Original Research Article

Genetic analysis for yield, its components, and protein and oil contents in diallel crosses of soybean

ABSTRACT

The study was conducted at Sakha Research Station, ARC, Egypt, during three successive seasons from 2021 to 2023. A half diallel cross of fifteen $F_1$and F_2 generations in addition to the six parental soybean genotypes namely, Japanese 13, Giza 111, Crawford, $H_{18}L_{54}$, Nc92-2231 and Linfordwere evaluated to determine the genetic behavior of yield and its components,as well as seed contents of protein and oilin F_1.Results indicated that mean squares of general combining ability (GCA) and specific combining ability (SCA) were significant and highly significant for all the studied characters of soybean genotypes in F_1's and F_2's, except SCA for 100-seed weight in F_2's only. The GCA/SCA ratios were less than unity in all traits, indicating that, the non-additive gene effects seemed to be responsible for the inheritance of these traits. The parental genotypes; $H_{18}L_{54}$, Nc 92-2231 and Linfordseemed to be excellent combiners for days to flowering and maturity; however, Giza 111 and Japanese 13 were good combiners for seed yield. Meanwhile, Giza 111 was a goodcombiner for protein and oil content; also,$H_{18}L_{54}$ and Nc 92-2231 were good combiners for protein content.The crosses C7, C9, C10, C11 and C13 were earlier for maturity date, and also showed the most negative significant desirable Ŝij effects.The best (Ŝij) values in F_2were shown in the C1, C5, C8 and C15 crosses for seed yield/plant, these crosses also had the highest seed yield values in F_2.The crosses (C5 and C8) showed significant to highly significant positive heterotic effects relative to the better parent for protein% and seed yield per plant.In addition three crosses (C13, C14, and C15) had highly significant positive heterotic effects relative to the better parent for oil% and seed yield per plant.

Key words: Soybean, combining ability, heterotsis, earliness, yield, protein%, oil%.

INTRODUCTION

Soybean is a versatile crop that is valuable not only for its oil and protein content but also for its nutritional benefits. The total production was over 353.46 million tons in 2020 harvested from 126.95 million hectares worldwide. In Egypt, the total harvested area in 2020 was 17000 hectares with a total production of 50000 tons **[1].** Soybean is a major player in the global edible oil and high protein meal markets, making significant contributions to human and animal nutrition. The high protein meal derived from soybean is widely used in poultry and human food production due to its rich nutrient profile. With its high oil content and essential nutrients, soybean is a valuable commodity that plays a crucial role in the food industry worldwide.

Soybean cultivation in Egypt faces challenges such as water scarcity, pests and diseases, as well as fluctuating market prices. However, efforts are being made to increase soybean production through research and extension programs to improve cultivation practices and develop new varieties that are better adapted to local conditions. Additionally, government support and incentives for soybean farmers are being provided to promote the crop's cultivation and increase its contribution to the agricultural sector in Egypt.

Soybean breeders aim to enhance soybean productivity by understanding the inheritance of key agronomic traits such as earliness and yield. This knowledge is crucial for developing improved soybean varieties that can meet the growing demand for this important crop. The objectives of this study could be defined as the production of high-yield genotypes and improving seed quality characters.

MATERIALS AND METHODS

The experiment was conducted at Sakha Agricultural Research Station, ARC, Egypt, during the three successive seasons from 2021 to 2023. Six parental soybean genotypes, namely Giza 111, Crawford, Japanese 13, H18L54, Nc92-2231 and Linford were used, as shown in Table 1. The choice of these parents was based on genetic diversity, differences in growth habits, and variations in yielding ability.

In the 2021 season, the parents were sown on three sowing dates to ensure synchronization of flowering periods for parental genotypes. Once flowering began, the crosses were made manually. All possible parental combinations (half diallel) excluding reciprocals were made among the six genotypes to produce fifteen F_1 crosses.

Table 1: Names, pedigree, origin, maturitygroup and growth habit of the parental soybean genotypes used in this investigation.

Parents	Pedigree	Original	Maturitygroup	Growth habit
P1 (Japanese 13)	**Introduced from Japan**	**Japan**	**II**	**Determinate**
P2 (Giza 111)	**Crawford x Celest**	**Egypt**	**III**	**Indeterminate**
P3 (Crawford)	**Williams x Columbus**	**USA**	**IV**	**Indeterminate**
P4 ($H_{18}L_{54}$)	**Crawford x Dekabig**	**Egypt**	**IV**	**Indeterminate**
P5 (Nc 92-2231)	**Introduced from USA**	**USA**	**IV**	**Indeterminate**
P6 (Linford)	**Williams82 x Fayette**	**USA**	**III**	**Indeterminate**

Duringthe 2022 season, the six parental genotypes were rehybridized to produce F_1seeds and the F_1 plants were sown to produce F_2seeds. In the 2023 season, seeds of the six parents and their F_1'sand F_2's were sown in three replications. The experimental plot consisted of one ridge for each parent,five ridges for F_1 andten ridges for F_2 generations, in addition to two border rows. The wet sowing method called Herati was used.Cultural practices were applied as usually recommended for ordinary soybean production.

The data were recorded on 30 plants for both parental genotypes and their F_1 and 300 F_2guarded individual plants, which were labeled for different genotypes on the following characters:days to flowering, days to maturity, plant height, number of branches per plant, number of pods per plant, 100-seed weight (g) and seed yield per plant (g).

The standard germination test was carried out according to the international testing rules**[2].** The germination percentage was determined on four replicates of 50 seeds for each seed sample placed in petri dishes containing filter paper soaked with distilled water. The petri dishes were then placed in an incubator at 25±1^{o}C for 8 days, and normal seedlings were counted. The Electrical Conductivity (EC) of leaches from four replicates of 50 seeds weighed (g) and soaked in 250 ml of distilled water for 24 hours, was measured. The mean values were expressed in µs $cm^{-1}g^{-1}$ seed weight using a conductivity meter, following the international rules **[2]**. Seed protein (%) and oil contents (%) were determined according to the procedures outlined by **AOAC [3].**

The data were analyzed on a plot mean basis. An ordinary analysis of variance was firstly performed for parents and their hybrids F_1 and F_2 diallel according to **Snedecor and Cochran [4]**.

Heterosis as proposed **by Mather and Jinks [5]** was determined as the deviation of the F_1 means from better parent (BP). The average heterosis value for each trait was computed for parents vs. F_1 and F_2 hybrids. In the procedure, genotypes were subdivided into their components (parents, crosses and parents vs. crosses). General and specific combining ability estimates were obtained using **Griffing's [6]**diallel cross analysis designated as method 2 model 1.GCA/SCA ratio was calculated as follows:

GCA/SCA ratio= Ms_{gca}- $(Ms_{error}/p)/Ms_{sca}$- Ms_{error}
Where: Ms_{gca} is the mean square of GCA
$Ms_{sca}$is the mean square of SCA
Ms_{error} is the mean square of error and P is the number of parents

RESULTS AND DISCUSSION

Tested of significance of F_1 as well as F_2 studied traits (Tables 2, 3 and 4) indicated that the mean squares of entries were highly significant for all studied traits. As the entries are partitioned into; parents, crosses and their interaction,the results pointed out that mean squares of parents as well as crosses were highly significant for all traits, except for 100-seed weight where it was not significant. The mean squares of parents vs. crosses as an indication to average heterosis overall crosses seems to be significant for all traits, except for days to flowering in both generations, plant height, No.of branches/plant and 100-seed weight in both generations and No. of pods/plant in F_2 generation where the differences did not reach the level of significance.

