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Combining ability studied for morphological and other quality traits of sunflower (*Helianthus annuus L.*) under line× tester fashion

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ABSTRACT

The objective of the present study was to check the improved oil contents, oil quality, and achene yield. The total number of five females' lines (PBG-101, 102,103,104, and 105) were crossed with three testers (PBG-106, 107, and 108) to produce fifteen crosses. Female lines were crossed with male testers for the production of hybrids in the first season. Then these hybrids with their parents were sown in RCBD design by using three replications in the next coming season for checking their performance. Then combining ability (GCA and SCA) of different yield contributing traits (internodal length, leaf area, number of leaves plant-1, achene yield plant-1, and quality-related traits (oil contents, oleic acid, and linoleic acid) were checked. Among the lines, PBG-103 had shown the highly considerable GCA for leaf area and significant GCA for internodal length, PBG-105 had shown the highly considerable GCA for the leaf area, oil contents, and negative considerable GCA for linoleic acid. Among the testers, PBG-105 was shown the highly considerable GCA for internodal length and oil contents. Hybrid (PBG-104 × PBG-106) had shown the highly considerable SCA effects for the number of leaves plant-1, achene yield plant-1, and oleic acid. The highly significant results were shown by the crosses (PBG-105 × PBG-108, PBG-103 × PBG-107, PBG-102 × PBG-106) for oil contents. The cross PBG-103 × PBG-106 shown highly considerable with negative SCA for linoleic acid. These hybrids would be used for the improvement of yield and other quality traits in future breeding programs.

Keywords: Helianthus *annuus* L., Combining ability, genetic variances, morphological and qualitative characters, Line× tester fashion

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INTRODUCTION

Sunflower is having a vital role in oilseed crops that belong to the Asteraceae family. In the world, it is at number two regarding edible oil production. The first time it was introduced by Spanish and then gained fame as an ornamental plant. The oil of sunflower also contains different kinds of vitamins (A, B, C, and K) and unsaturated fats. The fats which are present in sunflower oil acts as a regulator for controlling the cholesterol level in the human body. Unfortunately, Sunflower yield is very low in Pakistan as compared to other countries. Therefore, sunflower seeds imported from other countries. Sunflower oil is stable because its oil contains a low degree of hydrogenation and can be stored for a long period [1]. Inbreeding programs, at early stages, play a vital role to choose the genotypes [2]. Sunflower yield is higher than other oilseed crops. Sunflower average yield is about to the 613kg/acre [3]. That is very low than in other countries of the world. Low yield is due to the lack of local seed, lack of the proper market, lack of technology's adaptations related to agriculture the latter is the big main reason for low yield. Harvesting losses and high seed invite the disease, insect pests, weeds, and yield decreases [4]. Now the main purpose of breeding is to introduced local hybrids which are good in yield. Sunflower crop has obtained much importance at

the global and national level. It can be grown in different environmental conditions in Pakistan. The study of high yielding traits and share of these traits in seed yield is very important. Sunflower is harvested after 90 -110 days. It can be cultivated two times in a year successfully in both rainy and irrigated areas. We can check its quality by its use in frying and cooking. Edible oil which has good quality should have good resistance against high temperature, should have good oxidative stability, the minimum amount of saturated fatty acids, good color, and mild taste, rich in vitamins, minerals, and long shelf life [5]. It has a wider adjustable because of thermo and photo insensitive type of plant. The gap between supply and demand can be reduced without dependence on imports by increasing the genetic potential and by increasing the area under cultivation [6]. North America is native of genus 'Helianthus' and consists of 14, 37 annual, and perennial species respectively. The genus consists of the hexapod, tetraploid and diploid species. The first time, the sunflower was cultivated as an edible oilseed crop by North American Indians. It has written in archaeological reports. Sunflower oil used for human consumption and 10% is using as raw material for industrial purposes and manufacturing of biodiesel [7]. The development of hybrids on a commercial basis started when the male sterility gene of cytoplasm, PETI identified. The import of our country is at an extreme level related to edible oil because edible oil production is very low which is not to able to fulfill the basic requirements of increasing population. The local hybrids only fulfill the gap of yield because they were developed according to the local environment. Therefore, they can perform well. Pakistan import bill pertaining to import of edible oil was 320.893billion (US$3.063 billion) [8]. Parental inbred lines are very important for the development and selection of high yielding hybrids. The objective of the present study was to check combining ability for the development of high yielding hybrids regarding yield and other qualitative characters.

