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Original Research Article

GENETIC ASSESSMENT AND ESTIMATION OF COMBINING ABILITY FOR OIL AND YIELD RELATED TRAITS IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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Abstract: *Pakistan is inadequate in vegetable oil, and an enormous amount is spent on its import. This is due to the lack of local varieties of oilseed crops in the country. Sunflower (Helianthus annuus L.) is used as a supreme oilseed crop due to its higher oil content. Its hybrids are popular due to its cross-pollinated mode. The present study was conducted for the evaluation of crosses that were better in oil and yield-related traits. For this purpose, 8 parental genotypes were collected, including 5 female and 3 male parents. The subsequent Line × Tester breeding scheme crossed these parental genotypes. Fifteen crosses and eight parental lines were evaluated in Randomized Complete Block Design by using three repetitions. At maturity, data was collected for the following traits such as head diameter, time to bud formation, time to flower initiation, time to maturity, leaf area, plant height, no. of leaves per plant, no. of ray florets per head, 1000 achene weight, achene yield per plant, protein contents and oil contents. Crosses having better yield were selected. Among parents, lines 3-A, 11-A, and 23-A, while testers 79-R and 20-R were the best general combiners for head diameter, time to bud formation, time to flower initiation, time to maturity, leaf area, plant height, number of leaves/plants, 1000 achene weight, achene yield/plant and oil contents. SCA effects showed that cross combination of 12-A × 20-R, 11-A × 78-R, and 20-A × 79-R was best for time to bud formation, the number of leaves per plant, 1000 achene weight, plant height, time to flower initiation and oil contents, respectively. The information obtained from the hybrids can be used in further breeding programs.*

Keywords: Sunflower, Achene weight, Achene yield, Combining ability, Heterosis

Introduction

Sunflower is the fourth premium oilseed crop worldwide after soybean, groundnut and rapeseed (Nehru *et al.*, 2000). Its scientific name is *Heliannthus annus*, and its family name is *Asteraceae* (Panero and Funk, 2002). Its chromosome number is 2n= 34, and it is considered a highly cross-pollinated oilseed crop. The economy of Pakistan, is determined by agriculture. It contributes 19.4% to the gross domestic product. Despite this major share of agriculture in GDP, the discontinuity among consumption and demand of edible oil increases yearly (Mahmood *et al.*, 2017). During 2019-20 (July-March), total consumption of cooking oil was recorded at 3.255 million tons, out of which 0.507 million tons were locally manufactured, whereas leftover 2.85 million tons of cooking oil of price Rs 322.636 billion (US$ 2.046 billion) imported from other countries (Govt. of Pakistan, 2020). Sunflower can play their role to fulfil the gap in consumption and production of the crop for its high yield potential, an adjustment in the present cropping pattern, early maturity and drought resistance. In Pakistan, 0.219 million acres of area are under sunflower cultivation, producing 0.105 million tons of seeds and 40000 tons of edible oil. The average seed yield of a sunflower is 1.3 tons/hectare, but the sunflower has the potential to produce a yield of up to 4 tons/hectare. The less yield of sunflower is due to the non-availability of quality seeds, less research in sunflower crops, an imbalance marketing system and high prices of local hybrid seeds. The gap could be reduced by the production of new local high-yielded hybrids, by increasing the oil and seed quality and by increasing the area of seed cultivation.

Genetic variability is a vital tool for crop improvement in plant breeding (Kaya and Atakisi, 2004; Malik and Rasheed, 2022; Rasheed and Malik, 2022; Khalid and Amjad, 2019). The two principal objectives of plant breeding are selecting the desired parents for future purposes and identifying the superior lines for commercial use (Oakey *et al.*, 2006; Mehboob et al. 2020ab). Sunflower crops can be improved essentially through the information related to different types of combining ability and gene action estimation. The line × tester mating design is a common and reliable technique to study the kind of gene action and combining ability for oil and yield relevant characters (Kempthorne, 1957). This technique, lines and wide-based testers are crossed to develop hybrids. Different genetic effects, especially for quantitative trait expression, are estimated through line × tester analysis (Rashid *et al.,* 2007).

Combining ability is a successful mating design, defined as an estimate of the importance of genotypes based on their success as progeny in a reliable mating design. Keeping this in mind, the current study was conducted to comprehend the inheritance pattern of features that contribute to oil and yield and to identify more effective combining lines for successful breeding schemes in sunflower.

