Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.3, No.1, 2013

Estimation of Combining Ability for the Development of Hybrid Genotypes in *Helianthus annuus* L.

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ABSTRACT
Plant materials were developed by L×T crossing fashion of nine lines and four testers and their thirty six hybrids were sown in field during 2011 in RCBD design with three replications. Genetic variability, general and specific combining abilities among genotypes was assessed under the research area of department of plant breeding and genetics, university of agriculture, faisalabad, Pakistan. The Line G-93, and G-79 expressed highly significant GCA effects for days to flowering, days to maturity, internodal length, head diameter, %age of filled achenes, 100 achene weight, achene yield per plant and oil contents but they showed best general combiner. Among testers A-85 expressed highly significant GCA effects for days to flowering, days to maturity, 100 achene weight, achene yield per plant and oil contents whereas A-5 exibited best general combiner for days to flowering, days to maturity, internodal length, achene yield per plant and oil contents. The cross G-65×A-85 revealed highest SCA effect for days to 50% flowering and days to maturity, head diameter, 100 achene weight, achene yield per plant and oil contents. The results of analysis of variance were determine among entries for all the traits at significant level ($p \geq 0.01$-0.05).
Key words: GCA, SCA, line × tester, oil contents and yield.

INTRODUTCION

Edible oil is major component of our diet but Pakistan is constantly deficient in its production and large quantity of the country's edible oil necessities are met through imports. Oilseed region, due to always increasing utilization of edible oil, has attained vital importance in the economy of Pakistan. The edible oil using up in Pakistan has been increased from 0.3 million tons to 1.95 million tons during the last two decades, with increase in population (Bilal, 2004). The local production during 2010-11 (July-March) stood at 0.778 million tons. Total availability of edible oil during 2010-11 was 2.0686 million tones, whereas local production stood at 0.788 million tones which accounted for 28 % of the total availability while the remaining 73 % was made available through imports (Anonymous, 2011)

This gap in the production can be satisfied by introducing high yielding, disease resistant, and drought tolerant and early maturing cultivars. Domestic production of edible oil can be amplified by increasing the area and yield per acre of conventional and non-conventional oilseed crops. The area under oilseed crops cannot be increased because of limited land resources therefore, the only way left is the development of genetic potential of existing varieties of oilseed crops and introduction of better crops.

General (GCA) and specific combining abilities (SCA) are significant parameters in plant breeding. Due to high heterosis occurring generally in hybrids between genetically distinct inbred lines, all crop breeders that have potential for good combiners. Breeding programs can take benefit from such information on combining ability to locate top selection plan for developing high yielding lines and hybrids (Skoric, 1992). Also, evaluating genotypes for combining ability is important in determining suitable measures or genotypes to build up competently in breeding programs for main yield characters in sunflower (Miller, 1987).

The line × tester analysis is one of an efficient method of evaluating large number of inbred lines for general combining ability and specific combining ability effects for interpreting the genetic basis of significant plant traits. The performance of individual hybrids is used to get SCA and that of the lines crossed to structure that hybrid (Fick and Miller, 1997). Based on the combining ability analysis of different characters, higher SCA values refer to dominance gene effects and higher GCA effects show a better task of additive gene effects calculating these characters in the plant. If both the GCA and SCA values are non significant, epistatic gene effects share a significant role in formulating these traits.

The main purpose of this study was to improve the sunflower production by improving the hybrid seed and oil yield and the quality of oil. In the breeding programme to utilize the heterosis, development of inbred lines, use of diverse sources and restorer inbreds has much importance. In sunflower, the genetic makeup is being diversified through conventional breeding methods. New inbred lines were being developed and superior genotypes are being identified by combining ability studies and the best combining inbred lines are select to use in heterosis. For the utilization of heterosis in breeding programs, the selection of parent inbreds has much importance in the development of superior hybrids. So estimating the general combining ability (GCA) effects and specific combining ability (SCA) effects is helpful to select the best parent inbreds for superior hybrids in seed yield and oil contents. The line × tester analysis by Kempthorn, 1957 may be the simplest and efficient method for evaluating inbreds for their combining abilities. General combining ability (GCA) was defined by Sprague and Tatum (1942) as an average performance of lines when seed in several combinations of hybrids and specific combining ability (SCA) as the performance in specific hybrid combinations which are significantly different from the average performance of lines used. It is also useful to know the type of gene action involved in different characters and so proper breeding strategies.

