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THE POSSIBILITY OF COMBINING EARLINESS WITH HIGH SEED YIELD IN F1 GENERATION OF SESAME (*Sesamum Indicum L.*)

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Abstract

Diallel analysis has participated towards improving many crops as sesame. Thus, six parents were crossed in a half diallel mating to produce 15 F1s crosses (without reciprocal) at Agricultural Experiment and Research Station, Faculty Agriculture, Cairo University, Egypt in 2016 season. In 2017 season, genotypes (parents and 15 F1s crosses) were grown in randomize complete block design with five replications. The combining ability analysis was carried out using Griffing's method 4 fixed Model 1. The aim of this study was accomplished to develop serviceable genetic variability and would be of great importance in the selection of desirable lines possess earliness and high potential yield in the subsequence segregating generations. The results expressed that two crosses, P3 X P4, P3 X P5 had better seed yield plant-1 than their parents. Fourth parent was a good combiner for earliness, stem height to 1st capsule, 1000-seed weight, harvest index and seed yield plant^{-1}. One cross (P_3 X P_4) showed high significant negative SCA effects for days to maturity and showed high significant positive SCA effects for 1000-seed weight and seed yield plant^{-1}. Therefore, selection index which contains earliness and seed yield components will be apply in mulit - locations and years would be effective to develop of sesame lines that have earliness and high seed yield in the subsequence generations.

Keywords : breeding sesame, mating systems, general combining ability ,specific combining ability, transgressive segregation.

Introduction

Sesame (Sesamum indicum L.) is an important ancient oil-yielding crop cultivated for seed and high quality oil (Suh et al.2003). Sesame seed contains a high oil content (60%<) with unsaturated fatty acids (80%<), 20% proteins, vitamins and minerals, a large amount of lignans (sesamin, sesamol, sesamolin and tocopherols (Dar and Arumugam 2013, Onsaard 2012 and Dar et al.,2015). Egypt is facing acute shortage of edible oil. Demand of edible oil is increasing with population growth but production of edible oil is decreasing yearly. Sesame is one of the most suitable oil crops to resolve this problem. The sesame, by virtue of its earliest, confirmed well intercropping systems (Karande et al.,2018). It is often grown under different conditions few other crops can survive, requiring very few inputs. The cultivated area in Egypt is limited, in addition to the limited irrigation water, so the opportunity to extend sesame cultivation is limited. The development of early and high-yielding sesame varieties makes intercropping a convenient way to increase the sesame area. Moreover, the average productivity in Egypt is stagnant (Shabana et al., 2014 and Muhamad and Sedeck, 2015). Hybridization has been used to seed yield components improve and earliness in sesame then selection in segregating generations. Seed yield is polygenic trait and one of the most important, affected by many components therefore; analyzing various traits correlated to seed yield, as well as the selection of genetically proper parents in crosses are the important steps to achieve success in breeding programs. For this purpose, diallel method was used extensively to parent's selection in order to initiate the hybridization program to create variability for various traits to select the desired new lines in the next generations. It also supply with acquaintance about the nature and magnitude of the gene action controlled in the inheritance of characters (Ljubicic et al.,2017).Griffing (1956) proclaimed that diallel crosses in expression of breeding value of the cross (*i, j*) where the aggregate of general combining abilities (GCA) for the two parents and called main effects. Similarly, specific combining ability (SCA) represents the dominance deviation value with neglect epistatic deviation and called an interaction. Rahimi et al.(2008) pointed that method 4 without parents is better than method 2 due to biased estimated of the GCA and SCA variances as well as the method 4 is less cost and abridge time and is an usable. This study was accomplished to develop serviceable genetic variability and would be of great importance in the selection of desirable lines possess earliness and high potential yield in the subsequence segregating generations. Thus, general (GCA) and specific combining ability (SCA) of 6 parents of sesame and their progenies will be estimated for provides important information of inheritance of earliness and seed yield components in F1 generation.

Material and Method

Breeding materials used in this study were comprised of six genotypes of sesame which used to estimate general combining ability (GCA) and specific combining ability (SCA) in F1 generation. Characteristic lineaments of six selected parents are presented in Table 1.