However, it appeared that, the magnitudes of the mean squares of entries or any of its components were several times larger than their corresponding mean square of error. The sizable magnitudes of entries mean square indicated the presence of considerable differences between their entries, and therefore, it became statistically valid for the required diversity for the success of the planned crosses.

It could be concluded from the results listed in Tables 2,3, and 4 that the ratio of GCA/SCA mean squares exceeded unity for all traits, except for No. of branches/plant and No. of pods/plant in the F1 and seed yield per plant in both generations. These could be indicated that, the studied traits were controlled in their inheritance by additive genes, while for the excepted traits, the non- additive genes were responsible to the inheritance of the traits in view. Also, it could be indicated that both additive and non-additive genes were involved in the inheritance of all traits in different proportions where GCA and SCA mean squares were highly significance. Similar result for significant general and specific combining ability variances were reported by **El-Hosary et al [7], Yassien and Abd El-Mohsen [8], Mansour [9], Mansour et al [10], Fayiz [11], Waly [12], Waly and Ibrahim [13], and El-Seidy et al [14].**

Table 2: Mean squares for ordinary and combining ability analysis fordays to flowering, days to maturity, plant height and number of branches per plant characters associated with F_1 and F_2 soybean diallel crosses.

SOV	df	Days to flowering	Days to maturity	Plant height	Number of branches per

									plant
		F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Reps	2	9.87**	1.76	26.56**	0.73	58.26	5.6	1.8	0.43
Entry	20	188.75**	141.05**	343.56**	733.54**	1024.82**	760.77**	14.96**	10.85**
Parents (P)	5	132.06**	149.17**	534.41**	792.99**	1982.48**	2458.06**	28.71*	29.16**
Crosses (C)	14	222.22**	141.6**	291.2**	526.61**	651.62**	208.84**	9.37**	4.62**
P vs C	1	3.69	92.82	122.36*	3333.26**	1461.31	1.41	24.42	6.59
Error	40	1.7	1.35	2.25	1.88	27.08	33.66	1.77	1.09
GCA	5	71.82**	70.06**	259.44**	590.49**	488.63**	462.71**	2.76**	5.95**
SCA	15	59.95**	39.34**	66.22**	129.19**	292.6**	183.89**	5.73**	2.84**
Error	40	0.57	0.45	0.75	0.63	9.03	11.22	0.09	0.36
GCA/SCA		1.21	1.80	3.96	2.26	2.08	2.67	0.52	2.73

* and **refer to significance at 0.05 and 0.01 levels of probability, respectively.

Table 3: Mean squares for ordinary and combining ability analysis for number of pods per plant, 100-seed weight and seed yield per plant characters associated with F_1 and F_2 soybean diallel crosses.

SOV	df	Number of pods per plant		100-seed weight		Seed yield per plant	
		F_1	F_2	F_1	F_2	F_1	F_2
Reps	2	1392.68	170.56	1.59	6.26	165.73	111.72
Entry	20	28018.16**	10999.87**	16.23**	16.15**	10393.2**	1605.67**
Parents (P)	5	20036.4**	20293.61**	10.83*	15.09**	2493.43**	1386.4**
Crosses (C)	14	12591.73**	7940.48**	18.5**	17.53	9972.34**	1588.95**
P vs C	1	283897.05**	7362.69	11.31	2.18	55784**	2936.07*
Error	40	1256.84	832.34	1.61	6.27	356.78	118.48
GCA	5	2492.22**	7110.02**	10.75**	12.25**	455.72**	405.45**
SCA	15	11621.78**	2518.83**	3.63**	3.09	4467.29**	578.48**
Error	40	418.95	277.45	0.54	0.09	118.93	39.49
GCA/SCA		0.216	3.15	3.22	4.08	0.10	0.57

* and **refer to significance at 0.05 and 0.01 levels of probability, respectively.

Table 4: Mean squares for ordinary and combining ability analysis for Germination%, EC,Protein % and Oil %characters associated with F_1 and F_2 soybean diallel crosses.

SOV	df	Germination %	EC	Protein %	Oil %
Reps	2	1.25	0.05	4.76	0.3
Entry	20	118.83**	7.76**	183.21**	13.33**
Parents (P)	5	72.99**	3.61**	277.85**	8.14**
Crosses (C)	14	141.37**	9.5**	138.17**	16.03**
P vs C	1	32.46*	4.09**	340.52*	1.53*
Error	40	0.9	0.02	7.1	0.27
GCA	5	59.65**	4.51**	84.94**	0.67**
SCA	15	32.93**	1.94**	53.11**	5.7**
Error	40	0.3	2.33	2.37	0.09
GCA/SCA		1.99	0.82	1.66	0.12

* and **refer to significance at 0.05 and 0.01 levels of probability, respectively.

The Mean performance of the sixsoybean genotypes and their F_1 and F_2 for days to flowering, days to maturity, plant height and number of branches per plant are presented in Table 5.

The parental genotypes Linford was the earliest parent for days to flowering and maturity dates in both generations. Also, C13 ($H_{18}L_{54}$ x Nc 92-2231) in F_1 and F_2 generations was the earliest cross among all crosses in flowering and maturity dates, followed by C9 (Giza 111 x Linford). On the other hand, P_1 (Japanese 13) was the latest parent, also C1 (Japanese 13 x Giza 111), C2 (Japanese 13 x Crawford), C3 (Japanese 13 x $H_{18}L_{54}$) and C4 (Japanese 13 x Nc 92-2231) showed the latest crosses in F_1's for flowering and for C4 and C2 for maturity date since recorded 125.95 and 131.20 days, respectively.

Table 5: Mean performance of the sixsoybean genotypes, F_1 crosses and their F_2 generations for days to flowering, days to maturity, plant height and number of branches per plant characters.