Materials and Methods

***Helianthus annuus* germplasm:** Eight *Helianthus annuus* accessions, including 5 CMS lines (3-A, 11-A, 12-A, 20-A and 23-A) and 3 testers (20-R, 78-R and 79-R, were used.

Hybridization of sunflower accessions

Hybridization of sunflower was performed in the field during the crop growing season in August 2019. The experimental material was crossed in line × tester fashion (3-A×20-R, 3-A×78-R, 3-A×79-R, 11-A×20-R, 11-A×78-R, 11-A×79-R, 12-A×20-R, 12-A×78-R, 12-A×79-R, 20-A×20-R, 20-A×78-R, 20-A×79-R, 23-A×20-R, 23-A×78-R, 23-A×79-R).

The layout of field experiment

In the next growing season, March 2020, the seeds of 8 parents along with crosses were sown in the field in RCBD with 3 replications keeping plant × plant and row × row spacing 25 and 75cm, respectively. Different agronomic practices were carried out from germination to maturity of the crop.

Recording of data

At maturity, data of different oil and yield-related traits were collected from 10 randomly selected plants within each replication line. Data were re-corded on head diameter (cm), time to bud formation, time to flower initiation, time to maturity, leaf area (cm^2), plant height (cm), no. of leaves per plant, no. of ray florets per head, 1000 achene weight (g), achene yield per plant (g), oil contents (%) and protein contents (%).

Statistical Analysis

All the characters under study were subjected to analysis of variance (Steel *et al.*, 1997). Data were further analyzed for general combining ability, specific combining ability, and line × tester analysis was done as narrated by Kempthorne *et al.* (1957).

Results and Discussion

Analysis of variance revealed significant genotypic variances for the characteristics under investigation, as demonstrated in Table 2. For features like head diameter, time to maturity, and the number of leaves per plant, there were significant variations in the male parents. There were significant disparities for the attribute head diameter for the female parents. All of the examined features, except head diameter and protein contents, showed highly significant changes for line tester interaction, according to Table 2. These variations show that the breeding material under investigation contains sufficient variance. Gejli *et al*. (2011) and Khan *et al.* (2019) also reported similar results for the traits studied in sunflower.

Combining ability studies

Combining ability is defined as an estimate of the importance of genotypes based on their success as progeny in a reliable mating design. General combining ability (GCA) is the average inbred value in all cross combinations, while specific combining ability (SCA) is a line value in the desired cross.

Head diameter (cm)

Lines 3-A and 11-A showed positive and significant GCA effects (0.78) followed by 12-A (0.66), while the effects of GCA were significant and negative for lines 23-A (-2.13). Among testers, a significant and positive effect of GCA was observed for 78-R (1.34), while effects of GCA were significant and negative for 20-R (-.84) and 79-R (-0.51). Among crosses, significant and negative SCA effects were observed for cross combinations 23-A × 20-R (-1.32) and 20-A × 78-R (-1.17) for head diameter. The cross combination 20-A × 20-R appeared to be as best specific combiner for head diameter, as shown in Table 3. Ghaffari and Farrokhi (2008) also reported similar results. The value of the GCA variance was more than the SCA variance, which shows the additive kind of gene action as shown in Table 5. Additive gene action type for head diameter was also observed by Tabrizi *et al*. (2012).

Time to bud formation

Significant and positive effects of GCA were found in line 20-A (2.19) followed by 23-A (1.41) among lines, and significant negative effects of GCA were observed for line 3-A (-3.36) followed by 11-A (-1.21) for time to bud formation. Among testers, 20-R exhibited positive and significant GCA effects (0.89), while negative GCA effects were observed for 79-R (-0.65) for time-to-bud formation. Line 3-A and tester 79-R proved good general combiners for time-to-bud formation, as shown in Table 3. Among crosses, highly significant and positive SCA effects were observed by a cross combination 3-A × 20-R (3.48) and 11-A × 79-R (2.88), while significant and

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positive SCA effects showed by crosses 12-A × 78-R (2.42) and 20-A × 78-R (1.13) for time to bud formation. Significant and negative SCA effects were observed by crosses 12-A × 20-R (-2.25) followed by 11-A × 78-R (-2.07) and 3-A × 78-R (-1.92) for time to bud formation. A cross combination, 12-A × 20-R, was best specific combiner for time-to-bud formation as shown in Table 4. The SCA variance value was more than the GCA variance, indicating the non-additive form of gene activity, as seen in Table 5.