Experimental procedure and Experimental design: In 2016 season, the crossing program was carried out using parents by hand emasculation and pollination as described by Yermanos (1980) at Agricultural Experiment and Research. Station of Cairo University, Egypt. Fifteen crosses (F1s) were obtained from a half diallel mating design without reciprocal. In 2017 season, the complete set of six parents and their progenies crosses were grown on May 17. Genotypes were planted in two rows 2 m long with 60 cm of inter-row spacing and 10 cm spacing between plants in the row. The trial was assessed in a randomized complete block design, with five replications. Thinning was done after appearing three pairs of leaves to secure 2 plants/hill. Recommended agronomic practices of Ministry of Agric. And Land Reclamation, in Egypt for sesame production was applied at proper time during the two seasons.Data were recorded for ten guarded plants for both parents and F1 s in each plot at the stage of final maturity to study the following characters: Days to maturity (DM) , plant height cm (PH), stem height to the 1st capsule cm (SHC), fruiting zone length cm (FZL), number of capsules/ plant (NC), 1000-seed weight g (SW), harvest index % (HI) and seed yield /plant g (SY). Data were subjected to the thorough analysis of variance of randomized complete block design for parents, crosses and crosses vs parents comparison. Data were computed using the computer program MSTAT-C (1991).Combining ability effects were calculated according to method 4 (without reciprocal) (only F1′s) and mathematical model 1 (fixed effect for parents) of Griffing (1956).

Table 1: Characteristic lineaments of six selected parents

G.	Status breeding	Seed provenance	Main description characters
C1.5	F8-population	Cairo University	Early maturing,branching, first capsule set low, 3 capsules/ leaf axel and heavy seed weight and higher oil% (55 <.)
C2.2	F8-	Cairo University	Medium maturity , first capsule set low and 3 capsules/ leaf axel.
C3.8	F8-population	Cairo University	Branching, first capsule set low, 3 capsules/ leaf axel and drought tolerant and tolerance to welting disease.
C6.5	F8- population	Cairo University	Early maturing,branching, first capsule set low, 3 capsules/ leaf axel and high resistant fungi diseases.
So.	-	Ministry of Agric. And Land Reclamation, Egypt	3 capsules/ leaf axel creamy color, dehiscent shattering and tolerance to welting disease.
Sh.	-	Ministry of Agric. And Land	Medium tall, non-branched, white seed, long capsule, 3 capsules/aix

G: genotypes, So: Sohag commercial cultivar, Sh: Shandaweel commercial cultivar

Results and Discussion

Analysis of variance:

Mean square values for parents, crosses and crosses vs parents were estimated for scrutinized characters for judging the significance of genotypic differences. Mean squares showed substantially significant differences (p <0.05) among sesame genotypes comprehensive parents and their offspring, F1 generation, for in all traits studied (Table 2). It was clear that parents selected were variable, and the amount of variation in hybrids was created for all traits studied. Mean squares for crosses vs. parent's comparison were significant for all studied traits indicated that the heterotic effect was candid (Hoballah et al., 2009). The results manifested that entity of appropriate variability among parents and their progenies in F1 for studied traits. Comparable results recorded by Muhammad and Sedeck (2015) Ghada and Ghareeb (2018) and Karande et al.,(2018).

Average performance of genotypes

The mean performance of parents and their progenies for studied traits showed in Table 3.