Genotypes	Days to flowering		Days to maturity		Plant height		Number of branches per plant	
	F1	F2	F1	F2	F1	F2	F1	F2
P1 (Japanese 13)	51.30	53.81	133.15	149.39	62.50	58.33	4.76	6.00
P2 (Giza 111)	46.17	43.39	126.00	132.00	130.04	136.67	11.07	11.00
P3 (Crawford)	42.01	43.22	117.29	128.39	111.67	110.00	4.67	4.33
P4 ($H_{18}L_{54}$)	38.46	36.83	102.33	114.51	105.00	108.33	2.00	3.67
P5 (Nc 92-2231)	37.46	36.61	114.57	117.75	135.00	136.67	7.67	10.67
P6 (Linford)	32.75	34.80	98.42	102.45	108.33	108.33	6.33	7.00
Hybrids								
C1 (Japanese 13 x Giza 111)	41.38	38.15	122.25	130.65	91.94	110.28	8.36	6.45
C2 (Japanese 13 x Crawford)	38.11	39.17	121.42	131.20	115.00	118.30	6.32	5.84
C3 (Japanese 13 x H $H_{18}L_{54}$)	42.46	37.68	122.21	108.45	138.01	116.10	5.99	6.27
C4 (Japanese 13 x Nc 92-2231)	37.70	48.75	125.92	124.84	118.00	94.01	6.58	3.89
C5 (Japanese 13 x Linford)	37.07	29.39	111.33	106.44	126.29	111.39	8.52	5.42
C6 (Giza 111 x Crawford)	56.01	51.00	102.50	116.64	134.08	116.38	5.88	6.53
C7 (Giza 111 x H $H_{18}L_{54}$)	36.33	46.34	98.29	93.97	122.07	115.28	7.00	6.31
C8 (Giza 111 x Nc 92-2231)	55.47	48.93	123.48	113.76	141.85	123.83	6.29	8.37
C9 (Giza 111 x Linford)	28.99	30.85	101.96	95.09	114.33	107.84	5.43	4.76
C10 (Crawford x $H_{18}L_{54}$)	53.67	33.61	102.54	95.27	125.22	96.92	10.35	7.23
C11 (Crawford x Nc 92-2231)	36.47	34.30	114.04	95.57	112.76	105.30	8.29	6.90
C12 (Crawford x Linford)	43.34	36.36	116.53	112.49	87.47	108.68	6.04	6.12
C13 ($H_{18}L_{54}$ x Nc92-2231)	26.91	32.35	98.57	94.88	123.88	99.01	6.21	5.72
C14 ($H_{18}L_{54}$ x Linford)	41.26	36.81	116.54	97.16	119.76	104.72	10.78	7.58
C15 (Nc 92-2231 x Linford)	37.15	37.67	105.57	103.29	120.61	112.83	9.85	8.52
LSD0.05	2.15	1.92	2.24	4.09	13.65	8.74	4.14	3.35
LSD0.01	2.88	2.56	3.18	5.81	19.42	12.43	5.89	4.76

With respect to plant height, the results in Table 5 show that P_5 (Nc 92-2231) had the significantly highest mean values among the six parents in both generations with mean values of 135 and 136.67 cm in first and second generations, respectively. On the other hand, the parental variety P_1 (Japanese 13) was the shortest parent among all parents since it recorded 62.50 and 58.33 cm in the first and second generations, respectively. Regarding the crosses, C8 (Giza 111 x Nc 92-2231) was the tallest,with mean values of 141.85 and 123.83 cm in F_1 and F_2 generations, respectively. While C12 (Crawford x Linford) and C4 (Japanese 13 x Nc 92-2231) were the shortest crosses in F_1 and F_2, respectively.

Regarding the number of branches per plant, the results revealed that Giza 111 (11.07 and 11) had the significantly highest mean values in the first and second generations, respectively. Meanwhile, the lowest mean values were estimated for $H_{18}L_{54}$ (2 and 3.67) in the first and second generations, respectively. With regard to the highest F_1's crosses mean values were 10.78 for C14 ($H_{18}L_{54}$ x Linford)followed by10.35 for C10 (Crawford x $H_{18}L_{54}$). While the lowest mean value (5.43 and 4.76) were obtained in C9 (Giza 111 x Linford) in the F_1 and F_2, respectively. For F_2's crosses, the highest values were obtained from C15 (Nc 92-2231 x Linford)and C8 (Giza 111 x Nc 92-2231). While the lowest mean values were obtained from C4 (Japanese 13 x Nc 92-2231). Concerning the number of pods per plant, the parental variety P5 (Nc 92-2231) showed the highest mean values of 318.52 and 336.67 followed by P3 (Crawford) 313.33 and 303.67 in the first and second generations, respectively. While P4 ($H_{18}L_{54}$) had the lowest mean pods with mean values of 98.25and 104.92 in the first and second generations, respectively (Table 6). The highest F_1's mean values were471.84, 462.92 and 462.70 which estimated forC3, C5 and C13, respectively. For F_2's crosses, the highest mean value were328.97 and 399.50 obtained from C5 and C8, respectively.

Regarding the 100-seed weight per gram, the parental variety P6 (Linford) exhibited the highest mean values of 20.01 and 21.16 g in the first and second generations, respectively. The highest mean values were 22.45 and 21.07 for C5 (Japanese 13 x Linford) in F_1 and F_2 generations, respectively.

The results also indicated that the mean values for seed yield per plant character, P_3 (Crawford) had the highest mean values (119.64 and 111.73 g in the first and second generations, respectively), among the six parents used. However, the highest F_1's mean values were 261.44 g and 221.10 g for C1 and C13, respectively. For F_2's crosses, the significantly highest values were obtained from C15 (Nc 92-2231 x Linford) (131.10 g) followed by C5 (Japanese 13 x Linford) (124.54 g).

Table 6: Mean performance of the sixsoybean genotypes and F_1 crosses and their F_2 generations for number of pods per plant, 100-seed weight and seed yield per plant characters.

Parents	Number of pods per plant		100-seed weight		Seed yield per plant	
	F_1	F_2	F_1	F_2	F_1	F_2
P1 (Japanese 13)	210.62	250.00	19.97	21.16	71.09	76.22
P2 (Giza 111)	253.89	201.67	15.78	15.45	107.91	72.47
P3 (Crawford)	313.33	303.67	18.65	17.87	119.64	111.73
P4 ($H_{18}L_{54}$)	98.25	104.92	17.13	17.13	41.20	46.39
P5 (Nc 92-2231)	318.52	336.67	17.95	19.02	91.50	80.41
P6 (Linford)	209.78	212.33	21.01	21.01	67.81	64.67
Hybrids						
C1 (Japanese 13 x Giza 111)	383.47	266.89	18.10	18.79	261.44	110.79
C2 (Japanese 13 x Crawford)	368.35	289.16	13.10	16.98	74.56	90.43
C3 (Japanese 13 x H $H_{18}L_{54}$)	462.92	263.19	18.04	19.42	146.88	100.16
C4 (Japanese 13 x Nc 92-2231)	331.85	267.11	16.95	18.32	98.34	87.18
C5 (Japanese 13 x Linford)	471.84	328.97	22.45	21.07	174.54	124.54
C6 (Giza 111 x Crawford)	367.08	225.76	15.52	15.23	219.59	61.43
C7 (Giza 111 x H $H_{18}L_{54}$)	280.06	240.81	13.43	15.88	94.76	86.14
C8 (Giza 111 x Nc 92-2231)	417.05	399.50	18.38	16.33	148.32	118.11
C9 (Giza 111 x Linford)	263.33	202.77	20.17	18.36	84.66	82.32
C10 (Crawford x $H_{18}L_{54}$)	438.33	253.33	16.94	18.05	170.75	95.14
C11 (Crawford x Nc 92-2231)	362.65	251.20	17.86	18.45	94.14	70.00
C12 (Crawford x Linford)	336.69	226.66	17.24	17.22	96.42	77.76
C13 ($H_{18}L_{54}$ x Nc92-2231)	462.70	234.60	15.67	15.07	221.10	58.13
C14 ($H_{18}L_{54}$ x Linford)	435.33	190.12	17.77	24.59	186.29	63.18
C15 (Nc 92-2231 x Linford)	358.27	242.01	20.54	19.12	164.11	131.10
LSD0.05	70.19	66.30	2.91	1.89	8.53	25.40
LSD0.01	99.84	94.30	4.14	2.69	12.13	36.13

