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Exploiting heterosis and combining ability of sunflower at seedling stage

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Sunflower is a non-traditional crop used for edible purpose. It is mainly used as edible oil crop in Russia and Europe. It is fourth biggest edible source after soybean in world and second after rapeseed in Europe. Pakistan is also fulfilling its 18% oil's demand after cotton. Exploiting heterosis and combining ability of yield and oil content of sunflower will increase the oil percentage in crop. Experiment was performed in Department of Plant Breeding and Genetics and Centre of Agricultural Biochemistry and Biotechnology (CABB), University of Agriculture, Faisalabad. The data was taken for seven seedling traits viz, seedling germination percentage (%), root length (cm), shoot length (cm), fresh root weight (g), fresh shoot weight (g), dry root weight (g) and dry shoot weight (g). Sixteen hybrids grown in line x tester manner and were evaluated for seedling traits. Objective of this study was to evaluate the seedling traits and exploit heterosis, GCA and SCA of given genotypes for using them in better hybrid seed development. Results showed that lines and testers showed positive GCA effect for shoot length, root length and root fresh weight while hybrids have negative SCA effect for all the traits. Cross B-SIN-82 × RL-54 showed significant positive heterosis for seed germination percentage and root dry weight. Cross B-SIN-82 × RL-51 also showed significant positive heterosis for root length while all other crosses showed non-significant heterosis and heterobeltiosis for all the seedling traits. So, twoB-SIN-82 × RL-54 andB-SIN-82 × RL-51 crosses were used in hybrid development for improving seed germination percentage, root dry weight and root length of the hybrid.

Keywords: Heterosis (Het), Heterobeltiosis (Hetbl), Combining ability

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a non-traditional crop. It is an oilseed crop used for edible purpose. It is used as edible oil mainly in Russia and other European countries for last many years. Production of sunflower has risen many times due to its cultivation in different parts of world from last 25 to 30 years. Sunflower is fourth biggest source of edible oil after soybean worldwide and second edible oil source of Europe after rapeseed. Pakistan is fulfilling its needs of vegetable oil from the sunflower after the cotton seed. (Arshad *et al*. 2010)

For the last few years, the yield improvement in sunflower varieties has not been substantial, and narrow genetic base of the germplasm used, has been considered the major reason in the development of an ideally higher yielding local hybrid. Knowledge of diversity patterns allows the plant breeders better understand the evolutionary relationships among accessions and

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is essential aspect in plant breeding.

Sunflower being a rich source of good quality edible oil and has a nice fit in Pakistan's cropping pattern, is visualized as the most potential crop to narrow the gap between the total requirements and the domestic production of edible oil in the country. This could help saving the huge amount of foreign exchange that is being incurred on importing edible oil annually. Sunflower as an oil seed crop was introduced in Pakistan during 1960's as a non-conventional oil seed crop. Hybrids are preferred by sunflower growers in many countries in the world due to high yield performance, uniformity and quality (Kaya, 2003). The soil and climatic conditions of the Pakistan are highly favorable for sunflower. Unfortunately, in Pakistan, there is no local hybrid available for cultivation by the farmers for higher oil production. In addition, the imported hybrid sunflower seed is not completely acclimatized. Further, this very expensive imported seed does not give the desired oil yield. Therefore, development of local hybrid is the dire need of the day. Correct selection of parents of sunflower hybrids is important for achieving high yield performance in breeding programs. Superior hybrids have been obtained by crossing inbred female and restorer lines with high GCA and SCA values. Hybrid breeding is successful only if enough variation exists in the gene pool, male sterility mechanism is available, proper restorer and maintainer genes are available, and heterosis is very well manifested.

Heterosis is way to improve the crop production and quality in order to fulfill the need of increasing human population in our country. Sunflower is a crop in which heterosis has been much exploited for the better seed and oil yield. For developing hybrid heterosis is first trait that needs attention of breeders. General (GCA) and specific combining ability (SCA) are second important traits for hybrid development. Due to high heterosis occurring generally in hybrids between genetically unrelated inbred lines, all crop breeders that use heterosis have the challenge to find good combiners. Inbred lines having high positive general combing ability (GCA) and specific combing ability (SCA) are used in sunflower hybrid development. In hybrid breeding programme plant breeders are using and crossing these inbred lines to obtain superior hybrids so that they obtain hybrids having high oil and yield potential and resistance to pests and diseases (Miller and Fick, 1997).Hybrids genetically are uniform, more vigorous, self-fertile and resistant to important foliar diseases (Seetharam, 1975).