Two parents,P_5 and P_6 ,were expressed the highest seed yield plant^{-1} (52 and 53.6 g) followed by P_3 (51.0 g) against the lowest seed yield plant^{-1} expressed by P_2 (39.0 g) and this was expected because P_2 expressed the lowest days to maturity (99.0 days) followed by P_1 (108.0 days).The crosses combinations based on overall mean were taller, longer fruiting zone length, more capsules/plant, heavier 1000-seed weight, more harvest index and seed yield plant^{-1} than their parents as well as the crosses combinations were earlier than their parents in contrast the parents showed lower stem height to 1st capsule. The cross combination P_1 X P_6 was earlier than their parents and other crosses. One of the most important objectives of the study is to develop early lines in order to increase the cultivated area of sesame using intercropping. Moreover, Paroda (2013) claimed earliness trait is more important in sesame to adapt to climate change. The cross combination P_2 X P_5 was heavier 1000-seed weight than their parents and other crosses. The crosses combinations, P_1 X P_2, P_1 X P_6 , P_2 X P_4, P_2 X P_6 and P_3 X P_6 were higher harvest index than their parents and other crosses. Two cross combinations, P_3 X P_4 and P_3 X P_5, were expressed the highest seed yield/ plant (70.6 and 79.0 g) while two cross combination, P_2 X P_3 and P_1 X P_3 expressed the lowest seed yield plant^{-1}(52.0 and 52.4 g).Many researchers (Muhamad and Sedeck 2015, Tripathy *et al.*, 2016 and Karande *et al.*,2018) found similar results.

Table 2: Mean squares of ANOVA for parents, crosses and crosses vs parents for studied traits.

S.V.	D.F.	DM	PH(cm)	SHC (cm)	FZL(cm)	NC	SW (g)	HI	SY(g)
Block	4	84.2^{NS}	551.7^{NS}	33.2**	452.7^{NS}	4115.0^{NS}	0.00^{NS} 7	0.012^{NS}	170.7^{NS}
Genotypes	20	429.2**	3102.3**	1341.2**	1362.3**	3128.5**	0.98**	0.016**	442.8**
Error	80	49.8	277.2	150.7	372.5	1498.1	0.03	0.007	187.3
Parents	5	346.2**	257.2**	150.6**	150.4**	1139.3**	0.42**	0.007**	259.3**
Error	20	17.2	60	19.8	30	148	0.04	0.002	68
crosses	14	1270.1**	974.0**	851.2**	1847.2**	2094.0**	0.7**	0.019**	292.3**
Error	64	13.1	225.8	186.3	810.3	1498	0.04	0.005	92.3
C *vs* P	1	6.1**	25.9**	3.1**	15.4**	32.4**	0.51**	0.02**	9.6**
Error	4	0.01	0.49	0.89	0.03	1.2	0.006	0.002	0.42

SV: source of variation, D.F.: degree of freedom, MSe: Mean square. DM: day to maturity, PH: plant height (cm), SHC: stem height to 1st capsule, FZL: fruiting zone length, NC: number of capsules /plant, SW: 1000-seed weight, HI: harvest index, SY: seed yield/ plant, NS: Non-significant, **: significant (P < 0.05).

Table 3: Mean performance of 6 parents and 15 F_1s for studied traits

Parents	DM	PH	SHC(cm)	FZL(cm)	NC	SW(g)	HI	SY(g)
P_1	108.0	170.0	51.8	110.6	200.0	3.7	0.3	42.8
P_2	99.0	177.4	62.4	102.2	190.0	3.3	0.2	39.0
P_3	111.0	186.2	48.6	114.0	225.0	3.2	0.2	51.0
P_4	123.6	165.0	50.2	110.0	215.0	3.6	0.3	48.8
P_5	140.0	180.4	64.8	115.8	230.0	4.0	0.2	52.0
P_6	135.0	188.0	53.4	120.6	220.0	3.7	0.2	53.6
$\overline{X}$	119.433	177.3	54.9	112.2	213.3	3.6	0.3	47.9
Crosses								
P_1 XP_2	124.4	214.0	43.6	170.4	252.0	4.1	0.4	55.0
P_1 XP_3	130.0	232.6	90.2	142.4	230.0	4.0	0.3	52.4
P_1 XP_4	132.0	221.2	83.8	137.4	258.0	4.0	0.3	55.8
P_1 XP_5	88.0	202.6	60.0	142.6	253.0	4.2	0.3	64.8
P_1 XP_6	83.8	211.4	54.0	157.4	271.0	3.1	0.4	61.4
P_2 XP_3	128.0	195.0	58.0	137.0	256.0	4.2	0.3	52.0
P_2 XP_4	120.0	186.0	59.0	127.0	238.0	4.0	0.4	58.8
P_2 XP_5	115.8	195.0	66.8	128.2	244.0	4.3	0.3	63.8
P_2 XP_6	112.0	192.8	45.4	147.4	258.6	4.2	0.4	65.0
P_3 XP_4	117.6	217.6	61.6	156.0	275.0	3.8	0.3	70.6
P_3 XP_5	122.0	267.6	108.6	159.0	296.6	4.0	0.3	79.0
P_3 XP_6	107.0	203.2	70.4	132.8	268.0	3.8	0.4	57.2
P_4 XP_5	112.0	192.6	67.6	125.0	254.0	4.2	0.3	61.6
P_4 XP_6	117.0	206.8	73.6	133.2	259.2	4.0	0.3	68.2
P_5 XP_6	117.6	161.8	56.8	105.0	272.0	4.2	0.2	70.0
$\overline{X}$	115.1	206.7	66.6	140.1	258.3	4.0	0.3	62.2
SD	13.8	23.8	17.1	16.4	16.2	0.3	0.1	7.5