Regard to seed quality characteristics in F_1-generation only, P_4 ($H_{18}L_{54}$) had the highest germination percentage 95% and also it had the lowest EC value of 1.82 (Table 7). The highest germination percentage mean values were 96.67, 91.67 and97.67, %which estimated by C3,C14 and C15, respectively. With respect to F_1crosses, the same crosses had the lowest EC values 1.52, 1.94 and 1.25. There is a negative relationship between electrical conductivity and seed germination, which indicated that more cell leaches escaped from deteriorated seed and lowered the germination percentage of seed (Table 7).

The parental variety P_4 ($H_{18}L_{54}$) had the highest protein content (46.50%) followed by P5 (Nc 92-2231) (41.98%). For F_1 crosses, C4 (Japanese 13 x Nc 92-2231), C8 (Giza 111 x Nc 92-2231) and C13 ($H_{18}L_{54}$ x Nc 92-2231) had the highest protein content with mean values of 52.25%, 49.00% and 45.50%, respectively. Both P_1 (Japanese 13), P_2 (Giza 111) and P_4 ($H_{18}L_{54}$) showed the highest oil seed content 26.54, 26.43 and 25.05%, respectively. Meanwhile, C1 (Japanese 13 x Giza 111) and C14 ($H_{18}L_{54}$ x Linford) F_1 crosses showed the highest oil seed content (27.00 and 27.08%), respectively. The results are in agreement with those reported by **El-Garhy et al [15], Perez et al [16], Waly [12] and Waly and Ibrahim [13]** which found highly significant differences in the mean performances of seed yield and oil percentage in different genotypes of soybean.

Table 7: Mean performance of the sixsoybean genotypes and their F_1 crosses for Germination %, EC, protein %and oil % characters.

Parents	Germination %	EC	Protein %	Oil %
P1 (Japanese 13)	87.00	3.59	25.67	26.54

P2 (Giza 111)	80.00	5.27	34.42	26.43
P3 (Crawford)	88.00	3.42	31.58	23.16
P4 ($H_{18}L_{54}$)	95.00	1.82	46.50	25.05
P5 (Nc 92-2231)	84.33	3.74	41.98	23.34
P6 (Linford)	86.00	3.55	21.00	23.00
Hybrids				
C1 (Japanese 13 x Giza 111)	85.00	4.92	34.29	27.00
C2 (Japanese 13 x Crawford)	88.00	3.70	30.95	24.82
C3 (Japanese 13 x H $H_{18}L_{54}$)	96.67	1.52	33.25	18.85
C4 (Japanese 13 x Nc 92-2231)	87.00	3.60	52.25	24.67
C5 (Japanese 13 x Linford)	90.00	2.50	37.92	20.75
C6 (Giza 111 x Crawford)	77.33	6.27	39.08	23.78
C7 (Giza 111 x H $H_{18}L_{54}$)	78.33	6.27	40.83	24.48
C8 (Giza 111 x Nc 92-2231)	84.00	4.76	49.00	21.68
C9 (Giza 111 x Linford)	85.00	3.65	39.66	25.18
C10 (Crawford x $H_{18}L_{54}$)	75.00	6.95	28.00	23.19
C11 (Crawford x Nc 92-2231)	78.00	5.33	33.25	25.52
C12 (Crawford x Linford)	83.33	3.95	44.33	25.25
C13 ($H_{18}L_{54}$ x Nc92-2231)	80.00	5.33	45.50	26.60
C14 ($H_{18}L_{54}$ x Linford)	91.67	1.94	36.75	27.08
C15 (Nc 92-2231 x Linford)	97.67	1.25	35.00	24.81
LSD0.05	1.31	0.11	5.81	0.98
LSD0.01	1.87	0.16	8.27	1.40

General combining ability effects ((ĝi) were found to be significant for most characters in this study. High positive values of GCA (desirable) would be highly appreciated for yield and its component characters. Characters such as flowering date, maturity date and ECwith high negative effects would be useful (desirable) from the breeder̕s point of view.

It could be concluded from the results drawn in Table, 8 plant that, P_2 (Giza 111) exhibited highly significant in positive direction (ĝi) for plant height and No. of branches/ plant in F_1 as well as F_2 generations. The parental genotypes P_4 ($H_{18}L_{54}$) and P_6 (Linford) had highly significant (ĝi) in negative direction for days to flowering and maturity in both generations, while P_5 (Nc 92-2231) expressed highly significant (ĝi) in negative direction for days to flowering in $F_1$and days to maturity in F_2 and in positive direction for plant height in both generations and No. of branches/plant in F_2-generation. However, these parents mentioned above were considered as good combiners for the traits in view in the generation reffered.The results of (gi^) are in agreement with those reported by **Refat [17], Mansour et al [10], El-Shaboury et al [18], Chen [19], Perez et al [16] ,Waly [9] and El-Seidy et al [14].**

Table 8: Estimates of general combining ability (GCA) effects for days to flowering, days to maturity, plant height and number of branches per plant characters.

	Days to flowering		Days to maturity		Plant height		Number of branches per plant	
Parents	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
P1 (Japanese 13)	1.56**	3.01**	9.73**	14.04**	-12.55**	-12.46**	-0.52	-0.79**
P2 (Giza 111)	2.96**	3.17**	1.11*	3.26**	6.22**	10.07**	0.7*	1.03**
P3 (Crawford)	3.1**	0.53	0.00	2.49**	-2.09	-0.1	-0.4	-0.61*
P4 ($H_{18}L_{54}$)	-1.16**	-2.03**	-6.1**	-8.66**	3.04*	-2.21	-0.64*	-0.72*
P5 (Nc 92-2231)	-2.28**	-0.18	0.63	-2.53**	9.06**	5.24**	0.39	1.07**
P6 (Linford)	-4.19**	-4.5**	-5.36**	-8.59**	-3.68*	-0.53	0.48	0.03
S.E. gi	0.24	0.22	0.28	0.26	0.97	1.08	0.24815	0.19
LSD0.05 (gi-gj)	0.76	0.68	0.88	0.80	3.04	3.39	0.776967	0.61
LSD0.01 (gi-gj)	1.02	0.91	1.17	1.07	4.06	4.53	1.039682	0.82

* and **refer to significance at 0.05 and 0.01 levels of probability, respectively.