MATERIALS AND METHODS

The research work was conducted in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during 2011-2012. All the agronomic and cultural practices were performed regularly from sowing still harvest. These lines were choosen on the foundation of their origin. Lines and testers were crossed in the field experiment by line × tester fashion during spring, 2011. The experimental material consisted of 36 crosses and 13 parents.36 crosses were obtained from 9 line G-93, G-9, G-12, G-100, G-65, A-19, G-79, G-57, A-7and 4 testers A-94, A-5, A-85, A-18. The plant materials were developed by crossing 9 lines and 4 testers in L×T fashion and maintained by the Oil Seed Research Group, Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Crossed materials which was F_0, along with its parent lines, was sown in the next growing season of the same year 2011 having three replications in each as the sunflower can be grown in two seasons in a year in Punjab, Pakistan. The experimental unit which was consisting of single row of 5 m length having P × P distance of 25cm and R × R distance of 60 cm. All the standard agronomic and plant protection measures were used. Each sunflower capitulum (head) was covered with a Kraft paper bag (size 35 × 45 cm), a day before the initiation of anthesis (a stage where ray florets were visible) and kept covered until seed setting. From the male parent, they had also been previously bagged before flower opening pollen was collected in the bag by giving a gentle shake to the head. Each sunflower head was pollinated thrice on alternate days to cover all the floret whorls proceeding inwards. The data was recorded using ten randomly selected plants from each block for below traits i.e.

- Days to flowering,
- Days to maturity,
- Internodal length,
- Head diameter,
- %age of filled achenes,
- 100 achene weight (g),
- Achene yield per plant (g),
- Oil contents %age.

Oil contents of all the genotypes were analyzed from the department of Fiber technology, National Institute of Food Science and Technology University of Agriculture, Faisalabad.

RESULT AND DISCUSSION

Estimates of genetic variation and combining ability determined the value of source population and the appropriate procedure to use in a breeding programme. Genetic variation among plant traits associated with plant growth and resultant morphological and physiological differences serve as the basis for the development of cultivars with improved agronomic traits. Variation among characters such as days to flowering, days to maturity, head diameter, 100 achene weight, achene yield per plant, % filled achene, internodal length and oil contents particularly useful as these allows for development of types adapted to specific environments and agro climatic conditions (Fick, 1978). Line × tester analysis (Table-1) revealed significant difference among genotypes, crosses, parents, lines, tester, line × tester interaction and crosses Vs parents for all characters expect % filled achene. Muppidathi *et al.* (1996), Gvozdenovic *et al.* (2005) and Habib *et al.* (2006) reported same results.

Table-2. Revealed that the Line G-93, and G-79 expressed highly significant GCA effects for days to flowering, days to maturity, internodal lenth, head diameter, 100 achene weight, achene yield per plant and oil contents followed by the lines A-7 and G-9 which were highly significant for the traits days to flowering, internodal lenth, head diameter, achene yield per plant and oil contents. Among tester A-85 and A-5 expressed highly significant GCA effects for days to flowering, days to maturity, head diameter, internodal length, head diameter, 100 achene weight, achene yield per plant and oil contents. Dominant gene effects were reported for days to flowering, head diameter by Naik *et al*. (1999), Skoric *et al*. (2000) and Mehanasundaram *et al*. (2010). Over dominance effects for 100-achene weight were also reported by Naik *et al*. (1999) and Skoric *et al*. (2000).

Table-3. The cross G-9×A-18 and G-65×A-85 exibited maximum significant SCA effect for days to flowering, days to maturity, head diameter, 100 achene weight, achene yield per plant and oil contents followed by the hybrids G-93×A-18, G-79×A-5, G-100×A-5 and A-7× A-5 revealed significant SCA effect for only days to flowering, days to maturity, head diameter, %age of filled achenes, achene yield per plant and oil contents. So the cross G-9×A-18 was exibited best specific combiner followed by the hybrid G-65×A-85. Bajaj *et al*. (1997), Lande *et al*. (1997), Kumar *et al*. (1998), Shekar *et al*. (1998) reported the same study.

Conclusion

According to above research study, it is concluded that the evaluation of breeding materials had adequate genetic variability that may be exploited in further breeding programs. GCA and SCA ANOVAs proposed these characters under control of non-additive gene action. Further analysis revealed over-dominant gene action controlling the plant traits. Therefore, estimation of combining ability was suggested to improvement in yield and related traits using these sunflower breeding materials. Among the proposed genotypes i.e. G-93, A-7, G-9, A-5 and A-85 showed maximum GCA effects and considered to be good general combiner for almost 80% traits under study and The cross combinations G-9×A-18 and G-65×A-85 were showed best specific combining ability whereas these genotypes can be used for further hybrid development breeding programs for seed yield and oil contents improvement.

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Statistical significant level: *=significant at 0.05 level **=significant at 0.01 level

Abbrivations:
L×T= Line×Tester
SCA = Specific combining ability.
GCA = General combining ability.
SOV = Source of variation.
DF = Degree of freedom.
DTF= Days to flowering.
DTM=Days to maturity.
IL = Internodal length.
HD= Head diameter.
% FA= % Filled achene.
100-AW= 100- achene weight (g).
AYP= Achene yield per plant (g).
OC= Oil contents %age.