DM: day to maturity, PH: plant height (cm), SHC: stem height to 1st capsule, FZL: fruiting zone length, NC: number of capsules /plant, SW: 1000-seed weight, HI: harvest index SY: seed yield/ plant, $\overline{X}$: overall mean, SD: Stander deviation.

Combining ability analysis:

For the genetic improvement of the sesame, combining ability analysis has been applied to determine the nature of gene action for studying traits to identify superior combining parents. The analysis of variance of combining ability was made for parents and their progenies in the F1 generation (Table 4). The mean squares value due to GCA and SCA were highly significant for all studied traits. The mean square for the GCA was higher than SCA for all the studied traits except stem height to 1st capsule and fruiting zone length.However, non-additive gene action played the main role for studied traits proclaimed by GCA/SCA ration, less than unity indicated that non-additive gene effects and more than unity indicated that additive gene effects (Solanki et al.,2006). Pathirana (1999) found that genetic variance was due to additive gene action for plant height and number of capsules/plant while Muhamad and Sedeck (2015) found that genetic variance was due to non- additive gene action for day to maturity, stem height to 1st capsule, fruiting zone length and 1000-seed weight.However, additive gene effects were important as demonstrated by the significant variance in the GCA of all studied traits. In this case, breeding procedure which can enhance genetic recombination and also help increase of favorable genes in the next generation may prove most effective in improving seed yield components and earliness (Pawar and Monpara 2016).

Table 4: Combining ability analysis of 6 X 6 diallel crosses of sesame for eight traits in F1 generation (Griffing's model I Method 2).

S.V.	D.F.	DM	PH (cm)	SHC(cm)	FZL(cm)	NC	SW (g)	HI	SY(g)
GCA	5	1865.8**	1682.6**	636.0**	1166.6**	3531.7**	1.1**	0.02**	650.6**
SCA	15	939.9**	581.6.5**	971.2**	2225.2**	1296.3**	0.45**	0.01**	320.0**
Error	80	13.1	225.8	186.3	810.3	149.8	0.04	0.005	32.3
GCA/2 (GCA)+ SCA		0.4	0.43	0.28	0.26	0.42	0.42	0.4	0.4

DM: day to maturity, PH: plant height (cm), SHC: stem height to 1^{st} capsule, FZL: fruiting zone length, NC: number of capsules/plant, SW: 1000-seed weight, HI: harvest index and SY: seed yield/plant. GCA: general combining ability, SCA: specific combining ability, D.F.: degree of freedom, MSe: Mean square, NS: Non-significant; **: significant at P < 0.05%