METHODOLOGY

Five sunflower accession line (PBG-101, PBG-102, PBG-103, PBG-104, PBG-105) and 3 testers (PBG-106, PBG-107, PBG108) with their 15 crosses were used as experimental material. By crossing the parental lines underline x tester fashion, the breeding material was developed during 2018 (February – June). This experimental material imported from the United State of America (USA) under the PARB (Punjab Agricultural Research Board) project. The crosses with their parental lines were sown in the field in the next coming autumn season for further evaluation from September 2018 to February 2019. The parents with their crossed seeds were planted in rows with a row to row distance 75 cm and 25 cm plant to plant distance. All the cultural and other agronomical practices were implemented evenly from sowing to harvesting. Pre- and post-harvest plant traits data were recorded. Average 5 plant data were calculated from each entry from each replication. The data obtained from F1 hybrids related to internodal length, leaf area, number of leaves plant^{-1}, Achene yield plant^{-1}, Oil contents, Oleic acid, and Linoleic acid. The qualitative characters were checked by using Near-Infrared Reflectance Spectroscopy (NIRS) to determine the differences among entries. Then further data were used to line x tester analysis for checking the effects of general and specific combining ability [9].

RESULTS

Analysis Of Variance (ANOVA)

The results of mean values of variance related to 7 understudied traits were shown in Table 1. The table showed highly considerable variations for all traits of the genotype which were understudied. The variations among the parents were shown the considerable results for under examination traits. The significant variations were also shown by the crosses except for oil contents and linoleic acid. The differences between parents and crosses were shown the highly considerable variations for all under experimental traits. The variations among the lines were also shown the significant variations except for oil and oleic acid, whereas the testers showed significant variations only for internodal length and oleic acid. The interaction of line × testers was shown the significant variations among each other except the internodal length and linoleic acid.

Combining Ability Effects General (GCA):

The hybrids with desirable characters were usually required in the breeding program. For this, there was mainly a basic need to select the GCA effects for the different lines and testers. In this experiment 8 plants were used to select the best parents. These results are shown in Table 2. The different magnitude of GCA effects was studied among the lines and testers for different characters. Among the lines, PBG-103 showed a considerable magnitude for internodal length and PBG-108 tester showed a considerable GCA for internodal length. The highly considerable GCA showed by lines (PBG-105, PBG-103) for leaf area. The lines (PBG-104) showed considerable GCA for achene yield plant-1. The line (PBG-104) showed the highly considerable GCA for oil contents and tester (PBG-108) showed considerable results for this trait. The line (PBG-105) showed the highly considerable with negative GCA results for linoleic acid.

Effects Of Specific Combining Ability (SCA)

All the SCA effects were shown in Table 3. The magnitude and direction of these crosses as shown in Table 3. All the crosses showed the non-considerable

SCA effects for the internodal length and leaf area. The hybrid (PBG-104 × PBG-106) showed a considerable SCA for the number of leaves plant^{-1}. The crossed (PBG-102 × PBG-106, PBG-103 × PBG-107, PBG-105 × PBG-108) showed the highly considerable SCA for oil contents. The crossed (PBG-103 × PBG-106) showed the considerable with negative SCA for linoleic acid.

Table 1: Mean square values from ANOVA of morphological and other characters in sunflower

	Traits							
SOV	**Df**	**IL**	**LA**	**NLP**	**AYP**	**OC**	**OA**	**LA**
Replication	2	0.48	29.50	1.92	11.14	10.59	1.78	27.93**
Genotype	22	1.05**	11329.44**	37.99**	2638.1**	38.97**	28.85**	30.83**
Crosses(C)	14	0.72*	3680.29**	9.06**	229.8**	5.89	8.25**	5.98
LINE(L)	4	1.13*	11626.27**	11.91**	336.06**	4.01	2.53	13.28*
TEST(T)	2	1.12*	89.49	0.42	73.50	5.29	10.93**	0.94
L × T	8	0.42	604.99**	9.81**	215.75**	6.99**	10.44**	3.60
Parent(P)	7	0.97**	13494.07**	7.42*	455.39**	12.54**	13.24**	17.78**
P vs C	1	6.08**	103265.22**	656.79**	5163**	687.0**	426.5**	470.02**