The data in Table, 9 revealed that, the parental genotype P_1 (Japanese 13) had significant (ĝi) in positive direction for No. of pods/plant and seed yield/plant in F_2 generation, while P_2 (Giza 111) expressed significant (ĝi) in positive direction for seed yield/plant in F_1-generation. The parental genotype P_5(Nc 92-2231) expose significant (ĝi) in positive direction for No. of pods/plant in F_1 as well as F_2-generations and P_6 (Linford) revealed significant (ĝi) in positive direction for 100-seed weight.

With respect to the data shown in Table, 10, the parental genotype P_1 (Japanese 13) had highly significant (ĝi) in positive direction for germination percentage and protein percentage and in negative direction for EC. The parental genotype P_4 ($H_{18}L_{54}$) showed highly significant (ĝi) in positive direction for germination and protein percentage and negative direction for EC. The parental genotype P_5 (Nc92-2231) had highly significant in positive direction for protein percentage and the parental genotype P_6 (Linford) showed highly significant (ĝi) in positive direction for germination percentage and in negative direction for EC. However, it could be concluded from the obtained results that, P_2 and P_5 performed as good combiner parents for plant height and No. of pods/plant in both generations. P_4 and P_6 could be considered as good combiners parents for earliness in both generations. The results- in general – considered as poor results, which expected are became the studied traits controlled by non- additive genes as referred in tables 2, 3 and 4 which in turn the low contribution of additive genes in the inheritance of the traits and subsequent low estimates of general combining ability.

The positive and desirable general combining ability has been demonstrated in soybean growth traits by many authors before such as **Mansour et al [9], Agrawal et al [20], El-Shaboury et al [18], Maloo and Sharma [24], Chen [19], El-Garhy et al [15], Gavioli et al [21], Perez et al [16], Nassar [22], Waly [12], Rialch et al[23], Waly and Ibrahim [13] and El-Seidy et al [14].**

Table 9: Estimates of general combining ability (GCA) effects for Number of pods per plant, 100-seed weight and Seed yield per plant characters.

Parents	Number of pods per plant		100-seed weight		Seed yield per plant	
P1 (Japanese 13)	7.28	18.94*	0.55	1.09	-1.72	7.85*
P2 (Giza 111)	-20.33*	-3.09	-0.88*	-1.58*	14.11*	0.12
P3 (Crawford)	14.79	11.21	-0.78*	-0.81	-2.12	1.93
P4 ($H_{18}L_{54}$)	-13.2	-46.49**	-1.01**	-0.11	-1.19	-13.4**
P5 (Nc 92-2231)	23.51*	38**	0.14	-0.36	-0.33	2.82
P6 (Linford)	-12.05	-18.57*	2**	1.78*	-8.76	0.68
S.E. gi	6.61	5.38	0.24	0.47	3.52	2.03
LSD0.05 (gi-gj)	20.68	16.83	0.74	1.46	11.02	6.35
LSD0.01 (gi-gj)	27.68	22.52	0.99	1.95	14.75	8.50

* and **refer to significance at 0.05 and 0.01 levels of probability, respectively.

Table 10: Estimates of general combining ability (GCA) effects for germination %, EC, protein %and oil %characters in F_1- generation.

Parents	Germination %	EC	Protein %	Oil %
P1 (Japanese 13)	2.69**	-0.55**	-2.55**	-0.15
P2 (Giza 111)	-3.68**	1.08**	1.41*	0.57**
P3 (Crawford)	-2.68**	0.66**	-2.7**	-0.19
P4 ($H_{18}L_{54}$)	1.57**	-0.27**	2.12**	-0.01
P5 (Nc 92-2231)	-0.47*	0.00	4.82**	-0.05
P6 (Linford)	2.57**	-0.92**	-3.09**	-0.16
S.E. gi	0.18	0.03	0.50	0.10
LSD0.05 (gi-gj)	0.55	0.08	1.56	0.30
LSD0.01 (gi-gj)	0.74	0.11	2.08	0.40

* and **refer to significance at 0.05 and 0.01 levels of probability, respectively.

The data listed in Tables 11, 12 and 13 revealed that, the C1 (Japanese 13 X Giza 111) showed highly significant negative (Ŝij) for flowering date in F_1 as in F_2generations and in positive direction for No. of pods/plant in F_1, seed yield/plant in both generations and oil percentage. The second cross; C2 (Japanese 13 x Crawford) exhibited highly significant (Ŝij) in negative direction for flowering date in both generations, in positive direction for plant height in both generations, germination percentage and oil percentage and in negative direction for EC. The cross; C3 (Japanese 13 x $H_{18}L_{54}$) had highly significant (Ŝij) in positive direction for No. of pods/plant in both generations, seed yield /plant in F_2, germination percentage, oil percentage and in negative direction for EC. The cross; C5 (Japanese 13 x

Linford) exposed highly significant (Ŝij) in positive direction for plant height, No.of pods/plant and seed yield/plant in F_1 as well as F_2 generations and protein percentage. The cross; C8(Giza 111 x Nc92-2231) expressed highly significant (Ŝij) in positive direction for plant height in F_1, No. of pods/plant in both generations, seed yield/plant in F_2-generation, germination percentage and protein percentage and in negative direction for EC. The cross; C9 (Giza 111 x Linford) had highly significant (Ŝij) in negative direction for flowering and maturity dates in both generations. The cross; C10 (Crawford x $H_{18}L_{54}$) showed significant and/or highly significant (Ŝij) in negative direction for flowering date in F_2, maturity date in both generations and in positive direction for plant heightin F_1-generation, No. of branches/plant in both generations, No. of pods/plant in F_1 and seed yield/plant in both generations. The cross; C13 ($H_{18}L_{54}$ x Nc92-2231) expressed highly significant (Ŝij) in negative direction for flowering and maturity dates in both generations, positive direction for No. of pods/plant and seed yield/plant in F_1 and oil percentage. The cross; C14 ($H_{18}L_{54}$ x Linford) revealed significant and/or highly significant (Ŝij) in positive direction for No. of branches/plant in both generations, No. of pods/plant and seed yield/plant in F_1, 100-seed weight in F_2, germination percentage and oil percentage and the cross; C15 (Nc92-2231 x Linford) had significant (Ŝij) in positive direction for seed yield/plant in both generations, germination percentage, oil percentage and in negative direction for EC. These results are in agreement with those obtained by **Yassien and Abd El-Mohsen [8], Mansour et al [10], Agrawal et [20] , El-Shaboury et al [18], Maloo and Sharma [24], Chen [19], El-Garhy et al[15], Gavioli et al [21], Perez et al [16], Shiv et al [24], Nassar [13], Waly [12], Rialch et al [23], Bagateli et al [26], AbouSen [27], Waly and Ibrahim [13] and El-Seidy et al [14].**

Table 11: Estimates of specific combining ability (SCA) effects for days to flowering, days to maturity, plant height and number of branches per plant characters.