General Combining Ability Effects: In general, GCA effects of parents are expressed additive effects that can be passed on to the later generations (Kang 1994). Estimates of GCA effects for parents for each trait were expounded in Table 5. High positive values would be of interest for seed yield components in contrast, day to maturity and stem height to 1^{st} capsule where the reverse situation is desirable may be useful from the breeder standpoint. None of the parents showed GCA effects for all studied traits (Pandey *et al.*,2018). Three parents (P_3, P_4 and P_5) were good combiners for earliness indicated by significant negative value of GCA effect. Two parents, P_4 and P_5, were good combiners for seed yield/plant indicated by significant positive value of GCA effect. P_4 achieved the highest significant positive values of GAC effects for traits, 1000-seed weight (0.14), harvest index (0.02) and seed yield/plant (5.3) and achieved high significant negative values of GCA effects values for day to maturity (-6.1) and stem height to 1^{st} capsule (-7.3). This may be due to the discovery of more genes with additive effects or interaction effects of additive × additive which are facilely transmissible to following generation. Two parents, P_4

and P_5, were considered to be the best parents for possible of combination between earliness with high harvest index and high potential yield because they exhibited the highest positive values of GCA effects. Moreover, it noted that two parents showed that higher mean values of seed yield components. Therefore, direct selection for these traits in the next generations would be efficacious. P_6 showed that significant positive value of GCA effect for seed yield/ plant only while P_1 was the poorest GCA effect for most studied traits. Thus, it was proposed to use both P_4 and P_5 as parents in a numerous crossing program may be segregating lines combined between earliness and high yielding.

Table 5: Valuation GCA effects of six parents for eight characters in sesame

Parents	DM	PH (cm)	SHC (cm)	FZL (cm)	NC	SW(g)	HI	SY (g)
P_1	6.0**	-15.4**	1.8	3.8	-26.8**	-0.33**	-0.05	-9.7**
P_2	12.6**	12.5**	9.7**	-13.4**	3.1	0.09**	-0.01	-3.0
P_3	-11.1**	-2.1	-1.0	7.3	4.6	-0.17**	0.008	-0.21
P_4	-6.1**	-1.3	-7.3**	0.08	5.6	0.14**	0.02**	5.3**
P_5	-8.1**	3.1	-1.1	5.6	4.4	-0.07**	0.05**	3.4**
P_6	6.6**	3.1	-2.0	-3.1	8.9	0.03	-0.01	4.1**
S.E. (gi)	0.74	3.0	2.7	5.8	6.2	0.04	0.15	2.0
SE (gi -gj)	1.14	4.7	4.3	9.0	9.7	0.06	0.02	3.2

DM: day to maturity, PH: plant height (cm), SHC: stem height to 1st capsule, FZL: fruiting zone length, NC: number of capsules /plant, SW: 1000-seed weight, HI: harvest index SY: seed yield/ plant, S.E: Stander error.
**: Highly significant at P < 0.05% level. , P_1: C1.5 P_2: C2.2 P_3: C3.8, P_4: C6.5, P_5: Sohag, P_6:Shandweel.

Table 6 . Valuation of specific combining ability effects of 15 F_1 crosses for eight studied traits in sesame

Cross	DM	PH (cm)	SHC(cm)	FZL(cm)	NC	SW (g)	HI	SY(g)
P_1 XP_2	18.3**	-13.4**	-13.1**	-17.3**	18.6**	0.09	0.06	1.2
P_1 XP_3	7.0**	3.1	8.2**	21.6**	-22.9**	-0.02	-0.01	-5.3**
P_1 XP_4	0.55	5.8	-3.2	1.0	2.1	-0.41**	-0.02	1.0
P_1 XP_5	3.2**	-0.27	-2.4	-9.6	2.3	0.17**	-0.009	0.11
P_1 XP_6	7.4**	4.7	10.7**	4.3	-0.15	0.16**	-0.01	3.0
P_2 XP_3	13.6**	-14.3**	-4.7	25.9**	16.9**	-0.04	-0.03	2.6
P_2 XP_4	6.5**	5.2	-12.2**	21.8**	8.1	0.04	-0.05	-1.7
P_2 XP_5	5.2**	15.7**	20.4**	7.2	-12.6	0.15**	-0.008	-2.4
P_2 XP_6	-7.1**	6.7	9.7**	6.0	2.8	-0.25**	0.008	0.31
P_3 XP_4	-15.9**	2.9	4.1	-16.6**	4.6	0.40**	0.02	5.2**
P_3 XP_5	-16.4**	4.8	2.1	-3.1	25.1**	-0.50**	0.006	3.7
P_3 XP_6	11.6**	3.4	-10.8**	-27.7**	9.3	0.16**	-0.05	-6.2**
P_4 XP_5	14.3**	-9.7**	0.51	12.8	-9.1	0.10	0.006	-4.4
P_4 XP_6	-5.5**	-4.3	10.8**	24.6**	-5.6	-0.14**	0.06	-0.09
P_5 XP_6	-6.4**	-10.6**	-21.0**	-7.2	-6.4	0.06	-0.01	3.3
SE (Sij - Sik)	1.98	8.2	7.4	15.5	16.8	0.11	0.039	5.0
SE (Sij - Ski)	1.62	6.7	6.1	12.7	13.7	0.09	0. 32	4.3

