0.10**	-1.52	-0.32**	0.70**	2.00**	3.73**	0.36*
G65×G12	0.31	-7.23**	-3.46**	-15.9**	10.3**	0.34**	7.96*	1.78**	-0.45**	-1.09**	-2.64**	-0.59**
G2 ×G53	3.15**	0.71	2.63**	22.7**	5.12**	1.14**	-2.69*	0.80**	-0.35**	-5.63**	4.62**	-0.87**
G2×A26	-4.35**	0.09	-2.17**	-8.12*	-4.38**	-0.31*	-5.27**	-0.05	0.70**	-1.42**	-7.02**	1.06**
G2×G12	1.20	-0.81	-0.46	-14.6**	-6.01**	-0.82**	-2.18**	-0.76**	-0.35**	7.06**	2.40**	-0.18
G9×G53	0.61	-2.28**	0.63	-1.72	2.44**	-0.04	-5.59**	-0.14	0.40**	2.15**	-3.43**	-0.11
G9×A26	-3.33**	4.42**	-1.17**	3.17	1.93*	0.00	1.90	-2.17**	0.21**	-3.64**	1.11**	0.44**
G9×G12	4.46**	-6.92**	0.54	-16.9**	3.93**	0.04	3.69**	2.31**	-0.61**	1.48**	2.32**	-0.33*
G93×G53	1.94*	0.38	0.85**	-0.32	-1.84*	0.12	0.10	0.50**	0.05**	3.20**	-1.67**	0.01
G93×A26	1.07	-2.14**	-0.28	-10.1**	3.38**	0.11	5.34**	0.65**	-0.29**	-6.01**	6.18**	0.01
G93×G12	-3.02**	6.85**	-0.57	10.4**	-1.54	-0.23*	-5.45**	-1.15**	0.24**	2.80**	-4.51**	-0.02
G100×G53	-7.98**	0.04	-1.69**	-15.2**	0.17	0.16*	-4.87**	-1.98**	0.00	-2.64**	2.50**	1.16**
G100×A26	3.52**	0.09	-1.50**	24.6**	-0.74	-0.14	11.4**	0.79**	-0.50**	7.16**	-0.56**	-0.92**
G100×G12	2.72**	-0.14	3.20**	-9.38*	0.57	-0.01	-6.62**	1.19**	0.50**	-4.51**	-1.95**	-0.25
G7×G53	1.09	3.27**	-0.36	-27.5**	-3.36**	-0.54**	3.61**	1.41**	0.14**	4.49**	0.40**	-1.22**
G7×A26	2.22**	-4.68**	-2.17**	-1.45	1.06	0.08	-6.47**	0.20**	0.31**	-0.90**	-2.05**	0.22
G7×G12	-3.30**	1.41**	2.54**	44.5**	2.30**	0.45**	2.86**	-1.61**	-0.35**	-3.59**	1.66**	1.00**
SE	0.66	0.60	0.28	3.34	0.75	0.11	0.95	0.07	0.014	0.014	0.015	0.13

EM% = Emergence Percentage, DTFF = Days to 50 % flowering, DTM = Days to maturity, PH = Plant height, HD = Head diameter, 100AW = 100 achene weight, AY/P = Achene yield per plant, OC = Oil contents, PA= Palmitic Acid , OA= Oleic Acid, LA= Linoleic Acid, PC = Protein content

Results for specific combining ability are presented (Table 4). Results showed that eight out of 21 crosses had significant positive SCA effects for emergence percentage. Suitable combinations included G57×A26, G65×G53 and G9×G12. Six and eight crosses revealed significant negative specific combining ability effects for days to fifty percent flowering and days to maturity respectively revealing the non additive genetic effects for reducing these traits. The crosses G65×G12, G9×G12 and G7×A26 showed the favorable combinations for decreasing the days to fifty percent flowering and crosses G57×G53, G65×G12 and G7×A26 for days to maturity. For plant height 10 crosses showed significant negative SCA effects.

The crosses G9×G12, G65×G12 and G2×G12 showed favorable combinations for reducing plant height. For yield relating characters seven, six and eight crosses showed significant positive SCA effects for head diameter, 100 achene weight and achene yield per plant respectively. For head diameter the crosses G65×G12, G2×G53, and G9×G12 demonstrate the required combination. For 100 achene weight the combinations G2×G53, G57×G12 and G7×G12 demonstrate the favorable conjugation. For achene yield per plant G100×A26, G65×G12 and G57×G53 revealed favorable combination. 11 crosses showed significant positive SCA effects for oil contents. The combinations G9×G12, G65×G12 and G7×G53 exhibit favorable conjugation for oil contents (Andarkhor *et al.,* 2012; Karasu *et al.,* 2010; Khan *et al.,* 2009; Turkec and Goksoy, 2006). Nine crosses displayed significant negative SCA effects for palmitic acid content. Among these G9×G12, G100×A26 and G65×G12 crosses exhibit beneficial combination. Nine and 10 crosses showed significant positive SCA effects for oleic acid and linoleic acid respectively. For oleic acid G100×A26, G2×G12 and G7×G53 revealed desirable combination. For linoleic acid G93×A26, G2×G53 and G65×A26 demonstrate the useful combination. Six crosses revealed significant positive SCA effects for protein contents. Among these G100×G53, G2×A26 and G7×G12 manifest the required combinations.