crosses	Days to flowering		Days to maturity		Plant height		Number of branches per plant	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
C1 (Japanese 13 x Giza 111)	-4.12**	-7.56**	-1.67	0.78	-18.11**	3.18	1.11	-0.39
C2 (Japanese 13 x Crawford)	-7.52**	-3.89**	-1.4	2.1*	13.27**	21.37**	0.18	0.64
C3 (Japanese 13 x H $H_{18}L_{54}$)	1.09	-2.83**	5.5**	-9.51**	31.14**	21.29**	0.09	1.18
C4 (Japanese 13 x Nc 92-2231)	-2.56*	6.39**	2.47*	0.75	5.11	-8.26*	-0.35	-2.98**
C5 (Japanese 13 x Linford)	-1.28	-8.65**	-6.13**	-11.59**	26.15**	14.89**	1.5	-0.42
C6 (Giza 111 x Crawford)	8.97**	7.78**	-11.7**	-1.68	13.58**	-3.07	-1.48	-0.48
C7 (Giza 111 x H $H_{18}L_{54}$)	-6.45**	5.67**	-9.8**	-13.2**	-3.56	-2.06	-0.13	-0.6
C8 (Giza 111 x Nc 92-2231)	13.81**	6.42**	8.65**	0.45	10.19*	-0.96	-1.87*	-0.32
C9 (Giza 111 x Linford)	-10.75**	-7.34**	-6.88**	-12.16**	-4.57	-11.18*	-2.82**	-2.89**
C10 (Crawford x $H_{18}L_{54}$)	10.76**	-4.41**	-4.44**	-11.13**	7.9*	-10.25*	4.33**	1.97*
C11 (Crawford x Nc 92-2231)	-5.33**	-5.57**	0.32	-16.97**	-10.58*	-9.32*	1.24	-0.16
C12 (Crawford x Linford)	3.45**	0.81	8.8**	6.01**	-23.13**	-0.17	-1.1	0.11
C13 ($H_{18}L_{54}$ x Nc92-2231)	-10.63**	-4.96**	-9.06**	-6.5**	-4.6	-13.5**	-0.6	-1.23
C14 ($H_{18}L_{54}$ x Linford)	5.64**	3.81**	14.91**	1.83*	4.03	-2.02	3.87**	1.67*
C15 (Nc 92-2231 x Linford)	2.64*	2.82**	-2.79*	1.82*	-1.14	-1.36	1.92*	0.83
S.E (Sij)	0.67	0.59	0.77	0.70	2.66	2.97	0.68	0.53
LSD0.05 (Sij-gik)	2.01	1.79	2.32	2.11	8.03	8.96	2.06	1.61
LSD0.01 (Sij-gik)	2.70	2.40	3.10	2.83	10.75	11.98	2.75	2.16
LSD0.05 (gij-kl)	1.86	1.66	2.15	1.96	7.44	8.29	1.90	1.49
LSD0.01 (gij-kl)	2.50	2.22	2.87	2.62	9.95	11.10	2.55	2.00

* and **refer to significance at 0.05 and 0.01 levels of probability, respectively.

Table 12: Estimates of specific combining ability (SCA) effects for Number of pods per plant, 100-seed weight and Seed yield per plant characters.

Crosses	Number of pods per plant	100-seed weight	Seed yield per plant

	F_1	F_2	F_1	F_2	F_1	F_2
C1 (Japanese 13 x Giza 111)	56.32*	-0.93	0.7	0.97	118.81**	16.72*
C2 (Japanese 13 x Crawford)	6.07	7.04	-4.41**	-1.61	-51.85**	-5.46
C3 (Japanese 13 x H $H_{18}L_{54}$)	128.63**	38.77*	0.77	0.14	19.55	19.61*
C4 (Japanese 13 x Nc 92-2231)	-39.15	-41.79*	-1.48	-0.72	-29.85*	-9.59
C5 (Japanese 13 x Linford)	136.41**	76.63**	2.16*	-0.11	54.77**	29.9**
C6 (Giza 111 x Crawford)	32.42	-34.33	-0.56	-0.68	77.35**	-26.73**
C7 (Giza 111 x H $H_{18}L_{54}$)	-26.61	38.42*	-2.42*	-0.73	-48.41**	13.32
C8 (Giza 111 x Nc 92-2231)	73.66**	112.62**	1.38	-0.04	4.3	29.06**
C9 (Giza 111 x Linford)	-44.49	-27.54	1.31	-0.14	-50.94**	-4.6
C10 (Crawford x $H_{18}L_{54}$)	96.54**	36.64	0.99	0.67	43.81**	20.51*
C11 (Crawford x Nc 92-2231)	-15.86	-49.97*	0.76	1.3	-33.65*	-20.87*
C12 (Crawford x Linford)	-6.26	-17.94	-1.72*	-2.05	-22.95	-10.96
C13 ($H_{18}L_{54}$ x Nc92-2231)	112.18**	-8.88	-1.2	-2.77	92.38**	-17.4*
C14 ($H_{18}L_{54}$ x Linford)	120.38**	3.21	-0.95	4.62*	65.99**	-10.21
C15 (Nc 92-2231 x Linford)	6.6	-29.38	0.66	-0.61	42.96**	41.48**
S.E (Sij)	18.14	14.76	0.65	1.28	9.67	5.57
LSD0.05 (Sij-gik)	54.72	44.53	1.96	3.86	29.16	16.80
LSD0.01 (Sij-gik)	73.23	59.59	2.62	5.17	39.02	22.48
LSD0.05 (gij-kl)	50.66	41.23	1.81	3.58	26.99	15.56
LSD0.01 (gij-kl)	67.80	55.17	2.43	4.79	36.12	20.82

* and **refer to significance at 0.05 and 0.01 levels of probability, respectively.

Table 13: Estimates of specific combining ability (SCA) effectsfor germination %, EC, protein %and oil %characters in F_1.

Crosses	Germination %	EC	Protein %	Oil %
C1 (Japanese 13 x Giza 111)	0.4	0.41**	-1.77	2.24**
C2 (Japanese 13 x Crawford)	2.4**	-0.38**	-1	0.82*
C3 (Japanese 13 x H $H_{18}L_{54}$)	6.82**	-1.64**	-3.51*	-5.33**
C4 (Japanese 13 x Nc 92-2231)	-0.81	0.18	12.78**	0.54
C5 (Japanese 13 x Linford)	-0.85	0.00	6.36**	-3.27**
C6 (Giza 111 x Crawford)	-1.89*	0.57**	3.17	-0.95*
C7 (Giza 111 x H $H_{18}L_{54}$)	-5.14**	1.49**	0.1	-0.42
C8 (Giza 111 x Nc 92-2231)	2.57**	-0.28*	5.57**	-3.18**
C9 (Giza 111 x Linford)	0.52	-0.47**	4.14*	0.43
C10 (Crawford x $H_{18}L_{54}$)	-9.48**	2.59**	-8.61**	-0.95*
C11 (Crawford x Nc 92-2231)	-4.43**	0.71**	-6.07**	1.42**
C12 (Crawford x Linford)	-2.14**	0.25*	12.93**	1.27**
C13 ($H_{18}L_{54}$ x Nc92-2231)	-6.68**	1.63**	1.36	2.32**
C14 ($H_{18}L_{54}$ x Linford)	1.94*	-0.84**	0.53	2.92**
C15 (Nc 92-2231 x Linford)	9.98**	-1.79**	-3.93*	0.69*
S.E (Sij)	0.49	0.07	1.36	0.27
LSD0.05 (Sij-gik)	1.47	0.22	4.11	0.80
LSD0.01 (Sij-gik)	1.96	0.29	5.51	1.07
LSD0.05 (gij-kl)	1.36	0.20	3.81	0.74
LSD0.01 (gij-kl)	1.82	0.27	5.10	0.99

* and **refer to significance at 0.05 and 0.01 levels of probability, respectively.