DM: day to maturity, PH: plant height (cm), SHC: stem height to 1st capsule, FZL: fruiting zone length, NC: number of capsules /plant, SW: 1000-seed weight, HI: harvest index, SY: seed yield/ plant,SE : Stander error. **: significant at $P < 5\%$

Specific combining ability effects:

Specific combining ability effects (represent dominance and epistasis) of 15 F1 progenies are presented in Table 6. Significant positive and negative SCA effects were noted for most studied traits. Highly significant negative SCA effects for the sake of earliness were observed for five crosses namely; P2 X P6, P3 X P4, P3 X P5, P4 X P6 and P5 X P6.Mean performance of crosses were superior to their parents for seed yield components specially, number of capsules /plant (main component of seed yield). However, they were not early.None of the crosses showed a good combiner for all studied traits. The highest significant negative SCA effects of earliess noticed for two crosses, P3 x P5 and P3 x P4,.The type of GCA effects for these crosses were obtained from parents classified as good general combiner for earliness (high X high general combiner). The P3 was commonly found in these crosses as female and was classified as a good combiner for day to maturity. Concerning seed yield/ plant, one cross (P3 X P4) showed significant positive SCA effect and this cross showed highly significant negative SCA effects for earliness, indicating that possibility of amalgamate both earliness and high yield as well as it showed highly significant positive SCA effect for 1000-seed weight. And not gave significant negative SCA effects for yield components. This cross was obtained from type of GCA effects (low X high general combiner). The P3 was a poor general combiner for seed yield/ plant while P4 was a good general combiner for day to maturity, stem height to 1st capsule, 1000-seed weight, harvest index and seed yield/ plant. Suggesting that parents with high or low values of GCA effects may not always provide highly valuable crosses with high value of SCA effects (Kohan and Heidari 2014 and Pandey et al., (2018) pointed for this. The values of SCA effect elucidated the dominance and epistatic interactions. The higher positive value of SCA effect do not commonly participate in sesame crop (self-pollinated) improvement. Istipliler et al., (2015) pronounced that SCA is usually used for cross pollinated species, but SCA effects may be also profitable for self pollinated species for transgressive segregation. Selection in a population depends on additive variance, it could be used in crosses which obtained from parents with high value of GCA effects because the GCA effects is based on additive variance. Therefore, cross (P3 X P4) involving one parent with low and other with high GCA effects for seed yield could be utilized for isolating distinctive lines through delayed selection in subsequent generations (Tripathy et al.,2016 and Raikwar 2018).

Conclusion

It can concluded that, the mean performance of crosses combinations were higher than their parents for all studied traits expect stem height to 1th capsule. Non-additive gene action played the main role for all studied traits. Three parents P4, P5 and P6 were good combiners for earliness and P4 was a good combiner for seed yield components. This parent could be used in other hybridization program for combine between earliness with high yield in sesame. Cross combination (P3 X P4) showed significant positive SCA effects for seed yield /plant and showed highly significant negative SCA effects for earliness, indicating that possibility of amalgamate both earliness and high seed yield. Finally, selection index of traits related to seed yield components with earliness would be effective in the next generations in multi-locations and multi-years to segregate high potential yield varieties with earliness.

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