Time to flower initiation

Among testers, effects of GCA that were significant and positive were found in tester 78-R (0.52), while negative effects of GCA were exhibited for tester 79-R (-0.56). Line 23-A and tester 79-R proved good general combiners for time to flower initiation, as shown in Table 3. Cross 12-A × 20-R exhibited the best specific combining ability for time-to-flower initiation, as shown in Table 2. Azad *et al.* (2016) and Iqbal *et al*. (2018) also reported similar results.

Time to maturity

Highly significant and positive GCA effects were exhibited by testers 78-R (1.03) and 20-R showed significant GCA effects (0.33), while tester 79-R showed highly significant negative GCA effects (-1.36) for time to maturity. From lines 20-A and testers, 79-R appeared to be a good general combiner for time to maturity, as shown in Table 4.3. A cross combination 3-A × 79-R showed significant and positive SCA effects (1.07), followed by cross 23-A × 78-R (1.04) and 20-A × 79-R (0.94) for time to maturity. Significant and negative SCA effects were exhibited by crosses 20-A×78-R (-1.78), 11-A × 79-R (-1.37) and 3-A × 20-R (-1.09) for time to maturity. Among crosses, 20-A × 78-R proved a good specific combiner for time to maturity, as shown in Table 4. Asif *et al.* (2013), Kang *et al.* (2013), and Imran *et al.* (2015) also reported similar findings.

Leaf area (cm^2): All testers, 20-R, 78-R and 79-R, showed the non-significant GCA effects for leaf area, which means testers are not good general combiners, as shown in Table 3. Among crosses, cross 3-A × 20-R showed significant and positive SCA effects (30.78), followed by cross 23-A × 79-R (18.48) and 12-A × 20-R (15.62) for leaf area. Significant and negative SCA effects were exhibited by crosses 11-A × 20-R (-30.93) followed by cross 3-A × 79-R (21.1) and 23-A × 78-R (19.96) for leaf area in sunflower. Cross 23-A × 78-R proved to be the best specific combiner for leaf area as shown in Table 4. Hladni *et al.* (2006) also reported the same results. The value of SCA variance was more than the GCA variance that showed the non-additive kind of gene action, as shown in Table 5 favoring heterosis breeding.

Plant height (cm)

Highly significant and positive effects of SCA were exhibited by a cross 20-A × 78-R (19.05) followed by 3-A × 79-R (16.78) and 20-A × 78-R (15.91) for plant height. Highly significant and negative SCA effects were found in cross combination 20-A × 79-R (-20.26) followed by cross 3-A × 78-R (15.43) and 23-A × 78-R (12.91) for plant height. Draft plants are required to solve the lodging problem which causes a huge loss. So, cross 20-A × 79-R proved best specific combiner plant height as shown in Table 4. Hladni *et al*. (2006), Golabadi *et al.* (2015), Imran *et al.* (2015), Saleem *et al.* (2018) and Lakshman *et al.* (2019) also reported the same results in sunflower.

The number of leaves per plant

Among lines 23-A and 11-A, while among testers 78-R and 20-R proved good general combiners for no. of leaves/plants as shown in Table 3. Among crosses, highly significant and positive SCA effects were observed for cross combination 12-A × 20-R (2.33) followed by cross 23-A × 79-R (1.53) and 11-A × 78-R (1.30) for no. of leaves/plant. Highly significant and negative SCA effects were observed for cross combination 12-A × 78-R (-2.99) followed by cross 23-A × 20-R (-2.54) and 11-A × 79-R (-1.79) no. of leaves/plant. More no. of leaves increases the rate of photosynthesis as more chlorophyll will be available, thus increasing the seed yield. So, cross 12-A × 20-R appeared to be a good specific combiner for no. of leaves/plants as shown in Table 4. Hladni *et al.* (2011), Imran *et al.* (2015), Iqbal *et al.* (2018) also reported the same results for no. of leaves per plant.