CONCLUSION

Broader genetic variances were observed in genotypes for the studied traits. Estimation of combining abilities is prerequisite for the execution of successful breeding program. Variances due to specific combining abilities (SCA) are greater than the variances due to general combining abilities (GCA) reporting the presence of non additive genetic effects for all traits. Different lines demonstrated notable GCA effects for different traits concluding that the line G9 can be used for producing high yielding early maturing hybrids, the line G100 with high negative GCA effects for plant height can produce the short stature genotypes, the line G2 can be used in the breeding program to improve the oil and oleic acid content whereas G65 for linoleic acid and protein contents. Crosses showed highly significant SCA effects for most of the traits. The crosses G9×G12 and G65×G12 demonstrated the best combinations for most of the traits studied.

ACKNOWLEDGMENTS

A special thanks to Mr. Iftikhar Ali (CSO, NIFA) for his skillfull help in carrying out this research.

REFERENCES

Andarkhor, S.A., Mastibege, N. and Rameeh (2012) Combining ability of agronomic traits in sunflower (*Helianthus annuus L*.) using line×tester analysis. Int. J. Biol. 4(1), 89-95.

Aslam, S., Khan, S.K., Saleem, M., Qureshi, A.S., Khan, A., Islam, M. & Khan, S.M. (2010) Heterosis for the improvement of oil quality in sunflower (*Helianthus annuus* L.) Pakistan J. Bot. 4(2), 1003-1008.

Devi, K.R., Ranganatha, A.R.G. and Ganesh, M. (2005) Combining ability and heterosis for seed yield and its attributes in sunflower. Agric. Sci. Digest 25(1), 11-14Chandra, B. S., Kumar, S. S., Ranganadha, A. R. G. and Dudhe, M. Y. (2011) Combining ability studies for the development of new hybrids over environments in sunflower (*Helianthus annuus* L.). J. Agri. Sci. 3(2), 230-237.

Dudhe, M.Y., Moon, M.K. and Lande, S.S. (2009) Evaluation of restorer lines for heterosis studies on sunflower (*Helianthus annuus L*.). J. Oilseeds Res. 26 (Special Issue), 140-142.

Economic Survey of Pakistan (2012-13) Govt. of Pakistan, statistical supplement, Economic advisor's Wing, Ministry of Finance, Govt. of Pakistan, Islamabad.

Evertt, N.P., Robinson, K.E. and Mascarenhas, D. (1987) Genetic engineering of sunflower (*Helianthus annuus L*.). Biotechnology 5(1), 1201-1204.

Ghaffari, M., Farrokhi, L. and Mirzapour, M. (2011) Combining ability and gene action for agronomic traits and oil content in sunflower (*Helianthus annuus L*.) using F_1 hybrids. Crop Breed. J. 1(1), 75-87.

Kadkol, G.P., Anand, I.J. & Sharma, R.P. (1984) Combining ability and heterosis in sunflower. Indian Journal of Genetics and Plant Breeding 44, 447-451.

Karasu, A., Oz, M., Sincik, M., Gokosoy, A.T. & Turan, Z. M. (2010) Combining ability and heterosis for yield and yield components in sunflower, Not. Bot. Hort. Agrobot. Cluj. 38(3), 259-264.

Kaya, Y. & Atakisi, I.K. (2004) Combining ability analysis of some yield characters of sunflower (*Helianthus annuus L*.). Helia 27(41), 75-84.

Kempthorne, O. (1957) An introduction to genetic statistics. John Wiley and Sons Inc, New York. Chapman and Hall Ltd, London.

Khan, H., Rahman, H.U., Ahmad, H., Ali, H., Inamullah and Alam, M. (2008) Magnitude of heterosis and heritability in sunflower over environments. Pakistan J. Bot. 40(1), 301-306.

Khan, S.A., Ahmad, H., Khan, A., Saeed, M., Khan, S.M. and Ahmad, B. (2009) Using line×tester analysis for earliness and plant height traits in sunflower (*Helianthus annuus L*.). Recent Res. Sci. Tech. 1(5), 202-206.

Khokhar, M., Sadaqat, H.A. and Tahir, M.H.N. (2006) Association and effect of yield related traits on achene yield in sunflower. Int. J. Agric. Biol. 8, 450-451.

Razzaq, H., Tahir, M.H.N. and Sadaqat, H.A. (2014) Genetic variability in sunflower (*Helianthus annuus L*.) for achene yield and morphological characters. I.J.S.N. 5(4), 669-676.

Shankar, V.G., Ganesh, M., Ranganatha, A.R.G., Suman, A. and Sridhar, V. (2007) Combining ability studies in diverse CMS sources in sunflower (*Helianthus annuus L*.). Indian J. Agric. Res. 41(3), 171-176.

Sprague G.F. and Tatum, L.A. (1942) General vs. specific combining ability in single crosses of corn. Journal of the American Society of Agronomy 34, 923-932.

Steel, R.G.D., Torrie, J.H. and Dickey, D.A. (1997) Principles and procedures of statistics: A Biometrical Approach (3rd ed). Mc Graw-Hill, New York.

Turkec, A. and Goksoy, A. (2006) Identification of inbred lines with superior combining ability for hybrid sunflower (*Helianthus annuus L*.) production in Turkey. New Zealand J. Crop and Horticultural Sci. 34, 7-10.