MATERIALS AND METHODS

The material was composed of four cytoplasmic male sterile lines (CMS) viz.,CM-612, HA-27, B-SIN-82, HA-314 and four sterility restorer male parents/testers viz., RL 54, RL 51, R SIN 82, RL 46. The experiment was conducted in the Department of Plant Breeding and Genetics and Centre of Agricultural Biochemistry and Biotechnology (CABB), University of Agriculture, Faisalabad during the year 2014-2016.Seven seedling traits viz., seedling germination percentage (%), root length (cm), shoot length (cm), fresh root weight (g), fresh shoot weight (g), dry root weight (g) and dry shoot weight (g) were measured..

Combining abilities were estimated following Kempthrone (1975).Percent heterosis over mid parent and better parent (Heterobeltiosis) was computed after calculating heterosis on respective parents using formulae based on the amount of heterosis, expressed as the difference between F_1 and the mid parent values, proposed by Falconer and Mackay (1996) for heterosis.

Mid parent heterosis (MPH) = 100 * (F_1 – MP) / MP
Better parent heterosis (BPH) = 100 * (F_1 – BP) / BP
MP = [Female parent (♀) + Male parent (♂)] / 2
A t-test was applied to test the significance of heterosis over mid and better parents as under:
$t_{(Static)}$ for heterosis= $(F_1 – MP) / (3/8\ \sigma^2 E)^{1/2}$
$t_{(Static)}$ for heterobeltiosis = $(F_1 – BP) / (1/2\ \sigma^2 E)^{1/2}$

RESULTS AND DISCUSSIONS

The GCA effects of lines and testers for seedling traits are presented in Table 1. Lines and testers showed positive GCA effects for shoot length, root length and root fresh weight. Earlier researchers Turkec *et al.,* (2006), Kaya *et al.,* (2004), Mayor *et al.,* (2006) also showed positive GCA effects.

The variable magnitude and direction of SCA effects between the hybrids is presented in Table 2**.** Hybrids showed negative SCA effects for all the seedling traits like Kandhola *et al.,* (1995) and Ashok *et al.,* (2000) found negative SCA effects for germination in sunflower.

Variance due to GCA (σ^2_{GCA}) and SCA (σ^2_{SCA}), ratio of SCA to GCA variances ($\sigma^2_{SCA}/\sigma^2_{GCA}$), additive variance ($\sigma^2_A$), dominance variance ($\sigma^2_D$), and degree of dominance $(\sigma^2_{D/}\ \sigma^2_A)^{1/2}$ for investigated traits in this study in sunflower genotypes are presented in Table 3 Pre-dominance of non-additive gene action was reflected through greater SCA:GCA ratio than one for seed germination percentage, shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight. Genetically, it is thought that heterosis is the result of accumulation of dominant or partial dominant genes (alleles) Popov *et al.,* (1965), Gundaev, (1966). It means one of the parent contribute beneficial alleles at the some loci while the other parent provide the desirable alleles at the remaining loci. A second type of the heterosis is that, in the cross of two morphologically different plants, the loci controlling the morphologies are partially to completely dominant and each effects yield positively, then the morphologically different contribution of each parent in the hybrid may create high yielding progeny by combining morphologies Ahire *et al.,* (1994) and Kandhola *et al.,* (1995).

Table 1: General combining ability (GCA) effects of lines and testers for various seedling traits.

Lines	SGP	SL	RL	SFW	RFW	SDW	RDW
CM 612	4.81	0.01	0.06	0.02	-0.02	-0.04	0.01
HA-27	-0.27	0.15	0.25	-0.02	0.02	-0.04	0.02
B-SIN-82	3.97	0.38	0.07	0.09	0.01	-0.06	-0.12
HA-314	-8.52	-0.54	-0.38	-0.02	0.011	0.15	-0.06
Testers							
RL 54	-2.27	0.08	-0.26	-0.06	0.09	-0.04	0.01
RL 51	5.31	-0.01	0.30	-0.02	0.01	-0.04	-0.05
R-SIN-82	-1.52	0.11	0.33	0.08	-0.17	0.02	-0.01
RL-46	-1.52	-0.19	-0.37	0.05	-0.01	0.06	0.02