Number of ray florets per head: GCA effects regarding magnitude and direction varied for no. of ray florets/head among lines and testers. Line 12-A and 23-A showed positive and significant GCA effects (1.73 and 1.22), while the effects of GCA were significant and negative for line 3-A (1.56) for no. of ray florets/head. Among testers, the significant and positive effect of GCA was observed for 20-R (0.68), while effects of GCA were significant and negative for tester 79-R (-0.71) for no. of ray florets/head. Lines 12-A and 23-A while tester 20-R proved a good general combiner for no. of ray florets/head as shown in Table 3. Among crosses, significant and positive SCA effects were observed for cross combination 20-A × 78-R (2.81) followed by cross 11-A × 20-R (2.46) and 3-A × 79-R (2.22) for no. of ray florets/head. Significant and negative SCA effects were observed for cross combinations 11-A × 78-R (-2.97) followed by cross 20-A × 79-R (-2.24) and 3-A × 78-R (-1.39) for no. of ray florets/head. A cross 20-A × 78-R appeared to be a good specific combiner for no. of ray florets/head, as shown in Table 4.

1000 achene weight (g): Among lines, significant and positive GCA effects were observed for line 23-

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A (0.81), while significant and negative GCA effects were observed for line 12-A (-0.75) for 1000 achene weight. So, line 23-A proved a good general combiner for 1000 achene weight. All testers 20-R, 78-R and 79-R showed non-significant GCA effects for 1000 achene weight which means testers are not good general combiners, as shown in Table 3. Among crosses, highly significant and positive SCA effects were observed for cross 12-A × 20-R (3.75) followed by cross 11-A × 78-R (3.15) and 3-A × 78-R (2.37) for 1000 achene weight. Negative and highly significant SCA effects were found in crosses 12-A × 78-R (-4.67) and 11-A × 20-R (-3.16), while cross 3-A × 79-R (-2.09) showed significant results in a negative direction for 1000 achene weight. Cross 12-A × 20-R proved to be as good specific combiner for 1000-grain weight, as shown in Table 4. Karasu *et al.* (2010), Andarkhor *et al.* (2012), Depar *et al.* (2017), and Iqbal *et al.* (2018) also reported similar results for 1000-achene weight on sunflower.

Achene yield per plant (g)

Among lines, significant and positive effects of GCA were observed for line 3-A (1) followed by 11-A (0.81), while significant and negative GCA effects were observed for 12-A (-1.04) and 23-A (-0.76) for achene yield/plant. Among testers, 20-R exhibited highly significant and positive GCA effects (1.12), while significant and negative GCA effects were observed for tester 78-R (-0.78) for achene yield/plant. Among crosses, significant and positive effects of SCA were observed for cross 23-A × 20-R (2.18), followed by cross 20-A × 78-R (1.78) and 12-A × 79-R (1.37) for achene yield/plant. Significant and negative SCA effects were exhibited by cross 20-A × 20-R (-2.45) followed by cross 23-A × 79-R (1.75) and 12-A×20-R (-0.97) for achene yield/plant. Cross 23-A × 20-R exhibited as good specific combiner for achene yield/plant among crosses as shown in Table 4. Hladni *et al.* (2011), Imran *et al.* (2015), Singh *et al.* (2017), Lakshman *et al.* (2019) also reported similar findings.

Protein contents (%)

Among lines, significant and positive GCA effects were observed for line 20-A (0.69) followed by 23-A (0.41) for protein contents. Among testers, effects of GCA that were significant and positive were found in tester 79-R (0.52), while negative effects of GCA were exhibited in tester 20-R (-0.44) for protein contents. Line 20-A, 23-A and tester 79-R proved good general combiners for protein contents, as shown in Table 3. Among crosses, significant and positive SCA effects were observed for cross combination 11-A × 78-R (0.85) followed by cross 3-A × 20-R (0.82) and 20-A × 78-R (0.78) for protein contents. Significant and negative SCA effects were observed for cross combination 12-A × 78-R (-0.89) followed by cross 20-A × 20-R (-0.74) and 20-A × 79-R (-0.05) for protein contents. So, cross 11-A × 78-R appeared to be a good specific combiner for protein contents, as shown in Table 4. Depar *et al.* (2017); Saeed et al., (2020) and Iqbal *et al.* (2018) also found similar results in sunflower for protein contents.