Heterosis

Heterosis over better parent is defined as the amount by which the mean of an F_1 hybrid exceeds its better parent.Breeders have adopted the convention that P_1 corresponds to the parent with the greater mean value and P_2 the parent with the smaller mean value, but according to the character under consideration, either P_1 or P_2 may be the better parent. In this investigation, the character earliness, usually implies that the F_1has a lower value than its lower parent. On the other hand, heterosis such as yield or its components characters implies that the F_1 analysis its greater yielding parent. It must be mentioned that, germination percentage, oil and protein percentages and EC were determined in F_1-generation only.

However, it could be concluded from the data drawn in Tables 14, 15 and 16 that, the cross; C1 (Japanese 13 x Giza 111) showed highly significant better parent heterosis in negative direction for flowering and maturity dates in both generations and EC and in positive direction for No. of pods and seed yield/plant in both generations. The cross; C2 (Japanese 13 x Crawford) have highly significant better parent heterosis in negative direction for flowering and maturity dates in both generations. The cross; C3 (Japanese 13 x $H_{18}L_{54}$)

exposed highly significant better parent heterosis in negative direction for maturity date in both generations; in positive direction for plant height in F_1, No. of pods and seed yield/plant in both generations, germination percentage and EC in negative direction. The cross; C5 (Japanese 13 x Linford) expressed highly significant better parent heterosis in negative direction for flowering and maturity dates in both generations, in positive direction for plant height, No. of branches, pods and seed yield/plant in both generations and protein percentage and in negative direction for EC. The cross; C8 (Giza 111 x Nc92-2231) had highly significant better parent heterosis in negative direction for maturity date in both generations and EC and in positive direction for No. of pods and seed yield/plant in both generations and protein percentage. The cross; C9 (Giza 111 x Linford) showed highly significant better parent heterosis in negative direction for flowering and maturity dates in both generations, EC and in positive direction for protein percentage. The cross; C10 (Crawford x $H_{18}L_{54}$) revealed highly significant better parent heterosis in negative direction for flowering and maturity dates in both generations, in positive direction for plant height in F_1, No. of branches/plant in both generations, No. of pods/plant and seed yield/plant in F_1- generation. The cross; C13 ($H_{18}L_{54}$ x Nc92-2231) showed highly significant better parent heterosis in negative direction for flowering and maturity dates in both generations, No. of pods and seed yield/plant in positive direction in F_1 and oil percentage.The cross; C14 ($H_{18}L_{54}$x Linford) expressed highly significant better parent heterosis in positive direction for plant height, No. of branches/plant, No. of pods, seed yield/plant and oil percentage in F_1-generation and in negative direction for EC. The cross C15 (Nc92-2231 x Linford) exposed highly significant better parent heterosis in negative direction for maturity date in both generations, No. of branches/plant in F_1, seed yield/plant in both generations,germination percentage, oil percentage and in negative direction for EC.

Generally, it could be observed from the data shown in the present investigation that, there is equivalence between the data concerning better parent heterosis and specific combining ability effects (Ŝij) in many studied crosses i.e., C1, C5, C7, C9, C10, C11, C13, C14 and C15 for many characters. This could be attributed to the non-additive genes especially dominance, responsible for exposing both parameters. As mentioned before the present genetic material for all studied traits are controlled in their inheritance by non-additive genes. Therefore, the expected selection program in these materials in the advanced segregating generations would be not limited to the superior specific hybrids and the expected improvement would be fruitful and the bulk method is the more suitable in such case. These results are similar to those obtained before by **Mansour et al [9], Pandini et al [28], Gravina et al [29], Ramana and Satyanarayana [30], El-Shaboury et al [18], EL-Garhy et al [15], Fayiz [11], Perez et al [16], Yang and Gai [32], Sudaric et al [33], Yin, and Yi [34], Nassar [22], AbouSen [27] and Waly and Ibrahim [13].**

Table 14: Estimates of heterosis over better parent (B.P.%) for days to flowering, days to maturity, plant height and number of branches per plant characters.

Crosses	Days to flowering	Days to maturity	Plant height	Number of branches per plant

	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
C1 (Japanese 13 x Giza 111)	**-10.38****	**-12.06****	**-8.19****	**-12.54****	**-29.30 ****	**-19.30 ****	**-24.49 ***	**-41.33 ****
C2 (Japanese 13 x Crawford)	**-9.28****	**-9.36****	**-8.81****	**-12.18****	**2.99 ns**	**7.54 ns**	**32.80 ns**	**-2.67 ns**
C3 (Japanese 13 x H $H_{18}L_{54}$)	**10.42****	**2.29**	**-8.22****	**-27.41****	**31.44 ****	**7.17 ns**	**25.86 ns**	**4.56 ns**
C4 (Japanese 13 x Nc 92-2231)	**0.63**	**33.14****	**-5.43****	**-16.44****	**-12.59 ****	**-31.21 ****	**-14.13 ns**	**-63.47 ****
C5 (Japanese 13 x Linford)	**13.19****	**-15.56****	**-16.39****	**-28.75****	**16.58 ****	**2.82 ns**	**34.53 ***	**-22.67 ns**
C6 (Giza 111 x Crawford)	**33.32****	**18.01****	**-18.65****	**-11.63****	**3.10 ns**	**-14.85 ****	**-46.84 ****	**-40.61 ****
C7 (Giza 111 x H $H_{18}L_{54}$)	**-5.54**	**25.82****	**-21.99****	**-28.81****	**-6.13 ns**	**-15.65 ****	**-36.75 ****	**-42.64 ****
C8 (Giza 111 x Nc 92-2231)	**48.07****	**33.64****	**-2***	**-13.82****	**5.07 ns**	**-9.39 ****	**-43.13 ****	**-23.91 ****
C9 (Giza 111 x Linford)	**-11.47****	**-11.35****	**-19.08****	**-27.96****	**-12.08 ****	**-21.09 ****	**-50.96 ****	**-56.73 ****
C10 (Crawford x $H_{18}L_{54}$)	**39.57****	**-8.75****	**-12.57****	**-25.79****	**12.14 ****	**-11.89 ****	**121.86 ****	**66.92 ****
C11 (Crawford x Nc 92-2231)	**-2.63**	**-6.32***	**-2.77***	**-25.57****	**-16.47 ****	**-22.95 ****	**8.17 ns**	**-35.31 ****
C12 (Crawford x Linford)	**32.34****	**4.47**	**-0.65**	**-12.38****	**-21.67 ****	**-1.20 ns**	**-4.58 ns**	**-12.57 ns**
C13 ($H_{18}L_{54}$ x Nc92-2231)	**-28.16****	**-11.64****	**-13.97****	**-19.42****	**-8.24 ***	**-27.55 ****	**-18.96 ns**	**-46.34 ****
C14 ($H_{18}L_{54}$ x Linford)	**25.99****	**5.77***	**13.88****	**-15.15****	**10.55 ****	**-3.34 ns**	**70.16 ****	**8.29 ns**
C15 (Nc 92-2231 x Linford)	**13.42****	**8.23****	**-7.85****	**-12.28****	**-10.66 ****	**-17.44 ****	**28.52 ***	**-20.09 ***
LSD0.05	2.15	1.92	2.24	4.09	13.65	8.74	4.14	3.35
LSD0.01	2.88	2.56	3.18	5.81	19.42	12.43	5.89	4.76