Table 2: Specific combining ability (SCA) effects for various seedling traits

Hybrids	SGP	SL	RL	SFW	RFW	SDW	RDW
CM-612 × RL-54	3.60	-0.40	-0.05	-0.01	0.01	0.05	0.11
CM-612 × RL-51	-7.64	0.19	-0.57	-0.05	-0.03	0.03	0.06
CM-612 × R-SIN-82	7.85	1.36	1.44	0.05	0.02	-0.03	-0.02
CM-612 × RL-46	-3.81	-1.16	-0.81	0.01	-0.01	-0.05	0.01
HA-27 × RL-54	-10.97	-0.34	-0.51	-0.05	-0.01	0.06	0.03
HA-27 × RL-51	-0.56	-1.37	-0.07	0.11	-0.01	0.03	-0.02
HA-27 × R-SIN-82	-1.72	0.68	-0.21	-0.04	0.01	-0.01	0.03
HA-27 × RL-46	13.27	1.03	0.79	-0.02	0.06	-0.08	-0.04
B-SIN-82 × RL-54	10.77	0.62	0.57	-0.04	0.01	0.02	0.01
B-SIN-82 × RL-51	12.18	1.48	0.44	0.04	0.01	0.03	0.02
B-SIN-82 × R-SIN-82	-10.97	-2.54	-0.32	-0.01	-0.01	-0.02	-0.01
B-SIN-82 × RL-46	-11.97	0.43	-0.68	0.05	-0.01	-0.04	-0.02
HA-314 × RL-54	-3.39	0.12	-0.05	0.11	-0.01	-0.15	-0.02
HA-314 × RL-51	-3.97	-0.31	0.20	-0.10	0.02	-0.10	-0.02
HA-314 × R-SIN-82	4.85	0.48	-0.90	-0.04	-0.05	0.06	0.03
HA-314 × RL-46	2.52	-0.30	0.70	-0.00	0.01	0.18	0.01
Standard Error	4.99	0.53	0.31	0.04	0.01	0.07	0.01

Table 3: Estimates of variance due to GCA(σ^2_{GCA}), SCA (σ^2_{SCA}), additive (σ^2_A), dominance (σ^2_D), ratio of SCA to GCA ($\sigma^2_{SCA}/\sigma^2_{GCA}$) and degree of dominance (σ^2_D/σ^2_A)$^{1/2}$

Traits	Genetic Components							
	σ^2_{GCA}= {(1+F) /4} σ^2_A	(a) with F=0, σ^2_A	(b) with F=1, σ^2_A	σ^2_{SCA}= {(1+F) /2}^{2} σ^2_D	(a)with F=0, σ^2_D	(b)withF=1, σ^2_D	σ^2_{SCA}/ σ^2_{GCA}	(σ^2_D/σ^2_A)^{½}
SGP	14.12	56.49	14.12	179.69	359.37	89.84	12.72	2.52
SL	-0.19	-0.76	-0.19	3.14	6.27	1.56	-16.50	2.87
RL	0.02	0.08	0.02	1.24	2.48	0.62	62.00	5.57
SFW	0.00	0.01	0.01	0.02	0.03	0.01	6.00	1.73
RFW	0.00	0.01	0.01	-0.01	-0.01	-0.01	-2.00	1.00
SDW	0.01	0.02	0.01	0.01	0.02	0.01	2.00	1.00
RDW	0.00	0.01	3.50	0.01	0.01	0.01	2.00	1.00

Table 4: Heterosis and Heterobeltiosis for Seedling traits.

Hybrids	SGP (%age)		SL (cm)		RL (cm)		SRW (cm)		RFW (cm)		SDW (cm)		RDW (cm)	
	Het	Hetbl	Het	Hetbl	Het	Hetbl	Het	Hetbl	Het	Hetbl	Het	Hetbl	Het	Hetbl
CM-612 × RL-54	11.16	8.64	9.75	-14.61	-41.42*	-50.70*	22.07	19.27	120.69	64.10	47.06	42.86	61.54	23.53
CM-612 × RL-51	11.22	8.57	11.71	-6.18	-38.26	-50.00	5.44	3.72	122.22	71.43	2.50	-12.77	30.77	0.00
CM-612 × R-SIN-82	18.14	15.45	20.47	15.73	7.69	-6.34	42.65	39.90	123.08	75.76	5.00	-10.64	-78.95	-80.95
CM-612 × RL-46	1.86	-0.45	-31.05	-32.02	-64.37	-69.01	-6.21	-15.44	68.97	25.64	33.33	23.08	56.25	47.06
HA-27 × RL-54	-16.28	-18.18	16.61	-8.14	-22.50	-36.08	5.64	-5.50	116.13	71.79	25.93	10.87	73.33	23.81
HA-27 × RL-51	14.15	11.43	-15.36	-27.91	21.85	4.55	4.39	-6.05	151.72	108.57	-13.98	-14.89	0.00	-28.57
HA-27 × R-SIN-82	-2.33	-4.55	13.10	10.47	5.95	-15.24	40.32	30.50	157.14	118.18	3.23	2.13	-28.57	-28.57
HA-27 × RL-46	18.60	15.91	10.72	10.40	16.67	-6.67	18.33	-1.54	106.45	64.10	-10.59	-17.39	16.67	0.00
B-SIN-82 × RL-54	22.86*	17.27	59.02	33.79	24.48	-8.25	5.85	-0.46	129.41	100.00	-17.24	-30.77	92.00*	50.00
B-SIN-82 × RL-51	42.50	42.50	63.16	49.66	52.24*	15.91	38.08	30.70	137.50	117.14	-23.23	-26.92	76.00	37.50
B-SIN-82 × R-SIN-82	-7.14	-11.36	-35.28	-39.02	5.96	-23.81	10.71	8.50	106.45	93.94	-17.17	-21.15	-56.76	-61.90
B-SIN-82 × RL-46	-8.57	-12.73	13.21	4.05	-36.42	-54.29	9.53	-4.63	79.41	56.41	1.10	-11.54	-35.48	-37.50
HA-314 × RL-54	-22.61	-25.83	15.71	-6.79	-32.56	-40.21	-15.57	-21.12	83.33	69.23	5.88	-10.00	-4.35	-21.43
HA-314 × RL-51	-9.55	-17.08	-4.59	-16.67	-0.61	-7.95	-3.86	-10.76	111.76	105.71	21.65	18.00	-56.52	-64.29
HA-314 × R-SIN-82	-10.87	-14.58	0.00	-0.61	-45.56	-53.33	27.72	14.74	100.00	100.00	168.04	160.00	20.00	0.00
HA-314 × RL-46	-13.91	-17.50	-22.39	-24.86	-15.56	-27.62	-2.35	-3.86	86.11	71.79	302.25	258.00	44.83	40.00