Oil contents (%)

Significant and positive GCA effects were exhibited by line 11-A (1.41) and line 3-A (1.31), while line 23-A exhibited significant and negative GCA effects (-1.13) followed by line 12-A (-0.92) and line 20-A (-0.67) for oil contents. So, lines 11-A and 3-A proved to be a good general combiner for oil contents. All testers 20-R, 78-R and 79-R showed non-significant GCA effects for oil contents which means testers are not good general combiners, as shown in Table 3. Among crosses, highly significant and positive SCA effects were observed for cross 3-A × 78-R (3.1) followed by cross 20-A × 79-R (2) and 11-A × 20-R (1.78), which showed significant results for oil contents. Negative and significant SCA effects were found in crosses 3-A × 79-R (-2.61), 20-A × 20-R (-1.32) and 23-A × 78-R (-1.02) for oil contents. Cross 3-A × 78-R proved to be a good specific combiner for oil contents, as shown in Table 4. Chigeza *et al.* (2008), Awaad *et al.* (2016), Khan *et al.* (2019), and Lakshman *et al.* (2019) also reported similar findings. The value of SCA variance was more than the GCA variance that showed the non-additive kind of gene action, as shown in Table 5.

Conclusion

The current study aimed to evaluate the genetic relationships between the fifteen sunflower hybrids and their eight parents. The genotypes 3-A, 11-A, and 23-A while testers 79-R and 20-R were the best general combiners for head diameter, time to bud formation, time to flower initiation, time to maturity, leaf area, plant height, number of leaves/plants, 1000 achene weight, achene yield/plant and oil contents. SCA effects showed that a cross combination of 12-A × 20-R, 11-A × 78-R, and 20-A × 79-R was best for time to bud formation, the number of leaves per plant, 1000 achene weight, plant height, time to flower initiation and oil contents, respectively. Except head size, all traits exhibited dominant forms of gene activity, supporting the actuality of heterosis breeding. It has been determined that this breeding material efficiently increases sunflower achene output and oil quality. This breeding material would be utilized in future breeding efforts to meet the need for oil since it possesses sufficient genetic diversity.

Conflict of interest

The authors declared absence of conflict of interest.

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Table 1. Mean squares of oil and yield related traits in sunflower (*Helianthus annuus* L.)

SOV	Head diameter (cm)	Time to bud formation	Time to flower initiation	Time to maturity	Leaf area (cm^2)	Plant Height (cm)	No. of leaves per plant	No. of ray florets per head	1000 achene weight (g)	Achene yield per plant (g)	Protein content (%)	Oil content (%)
Replications	0.97	1.49	0.18	0.69	5.64	230.77**	1.69	4.35	5.96	2.00	0.44	3.64
Treatments	6.70**	22.67**	18.96**	7.35**	2218.77**	1086.27**	15.32**	30.77**	61.61**	132.79**	10.23**	12.93**
Parents	2.31	7.62*	13.10**	4.15**	853.59	1046.75**	12.09**	25.53**	49.45**	227.34**	1.86	6.76**
P vs C	13.34*	106.08**	231.87**	37.52**	3079.65**	1379.17**	17.13**	298.83**	756.79**	1204.17**	179.23**	85.08**
Crosses	8.42**	24.24**	6.69**	6.79**	2839.87**	1085.10**	16.81**	14.24**	18.03**	8.98**	2.34	10.86**
Lines	13.91*	46.17	9.08	3.07	6366.65	1157.56	7.04	17.80	4.23	7.47	2.90	14.06
Testers	20.73*	9.62	4.38	22.61*	121.62	2562.75	55.63*	7.22	3.00	14.73	3.55	0.73
L X T	2.60	16.93**	6.07**	4.70**	1756.04**	679.47**	11.99**	14.21**	28.69**	8.30**	1.75	11.80**
Error	1.99	2.54	1.31	1.00	367.56	42.44	0.86	3.70	3.32	1.96	1.31	2.15

Table 2. GCA effects of lines and testers for oil and yield related traits in sunflower (*Helianthus annuus* L.)