* and **refer to significance at 0.05 and 0.01 levels of probability, respectively.

Table 15: Estimates of heterosis over better parent (B.P.%) for number of pods per plant, 100-seed weight and seed yield per plant characters.

Crosses	**Number of pods per plant**		**100-seed weight**		**Seed yield per plant**	
	F_1	**F2**	**F_1**	**F_2**	**F_1**	**F_2**
C1 (Japanese 13 x Giza 111)	51.04 **	6.76 ns	-9.36 ns	-11.19 ns	142.28 **	45.36 **
C2 (Japanese 13 x Crawford)	17.56 ns	-4.78 ns	-34.43 **	-19.76 *	-37.68 **	-19.07 *
C3 (Japanese 13 x H $H_{18}L_{54}$)	119.79 **	5.28 ns	-9.68 ns	-8.18 ns	106.63 **	31.41 **
C4 (Japanese 13 x Nc 92-2231)	4.18 ns	-20.66 **	-15.14 **	-13.38 ns	7.48 ns	8.42 ns
C5 (Japanese 13 x Linford)	124.03 **	31.59 **	6.84 ns	-0.41 ns	145.53 **	63.40 **
C6 (Giza 111 x Crawford)	17.15 ns	-25.66 **	-16.78 **	-14.76 ns	83.54 **	-45.02 **
C7 (Giza 111 x H $H_{18}L_{54}$)	10.31 ns	19.41 ns	-21.58 **	-7.26 ns	-12.19 ns	18.87 ns
C8 (Giza 111 x Nc 92-2231)	30.93 **	18.66 *	2.36 ns	-14.11 ns	37.44 *	46.88 **
C9 (Giza 111 x Linford)	3.72 ns	-4.51 ns	-4.01 ns	-12.63 ns	-21.55 ns	13.59 ns
C10 (Crawford x $H_{18}L_{54}$)	39.89 **	-16.58 *	-9.19 ns	1.04 ns	42.71 **	-14.85 ns
C11 (Crawford x Nc 92-2231)	13.86 ns	-25.39 **	-4.27 ns	-3.00 ns	-21.32 ns	-37.35 **
C12 (Crawford x Linford)	7.45 ns	-25.36 **	-17.94 **	-18.02 ns	-19.41 ns	-30.40 **
C13 ($H_{18}L_{54}$ x Nc92-2231)	45.26 **	-30.32 **	-12.74 *	-20.75 ns	141.64 **	-27.70 *
C14 ($H_{18}L_{54}$ x Linford)	107.52 **	-10.46 ns	-15.41 **	17.04 ns	174.73 **	-2.31 ns
C15 (Nc 92-2231 x Linford)	12.48 ns	-28.12 **	-2.22 ns	-9.01 ns	79.35 **	63.04 **
LSD0.05	70.19	66.30	2.91	1.89	8.53	25.40
LSD0.01	99.84	94.30	4.14	2.69	12.13	36.13

* and **refer to significance at 0.05 and 0.01 levels of probability, respectively.

Table 16: Estimates of heterosis over better parent (B.P.%) for germination %, EC, protein %and oil %characters in F_1-generation.

Crosses	**Germination %**	**EC**	**Protein %**	**Oil %**
C1 (Japanese 13 x Giza 111)	-2.30 *	-6.76**	-0.37 ns	1.72 ns
C2 (Japanese 13 x Crawford)	0.00 ns	3.06	-2.01 ns	-6.51 **
C3 (Japanese 13 x H $H_{18}L_{54}$)	1.75 *	-57.66**	-28.49 **	-29.00 **
C4 (Japanese 13 x Nc 92-2231)	0.00 ns	-3.83	24.45 **	-7.06 **
C5 (Japanese 13 x Linford)	3.45 **	-30.36**	47.73 **	-21.81 **
C6 (Giza 111 x Crawford)	-12.12 **	18.96**	13.56 *	-10.04 **
C7 (Giza 111 x H $H_{18}L_{54}$)	-17.54 **	18.9**	-12.19 *	-7.39 **
C8 (Giza 111 x Nc 92-2231)	-0.40 ns	-9.67**	16.71 **	-17.98 **
C9 (Giza 111 x Linford)	-1.16 ns	-30.78**	15.24 *	-4.75 **
C10 (Crawford x $H_{18}L_{54}$)	-21.05 **	103.31**	-39.78 **	-7.44 **
C11 (Crawford x Nc 92-2231)	-11.36 **	42.48**	-20.80 **	9.33 **
C12 (Crawford x Linford)	-5.30 **	11.27**	40.37 **	9.04 **
C13 ($H_{18}L_{54}$ x Nc92-2231)	-15.79 **	42.39**	-2.15 ns	6.17 **
C14 ($H_{18}L_{54}$ x Linford)	-3.51 **	-45.35**	-20.97 **	8.10 **
C15 (Nc 92-2231 x Linford)	13.57 **	-66.61**	-16.63 **	6.28 **
LSD0.05	1.31	0.11	5.81	0.98
LSD0.05	1.87	0.16	8.27	1.40

* and **refer to significance at 0.05 and 0.01 levels of probability, respectively.

CONCLUSION

From the data shown in the present investigation, there is equivalence between the data concerning better parent heterosis and specific combining ability effects (Ŝij) in many studied crosses i.e., C1(Japanese 13 x Giza 111), C5(Japanese 13 x Linford), C7(Giza 111 x $H_{18}L_{54}$), C9 (Giza 111 x Linford), C10 (Crawford x $H_{18}L_{54}$), C11 (Crawford x Nc 92-2231), C13($H_{18}L_{54}$x Nc 92-2231), C14 ($H_{18}L_{54}$ x Linford) and C15 (Nc 92-2231 x Linford) for many characters. This could be attributed to the non-additive genes especially dominance responsible for influencing both parameters. As mentioned before the present genetic material for all studied traits are controlled in their inheritance by non-additive genes. Therefore, the expected selection program in these materials in the advanced segregating generations would notbe limited to the superior specific hybrids and the expected improvement would be fruitful.The bulk method is more suitable in such case.

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