Heterosis and heterobeltiosis for seedling traits are given in Table 4**.**The cross B-SIN-82 × RL-54 showed significant positive heterosis for seed germination percentage and root dry weight. Cross B-SIN-82 × RL-51 also showed significant positive heterosis for root length only. Khan (2004) also found positive heterosis for different characters.

CONCLUSION

It is concluded that given lines and testers can be used as general combiners in hybrid development for traits i.e shoot length, root length and root fresh weight. Cross B-SIN-82 × RL-54 can be used in hybrid development and improving hybrid performance against traits i.e seed germination percentage and root dry weight. Moreover, only cross B-SIN-82 × RL-51 showing hybrid vigour against root length trait.

RECOMMENDATIONS

It is recommended that lines and testers will be used as good general combiner to develop hybrid with increase seed yield. Combination of lines and testers will give us better hybrid with improved seedling traits. These lines and testers can give hybrid with better yield in Pakistan.

REFERENCES

Ahire NR, BB Pawar and AD Dumbre (1994). Heterosis and inbreeding depression in sunflower. J. Maharashtra Agri. Univ. 19(2): 183-187.

Arshad M, MA Khan, SA Jadoon and AS Mohamad (2010). Factor Analysis in Sunflower (*Helianthus Annus* L.) to investigate desirable hybrids. Pak. J. Bot., 42(6): 4393-4402, 2010.

Ashok S, SN Muhammad and SL Narayanan (2000). Combining ability studies in sunflower (*Helianthus annuus* L.). Crop. Res. Hiser 20(3): 457-462.

Gundaev AI (1966). The manifestation of heterotic effect in sunflower and obtaining of hybrid seeds on basis of male sterility. In: “Geterozis v rastenievodstve” Leningrad (in Russian). pp. 358-367.

Kandhola SS, RK Behl and MS Punia (1995). Heterosis in sunflower. Annals of Biology (Ludhiana). 11(1/2): 98-102.

Kaya Y and IK Atakisi (2004). Combining ability analysis of some yield characters of sunflower (Helianthus annuus L.). Helia 27: 75-84.

Kempthorne O (1957). An Introduction to genetic statistics.John Wiley and Sons, Inc. New York, USA pp 468-473.

Khan H (2004). Magnitude of heterosis and combining ability in sunflower over environment. NWFP Agri. Uni. Faculty of crop prod. Sciences.

Mayor M, LG Nestares, R Zorzoli and LA Picardi (2006). Analysis for combining ability in sunflower organogenesis-related traits. Aus. J. Agric. Res., **57**: 1123-1129.

Popov A, M Lazarov, M Spirova and Y Stoyanova (1965). On the problems in obtaining hybrid seeds in sunflowers (in Bulgarian). IzdatelstvonaBugarskataAkademianaNaukite.Sofia.

Sheetharam AP, K Kumari and NM Patil (1975). Performance of hybrid sunflower produced by mean of cytoplasmic male sterility. Sabro, J 9(1): 51-55.

Turkec A and AT Goksoy (2006). Identification of inbred lines with superior combining ability for hybrid sunflower (Helianthus annuus L.). NZ. J. Crop Horti. Sci. **34**: 7-10