Parents	Head diameter (cm)	Time to bud formation	Time to flower initiation	Time to maturity	Leaf area (cm^2)	Plant Height (cm)	No. of leaves per plant	No. of ray florets per head	1000 achene weight (g)	Achene yield per plant (g)	Protein content (%)	Oil content (%)
Lines												
3-A	0.78*	-3.36 **	1.22 **	-0.14	-20.23 *	0.57	-0.23 *	-1.56 *	0.53	1 *	-0.38	1.31 *
11-A	0.78*	-1.21 *	0.28	0.17	-7.59	-13.63 **	0.66 **	-0.78	0.02	0.81 *	-0.7	1.41 *
12-A	0.66*	0.97 *	0.53 *	0.86 *	-5.94	-0.74	-0.19	1.73 *	-0.75 *	-1.04 *	-0.03	-0.92 *
20-A	-0.09	2.19 **	-1.27 **	-0.74 *	-12.76 *	17.68 **	-1.25 **	-0.62	-0.62	-0.01	0.69 *	-0.67 *
23-A	-2.13 **	1.41 *	-0.76 *	-0.16	46.52 **	-3.89 *	1.02 **	1.22 *	0.81 *	-0.76 *	0.41 *	-1.13 *
S.E. (GCA of Lines)	0.47	0.54	0.34	0.37	7.62	2.35	0.22	0.76	0.62	0.52	0.38	0.55

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Testers												
20-R	-0.84 **	0.89 *	0.03	0.33 *	2.36	-13.12 **	0.73 **	0.68 *	-0.01	1.12 **	-0.44 *	0.25
78-R	1.34**	-0.24	0.52 *	1.03 **	0.81	0.1	1.45 **	0.04	0.45	-0.78 *	-0.08	-0.15
79-R	-0.51 **	-0.65 *	-0.56 *	-1.36 **	-3.16	13.02 **	-2.18 **	-0.71 *	-0.44	-0.34	0.52 *	-0.1
S.E. (GCA of Testers)	0.36	0.42	0.26	0.29	5.9	1.82	0.17	0.59	0.48	0.40	0.29	0.42

Table 3. SCA effects of lines and testers for oil and yield related traits in sunflower (*Helianthus annuus* L.)

Crosses	Head diameter (cm)	Time to bud formation	Time to flower initiation	Time to maturity	Leaf area (cm2)	Plant Height (cm)	No. of leaves per plant	No. of ray florets per head	1000 achene weight (g)	Achene yield per plant (g)	Protein content (%)	Oil content (%)
3-A×20-R	0.18	3.48 **	-1.23 *	-1.09 *	30.78 *	-1.35	0.58 *	-0.83	-0.29	0.33	0.82 *	-0.5
3-A×78-R	0.06	-1.92 *	-0.39	0.02	-9.68	-15.43 **	0.26	-1.39 *	2.37 **	-0.41	-0.63	3.1 **
3-A×79-R	-0.24	-1.57 *	1.62 *	1.07 *	-21.1 *	16.78 **	-0.84 **	2.22 *	-2.09 *	0.08	-0.2	-2.61 *
11-A×20-R	0.14	-0.8	1.30 *	0.6	-30.93 *	-1.42	0.49 *	2.46 *	-3.16 **	0.91 *	-0.64	1.78 *
11-A×78-R	-0.04	-2.07 *	-0.12	0.77 *	16.55 *	-1.34	1.30 **	-2.97 *	3.15 **	-0.54	0.85 *	-0.66
11-A×79-R	-0.1	2.88 **	-1.18 *	-1.37 *	14.39 *	2.77	-1.79 **	0.51	0.01	-0.37	-0.21	-1.11 *
12-A×20-R	-0.31	-2.25 *	-1.74 **	0.58	15.62 *	-9.78 *	2.33 **	-0.39	3.75 **	-0.97 *	0.46	0.36
12-A×78-R	0.78	2.42 *	0.90 *	-0.05	2.44	10.64 *	-2.99 **	0.79	-4.67 **	-0.4	-0.89 *	-0.74
12-A×79-R	-0.47	-0.17	0.84 *	-0.53	-18.06 *	-0.94	0.65 *	-0.4	0.91	1.37 *	0.43	0.38
20-A×20-R	1.31 *	-0.07	1.39 *	0.84 *	-16.96 *	1.21	-0.87 *	-0.56	-1.7 *	-2.45 *	-0.74 *	-1.32 *
20-A×78-R	-1.17 *	1.13 *	0.03	-1.78 *	10.66	19.05 **	0.41 *	2.81 *	-0.28	1.78 *	0.78 *	-0.68
20-A×79-R	-0.15	-1.06 8	-1.42 *	0.94 *	6.3	-20.26 **	0.45 *	-2.24 *	1.98 *	0.68	-0.05 *	2 *
23-A×20-R	-1.32 *	-0.36	0.28	-0.93 *	1.49	11.26 **	-2.54 **	-0.68	1.39 *	2.18 *	0.1	-0.31
23-A×78-R	0.37	0.44	-0.41	1.04 *	-19.96 *	-12.91 **	1.01 *	0.76	-0.58	-0.43	-0.12	-1.02 *
23-A×79-R	0.95 *	-0.08	0.13	-0.11	18.48 *	1.65	1.53 **	-0.09	-0.82	-1.75 *	0.02	1.33 *
S.E. (SCA)	0.82	0.94	0.59	0.65	13.2	4.06	0.38	1.31	1.07	0.89	0.65	0.95