Table-1. Mean square values from ANOVA of yield and related traits in sunflower.

SOV	DF	DTF	DTM	IL	HD	% FA	100- AW	AYP	O.C
Replication	2	0.0866ns	8.0842**	7.6656**	3.6450**	557379.97ns	0.1655 ns	1.1754ns	0.7917*
Genotype	48	85.7144*	27.674**	3.0227**	36.4305**	556275.96ns	3.8787**	201.9960**	205.6661**
Crosses	35	69.3074*	26.6331**	2.2483**	21.4829**	755223.801 ns	2.4848**	147.6508**	175.3699**
Parents(P)	12	105.947*	9.1844**	5.2224**	37.6127**	299.8943 ns	1.4726**	175.9941**	6.6812**
Lines (L)	8	105.4205*	23.0889**	5.6189**	53.0941**	755823.554 ns	2.7436**	296.7160**	672.8732**
Testers (T)	3	72.9477*	20.9199**	2.07**	12.5929**	758118.188 ns	4.2435**	525.2895**	24.2989**
L x T	24	56.8146*	28.528**	1.1466**	12.0571**	754662.086 ns	2.1787**	50.7576**	28.41**
Cross v Par	1	417.2334*	286.02**	3.7278**	545.411**	264814.606 ns	81.5376**	2416.980**	3659.484**
Error	96	1.6928	0.9734	0.3650	0.5752	555035.40	0.4358	1.1535	0.6167

Table-2.Estimation of General combining ability effects of sunflower lines and testers for yield and its related traits.

Genotypes	DTF	DTM	IL	HD	%FA	100 AW	AYP	OC
Lines								
G-93	-4.79**	-1.24**	0.26**	-1.90**	-82.24ns	0.55**	1.99**	6.26**
G-57	0.20ns	-1.05**	-0.51**	-3.65**	-84.74ns	-0.14 ns	3.69**	6.34 **
A-19	0.73 ns	-2.39**	0.88**	1.53**	-83.74 ns	0.40 ns	3.09**	6.7 **
A-7	1.35**	-0.61*	-0.70**	2.7**	320.34**	0.50*	8.13**	6.03**
G-9	1.74**	1.59**	0.77**	-.85**	-84.89 ns	-0.32 ns	-7.19**	5.57 **
G-12	0.35 ns	1.34**	-0.08ns	1.38**	-82.38 ns	-.26 ns	-6.70**	-5.34 **
G-100	-5.05**	0.59*	-1.07**	2.19**	-83.56 ns	-0.03 ns	-2.25**	-6.58**
G-65	1.90**	0.44ns	-0.17ns	-0.97**	-82.3 ns	0.23 ns	-1.50**	-8.05**
G-79	3.56**	1.33**	0.62**	-0.49**	-85.36 ns	-0.93**	0.75**	-10.95 **
Testers		.						
A-18	-1.26**	0.08ns	0.13*	0.74**	-84.60 ns	-0.51**	-5.67**	1.33 *
A-94	0.84**	0.73*	-0.36**	0.25**	-82.97 ns	-0.11 ns	3.83**	-0.19**
A-5	1.90**	0.79**	0.28**	-0.11*	251.35 ns	0.23 ns	3.14**	-.22 **
A-85	-1.48**	-1.25**	-0.05ns	-0.88ns	-83.78 ns	0.38**	-1.30**	-0.92 **

Table-3. Specific combining ability effects of 36 sunflower crosses for yield and related traits.