Df = Degree of freedom, ***** = *Significant level at 0.05* ****** = *Significant level at 0.01*
IL (internodal length), **LA** (leaf area), **NLP** (number of leaves plant^{-1}), **AYP** (achene yield plant^{-1}, **OC** (oil contents), **OA** (oleic acid), **LA** (linoleic acid)

Table 2: General combining ability (GCA) of sunflower lines and testers

Parents	**Lines**					**Testers**		
	PBG-101	**PBG-102**	**PBG-103**	**PBG-104**	**PBG-105**	**PBG-106**	**PBG-107**	**PBG-108**
IL	-0.28	-0.42 *	0.47 *	0.07	0.16	-0.21	-0.10	0.31 *
LA	1.05	-44.96 **	25.14 **	-24.80 **	43.56 **	-2.10	-0.59	2.68
NLP	-1.64 *	0.80	1.02	-0.76	0.58	-0.18	0.16	0.02
AYP (g)	-5.26 *	-1.21	-2.09	10.57 **	-2.02	-2.50	0.78	1.72
OC (%)	-0.71 **	0.08	-0.65 *	0.76 **	0.53 *	0.27	-0.68 **	0.41 *
OA	-0.48	-0.18	0.88	-0.30	0.08	-0.98 *	0.45	0.53
LA	1.70 **	0.03	0.11	-0.11	-1.73 **	0.14	0.15	-0.29

***** = *Significant level at 0.05* ****** = *Significant level at 0.01*
IL (internodal length), **LA** (leaf area), **NLP** (number of leaves plant^{-1}), **AYP** (achene yield plant^{-1}, **OC** (oil contents), **OA** (oleic acid), **LA** (linoleic acid)

Table 3: Specific combining ability (SCA) effects of 15 sunflower crosses for morphological and quality traits

Crosses	Parameters						
	IL	**LA**	**NLP**	**AYP**	**OC**	**OA**	**LA**
PBG-101 × PBG-106	0.01	15.07	-0.49	-14.80 **	0.11	-0.68	0.75
PBG-101 × PBG-107	0.06	8.48	-0.49	8.22 *	0.81	-0.02	-0.49
PBG-101 × PBG-108	-0.08	-23.54 *	0.98	6.58	-0.92 *	0.70	-0.25
PBG-102 × PBG-106	0.44	-7.08	1.07	-1.78	1.62 **	-0.78	0.35
PBG-102 × PBG-107	0.23	8.71	0.40	-3.95	-1.65 **	-1.67	0.21
PBG-102 × PBG-108	-0.67 *	-1.63	-1.47	5.73	0.03	2.44 **	-0.55
PBG-103 × PBG-106	-0.09	-3.55	-2.16 *	5.46	-0.64	-0.95	-2.05 *
PBG-103 × PBG-107	-0.16	4.64	0.84	-1.78	1.63 **	0.98	0.36
PBG-103 × PBG-108	0.24	-1.08	1.31	-3.69	-0.99 *	-0.02	1.69
PBG-104 × PBG-106	-0.26	-3.22	2.62 *	8.66 *	0.74	2.67 **	0.59
PBG-104 × PBG-107	-0.21	-10.75	-2.04	-0.78	-1.22 **	0.17	0.14
PBG-104 × PBG-108	0.47	13.97	-0.58	-7.88 *	0.49	-2.84**	-0.73
PBG-105 × PBG-106	-0.10	-1.21	-1.04	2.46	-1.83 **	-0.26	0.37
PBG-105 × PBG-107	0.06	-11.07	1.29	-1.71	0.43	0.55	-0.21
PBG-105 × PBG-108	0.04	12.28	-0.24	-0.75	1.39 **	-0.29	-0.15