References

Andarkhor, S. A., Mastibege, N., & Rameeh, V. (2012). Combining ability of agronomic traits in Sunflower (Helianthus annuus L.) using line X tester analysis. *International Journal of Biology* **4**, 89.

Asif, M., Shadakshari, Y., Naik, S., Venkatesha, S., Vijayakumar, K., & Basavaprabhu, K. (2013). Combining ability studies for seed yield and it's contributing traits in sunflower (Helianthus annuus L.). *International Journal of Plant Sciences* **8**, 19-24.

Awaad, H., Salem, A., Ali, M., & Kamal, K. (2016). Expression of heterosis, gene action and relationship among morpho-physiological and yield characters in sunflower under different levels of water supply. *Journal of Plant Production* **7**, 1523-1534.

Azad, K., Shabbir, G., Khan, M., Mahmood, T., Shah, Z., Alghabari, F., & Daur, I. (2016). Combining ability analysis and gene action studies of different quantitative traits in sunflower by line x tester. *Crop Res* **51**, 1-4.

Chigeza, G., Mashingaidze, K., & Shanahan, P. (2014). Advanced cycle pedigree breeding in sunflower. II: combining ability for oil yield and its components. *Euphytica* **195**, 183-195.

Depar, S., Baloch, M., Kumbhar, M., & Chachar, Q. (2017). Heterotic performance of F1 hybrids for phenological, yield, oil and protein traits of sunflower. *Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences* **33**, 12-22.

Gejli, K., Shanker, G. I., & Boraiah, K. (2011). Studies on the combining ability of dwarf restorer lines in sunflower (Helianthus annuus L.). *Helia* **34**, 89-98.

Ghaffari, M., & Farrokhi, K. (2008). Principal component analysis as a reflector of combining abilities. Proceedings of the 17th International Sunflower Conference, Cordoba, Spain,

Golabadi, M., Golkar, P., & Shahsavari, M. R. (2015). Genetic analysis of agro-morphological traits in promising hybrids of sunflower (Helianthus annuus L.). *Acta Agriculturae Slovenica* **105**, 249-260.

Govt. of Pakistan. (2020). Pakistan Economic Survey, Ministry of Finance, Economic Advisor's Wing, Islamabad.

Hladni, N., Terzić, S., Mikličč, V., Jocić, S., Kraljević-Balalić, M., & Škorić, D. (2011). Gene effect, combining ability and heterosis in sunflower morphophysiological traits. *Helia* **34**, 101-114.

Imran, M., Saif-ul-Malook, S. A., Nawaz, M. A., Ahabaz, M., Asif, M., & Ali, Q. (2015). Combining ability analysis for yield related traits in sunflower (Helianthus annuus L.). *American-Eurasian J. Agric. & Environ. Sci* **15**, 424-436.

Iqbal, Q., Safdar, A., Tahir, M. N., Shafique, O., Khan, B. A., Ijaz, A., & Khan, I. (2018). Assessment of different exotic sunflower hybrids for their agro-ecological adaptability. *Pakistan Journal of Agricultural Research* **31**.

Kang, S., Khan, F., Ahsan, M., Chatha, W., & Frasat, S. (2013). Estimation of combining ability for the development of hybrid genotypes in Helianthus annuus L. *Journal of Biology, Agriculture and Healthcare* **3**, 68-74.

Karasu, A., Mehmet, O., Sincik, M., Goksoy, A. T., & Turan, Z. M. (2010). Combining ability and heterosis for yield and yield components in sunflower. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* **38**, 259-264.