Crosses	DTF	DTM	IL	HD	% FA	100 AW	AYP	O.C%
G-93× A-18	3.18 **	-2.84 **	0.91 **	0.68 *	85.01 ns	0.66 ns	**-5.58** **	-1.69 **
G-93 × A-94	3.91 **	-1.03 *	-0.53 **	0.95 **	85.73 ns	-0.06 ns	1.89 **	0.78 *
G-93 × A-5	-2.98 **	1.46 **	-0.38 *	-2.29 **	-253.89 ns	-0.20 ns	1.49 *	-0.52 ns
G-93 × A-85	-4.12 **	2.40 **	-0.00 ns	0.67 *	83.16 ns	-0.40 ns	2.20 **	1.43 **
G-57 × A-18	0.27 ns	2.99 **	0.33 ns	-1.60 **	82.66 ns	-0.28 ns	5.87 **	1.14 **
G-57 × A-94	-1.78 *	1.50 **	-1.42 **	2.19 **	87.78 ns	-0.75 ns	0.29 ns	0.36 ns
G-57 × A-5	-0.95 ns	0.20 ns	0.96 **	0.90 **	-254.18 ns	0.56 ns	-5.75 **	-2.30 **
G-57 × A-85	2.47 **	-4.68 **	0.12 ns	-1.49 **	83.74 ns	0.47 ns	-0.41 ns	0.80 *
A-19 × A-18	-0.31 ns	-2.41 **	-0.27 ns	-1.49 **	79.77 ns	-0.83 *	-7.57 **	-3.62 **
A-19 × A-94	-2.25 **	-0.77 ns	0.29 ns	0.95 **	81.89 ns	1.50 **	0.89 ns	0.94 *
A-19 × A-5	1.59 *	5.48 **	-0.06 ns	-0.13 ns	-249.39 ns	-1.57 **	2.73 **	1.33 **
A-19 × A-85	0.98 ns	-2.30 **	0.03 ns	-1.30 **	87.73 ns	0.89 *	3.95 **	1.34 **
A-7 × A-18	-2.47 **	1.80 **	0.30 ns	0.20 ns	-669.32 ns	0.18 ns	3.31 **	-1.63 **
A-7 × A-94	4.19 **	3.27 **	-0.14 ns	-2.40 **	-668.47 ns	0.00 ns	-1.04 ns	1.40 **
A-7× A-5	-6.07 **	-4.01 **	0.17 ns	-1.08 **	200.18**	0.51 ns	-4.41 **	0.74 *
A-7 × A-85	4.35 **	-1.06 *	-0.32 ns	3.28 **	-668.39 ns	-0.69 ns	2.14 **	-0.51 ns
G-9 × A-18	-3.66 **	3.45 **	-0.39 *	-0.89 **	83.89 ns	-1.27 **	4.72 **	-2.63 **
G-9 × A-94	4.16 **	-1.98 **	0.44 *	-0.17 ns	83.08 ns	-0.11 ns	-0.84 ns	-0.32 ns
G-9 × A-5	3.30 **	0.78 ns	0.01 ns	-0.14 ns	-251.94 ns	1.36 **	-0.21 ns	0.77 *
G-9× A-85	-3.80 **	-2.25 **	-0.06 ns	1.21 **	84.97 ns	0.01 ns	-3.66 **	2.18 **
G-12 × A-18	3.22 **	-0.00 ns	-0.26 ns	1.77 **	85.87 ns	-0.31 ns	1.21 ns	10.87 **

Table-3. continued..

Crosses	DTF	DTM	IL	HD	% FA	100 AW	AYP	O.C%
G-12 × A-94	2.82 **	-1.06 *	-0.45 *	-2.08 **	79.64 ns	-0.46 ns	-2.26 **	-4.71 **
G-12 × A-5	0.30 ns	-1.93 **	0.80 **	1.76 **	-249.74ns	-0.17ns	1.28 *	-1.99 **
G-12 × A-85	-6.34 **	2.99 **	-0.09 ns	-1.46 **	84.22 ns	0.94 *	-0.23 ns	-4.17 **
G-100× A-18	-3.18 **	-1.35 **	0.18 ns	-1.05 **	83.45 ns	0.36 ns	-0.23 ns	-1.30 **
G-100 × A-94	-7.11 **	2.18 **	0.92 **	0.55 ns	84.74 ns	0.44 ns	-4.82 **	-0.99 **
G-100× A-5	6.58 **	-2.62 **	-1.19 **	-0.52 ns	-249.90 ns	-0.51 ns	3.68 **	1.43 **
G-100× A-85	3.71 **	1.79 **	0.10 ns	1.02 **	81.71 ns	-0.29 ns	1.37 *	0.86 *
G-65× A-18	-0.14 ns	-2.28 **	-0.29 ns	-0.21 ns	81.39 ns	1.18 **	-3.42 **	-1.00 **
G-65 × A-94	0.96 ns	2.50 **	0.44 *	0.13 ns	83.77 ns	-0.14 ns	2.61 **	2.72 **
G-65 × A-5	1.26 ns	-2.36 **	-0.32 ns	3.95 **	-246.55 ns	0.16 ns	5.23 **	-0.46 ns
G-65 × A-85	-2.07 **	2.14 **	0.16 ns	-3.87 **	81.39 ns	-1.20**	-4.42 **	-1.27 **
G-79 × A-18	3.10 **	0.64 ns	-0.52 **	0.63 *	87.28 ns	0.31 ns	1.68 **	-0.15 ns
G-79 × A-94	-4.89 **	-4.61 **	0.44 *	-0.12 ns	81.84 ns	-0.43 ns	3.27 **	-0.18 ns
G-79 × A-5	-3.01 **	3.00 **	0.01 ns	-2.45 **	-250.58 ns	-0.15 ns	-4.03 **	1.00 **
G-79× A-85	4.81 **	0.97 *	0.06 ns	1.94 **	81.47 ns	0.28 ns	-0.92 ns	-0.66 ns