***** = *Significant level at 0.05* ***** = *Significant level at 0.01*
IL (internodal length), **LA** (leaf area), **NLP** (number of leaves plant^{-1}), **AYP** (achene yield plant^{-1}, **OC** (oil contents), **OA** (oleic acid), **LA** (linoleic acid)

Genetic Variances

Variance which is due to GCA and SCA, GCA/SCA ratio, SCA variances, additive, and dominance variance for the different morphological and other qualitative traits in sunflower were shown in Table 4. The predominance of non-additive type of gene action was reported when SCA/GCA ration more than one including traits like internodal length, leaf area, achene yield plant-1, and linoleic acid. Dominant genes had more effect rather than recessive genes if SCA was higher than GCA for the expression of traits. On the other side if the GCA effect more then it showed gene action which is additive type. Several leaves, oil contents, and oleic acid were shown this ratio less than one which showed the additive type of gene action.

The proportional contribution of lines, testers, and their interactions to the total variance

Table 4 has shown the lines had a valuable role for traits

Table 4: Genetic components and proportional contribution of lines, testers and their interaction total variance

Genetic components	Parameters						
	IL	**LA**	**NLP**	**AYP**	**OC**	**OA**	**LA**
VAR OF GCA	0.0106	108.7225	-0.0262	0.4968	-0.0386	-0.0774	0.0843
VAR OF SCA	0.04	123.5833	2.2026	58.3863	2.1546	2.8123	0.5026
VAR OF SCA/ VAR OF GCA	3.77	1.13	-84.06	117.52	-55.81	-36.33	5.96
Contribution of Lines (%)	44.47	90.26	37.52	41.78	19.46	8.78	63.38
Contribution of testers (%)	21.98	0.35	0.67	4.57	12.82	18.91	2.25
Contribution of line × Testers (%)	3.553	9.39	61.81	53.65	67.72	72.31	34.37

IL (internodal length), **LA** (leaf area), **NLP** (number of leaves plant^{-1}), **AYP** (achene yield plant^{-1}, **OC** (oil contents), **OA** (oleic acid), **LA** (linoleic acid)

like internodal length (44.47), leaf area (90.26), number of leaves plant^{-1} (37.52), achene yield plant^{-1} (41.78) and linoleic acid (63.38). However, line× tester interaction was maximum for only four characters like oleic acid (72.31), oil contents (67.72%), many leaves plant^{-1} (61.81), and achene yield plant^{-1} (53.65%).

DISCUSSION

The selection of the best yielding hybrids is an only considerable way to increase the yield of Sunflower. By crossing potential female lines with males was required for the development of such kinds of hybrids. The existence of genetic variability essential for the production of high yielding hybrids. Similar results with ANOVA among the genotypes for traits that were related to yield also done by [10, 11, 12, 13, 14]. The crossed (PBG-102 × PBG-108, PBG-104 × PBG-106) showed the highly considerable SCA for oleic acid. The crossed (PBG-101 × PBG-107, PBG-104 × PBG-106) showed the considerable SCA for achene yield plant-1. A similar investigation was also done [15, 16, 17].

The characters of the plant which exhibited the considerable genetic variability required for the development of sunflower related to yield. The main involvement of dominant alleles was only confirmed by SCA variances over GCA variance. Dominance variance was having an important value which was due to the SCA effect for the development of desired hybrids. Dominance gene action which was due to the predominance was testified by SCA: GCA ratio. SCA variance which was more than GCA variance could be contributed to the non-additive type of gene action for the betterment of desired traits. SCA more than GCA then yield-related traits controlled by the non-additive type of gene action [18]. The current studied was applied to obtain a proportional contribution to the experiment related to different traits. Similar results were also reported [19].

CONCLUSION

The results from combining ability showed that Hybrid (PBG-104 × PBG-106) had shown the highly considerable SCA effects for the number of leaves plant^{-1}, achene yield plant-1, and oleic acid. The highly significant results were shown by the crosses (PBG-105 × PBG-108, PBG-103 × PBG-107, PBG-102 × PBG-106) for oil contents. The cross PBG-103 × PBG-106 shown highly considerable with negative SCA for linoleic acid. These hybrids would be used for the improvement of yield and other qualitative characters in different breeding programs.

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