Kaya, Y., & Atakisi, I. K. (2004). Combining ability analysis of some yield characters of sunflower (helianthus annuus l.)/análisis de aptitud combinatoria de algunas características de rendimiento de girasol (Helianthus annuus L.). *Helia* **27**, 75-84.

Kempthorne, O., (1957). Introduction to Genetic Statistics. John Wiley and Sons, Inc. New York.

Khalid, M., & Amjad, I. (2019). Combining ability and heterosis studies in upland cotton (*Gossypium hirsutum* L.). *Bulletin of Biological and Allied Sciences Research*, ***2019***(1), 20. https://doi.org/10.54112/bbasr.v2019i1.20

Khan, I. U., Arshad, M., Khan, M. A., Ashraf, M., Saleem, A., Awan, S., Azam, S., & Shah, S. U. S. (2019). Heterosis expression analysis and its impact on different agro-morphological characters in sunflower (H. Annuus L.) hybrids. *Pakistan Journal of Agricultural Research* **32**, 325.

Lakshman, S., Chakrabarty, N., & Kole, P. (2019). Study on the combining ability and gene action in sunflower through line x tester matting design. *Electronic Journal of Plant Breeding* **10**, 816-826.

Malik, A., & Rasheed, M. (2022). An overview of breeding for drought stress tolerance in cotton. *Bulletin of Biological and Allied Sciences Research*, ***2022***(1), 22. https://doi.org/10.54112/bbasr.v2022i1.22

Mehboob, S., Kashif, M., Khalid, M., & Amjad, I. (2020a). Association study of assorted yield linked components in wheat crosses by involving exotic genotypes. *Bulletin of Biological and Allied Sciences*

Research, ***2020***(1), 18. https://doi.org/10.54112/bbasr.v2020i1.18

Mehboob, S., Kashif, M., Khalid, M., & Amjad, I. (2020b). Genetic diversity assay of the local wheat varieties and chinese crosses for yield linked attributes under local conditions. *Bulletin of Biological and Allied Sciences Research*, ***2020***(1), 19. https://doi.org/10.54112/bbasr.v2020i1.19

Nehru, S., Manjunath, A., & Basavarajaiah, D. (2000). Extent of heterosis for seed yield and oil content in sunflower. *Karnataka Journal of Agricultural Sciences* **13**, 718-720.

Oakey, H., Verbyla, A., Pitchford, W., Cullis, B., & Kuchel, H. (2006). Joint modeling of additive and non-additive genetic line effects in single field trials. *Theoretical and Applied Genetics* **113**, 809-819.

Panero, J., & Funk, V. A. (2002). Toward a phylogenetic subfamilial classification for the Compositae (Asteraceae). *Proceedings of the Biological society of Washington*.

Rashid, M., Cheema, A. A., & Ashraf, M. (2007). Line x tester analysis in basmati rice. *Pakistan Journal of Botany* **39**, 2035-2042.

Rasheed, M., & Malik, A. (2022). Mechanism of drought stress tolerance in wheat. *Bulletin of Biological and Allied Sciences Research*, ***2022***(1), 23. https://doi.org/10.54112/bbasr.v2022i1.23

Saeed, M., Khalid, M., & Amjad, I. (2020). A jaunt through sunflower: from its origin to the different breeding approaches for its improvement. *Bulletin of Biological and Allied Sciences Research*, ***2020***(1), 17. https://doi.org/10.54112/bbasr.v2020i1.17

Saleem, U., Khan, M., Gull, S., Usman, K., Saleem, F., & Siyal, O. (2018). Line× tester analysis of yield and yield related attributes in different sunflower genotypes. *Pakistan Journal of Botany* **46**, 659-665.

Singh, U., & Kumar, D. (2017). Development and identification of heterotic hybrid combinations in sunflower (Helianthus annuus L.). *Journal of Genetics Genomics and Plant Breeding* **1**, 36-48.

Steel, R. G. D., J. H. Torrie. and D. A. Dickey. 1997. Principles and Procedures of Statistics: A Biometrical Approach (2nd ed). McGraw Hill Book Co. Inc., Singapore. 172-177.

Tabrizi, M., Hassanzadeh, F., Moghaddam, M., Alavikia, S., Aharizad, S., & Ghaffari, M. (2012). Combining ability and gene action in sunflower using Line* Tester method. *Journal of Plant Physiology and Breeding* **2**, 35-44.

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