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EVALUATION OF SOYBEAN TOP CROSSES FOR SEED YIELD AND OTHER AGRONOMIC CHARACTERS

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ABSTRACT

Four genotypes of soybean (*Glycine max* (L.) Merril), namely, H3Z, H30Z, H73ZBC and H75ZBC, were used as females top crossed to each of the three different genetic base testers (male), namely, Gasoy, Hartwig and H5L23. The following characters were measured: plant height, number of branches per plant, number of days to flowering, number of days to maturity, number of pods per plant, number of seeds per plant, 100-seed weight and seed yield per plant. The mean squares due to parents, crosses and lines (females) by testers (males) were highly significant for all the studied traits. Relative estimates of the variance due to general combining ability (δ^2gca) and specific combining ability (δ^2sca) indicated that (δ^2sca) played a major role in the inheritance for all traits. The parental H5L23 (tester) gave the highest positive and higher significant "$\hat{g}i$" effect than other two testers for number of pods per plant, number of seeds per plant and seed yield per plant. The female line H30Z behaved as good combiner for all studied characters, except 100-seed weight. Significant positive "sca" effects were detected for number of pods per plant, number of seeds per plant and seed yield per plant in two crosses, i.e., (H30Z x Hartwig) and (H73ZBC x Hartwig). All crosses showed highly significant positive heterotic effects relative to mid and better parent values for yield and its component characters.

INTRODUCTION

The combining ability analysis gives very useful information with regard to selection of parents based on performance of their hybrids for the development of hybrids. Moreover, the combining ability analysis gives the nature and magnitude of various types of gene action involved in the expression of quantitative traits (El-Hosary *et al*., 1994).

The use of widely diverse germplasm in breeding programs has been studied in many crop species. Many authors suggested that genetic diversity was the key to obtain hybrid vigor. The crosses made in this study were from geographically diverse habitats. It was believed that they were from genetically diverse parents, as confirmed by the work of Paschal and Wilcox (1975). In self fertilizing crops, where commercial exploitation of heterosis is not feasible, the breeder will primarily be interested in higher magnitude of additive genetic variance for establishing superior genotypes. With regard to combining ability effects, several authors found the significance of both general and specific combining ability effects for important agronomic traits, yield and its components (Ma *et al*., 1983; Kunta *et al*., 1985; Cruz *et al*., 1987; El-Hosary *et al*., 1994 and Bastawisy *et al*., 1997).

The objectives of this study were: i) to determine the magnitude of heterosis for yield and its components and other agronomic characters, and ii) to estimate the relative importance of general combining ability "gca" and specific combining ability "sca" in a set of top crosses involving new local genotypes and exotic parental strains.

MATERIALS AND METHODS

Four female lines of soybean were top crossed to each of three different male testers. The females were H3Z, H30Z, H73ZBC and H75ZBC. The male testers were Gasoy 17, Hartwig and H5L23. Table (1) demonstrates a brief description of these genotypes, i.e., maturity group, pedigree and origin.

In 2000 summer season, 12 top crosses were made at Itai El-Baroud Agricultural Research Station. In the following season 2001, seven parental genotypes and 12 top crosses were evaluated in a randomized complete block design with three replications. Each plot consisted of three ridges of 3 m length and 60 cm width. Hills were spaced 20 cm with one seed per hill in one side of the ridge. Flowering time (in days) was recorded at 50% flowering of plants and maturity time (in days) was recorded at 95% pod maturity. At harvest, ten guarded plants were taken at random from each experimental plot to provide measurements for the following characteristics: plant height, number of branches per plant, number of pods per plant, number of seeds per plant, 100-seed weight and seed yield per plant.

Combining ability analysis and the estimation of various effects were conducted based on the procedure developed by Kempthorne (1957). The heterotic effects of F_1 crosses were estimated as percentage over mid and better parents (Mather and Jinks, 1971).

Estimation of "gca" effects:

a) Lines : $$g_i = \frac{x_{i}..}{tr} - \frac{x...}{ltr}$$

b) Testers : $$g_i = \frac{x.j.}{lr} - \frac{x...}{ltr}$$

Estimates of "sca" effects:

$$S_{ij} = \frac{x_{ij}.}{r} - \frac{x_{i}..}{tr} - \frac{x.j.}{lr} - \frac{x...}{ltr}$$

$$\delta^2 gca = \frac{1}{r\,(2lt - l - t)}\left[\frac{(l-1)(M_l) + (t-1)(M_t)}{l + t - 2} - M_{lxt}\right]$$

$$\delta^2 sca = \frac{M_{lxt} - M_e}{r}$$

where;

l = no. of lines.
t = no. of testers.
r = no. of replications.
M_l = mean square of line.

M_t = mean square of tester.
M_e = mean square of error.

Table (1): Maturity group, pedigree and origin of the soybean genotypes.

Genotype	Maturity group	Pedigree	Origin
H3Z	IV	Crawford x L62-1686	Egypt
H30Z	III	L75-6648 x Corsoy	Egypt
H73ZBC	IV	L75-6648 x (L75-6648 x Hardin)	Egypt
H75ZBC	IV	Hardin x (Calland x Hardin)	Egypt
Gasoy 17	VI	Bragg x Hood	Georgia, U.S.A
Hartwig	V	Forrest x PI437-654	Missouri, U.S.A
H5L23	V	Lakota x D79-10426	Egypt

RESULTS AND DISCUSSION

The analysis of variance (Table 2) show that mean squares due to genotypes, parents and crosses were highly significant for all studied characters. The results confirmed the existence of genetic diversity in the genotypes studied. Mean squares for parent vs. crosses as an indication of average heterosis were estimated for all crosses. There were highly significant differences among mean squares for all the studied traits. Highly significant mean squares of females by males interaction were obtained, indicating that females did not express identical orders of ranking for the performance of their crosses with each male (tester).

The estimates of the variance due to general combining ability (δ^2gca) and specific combining ability (δ^2sca), presented in Table (2), showed that (δ^2sca) played a major role in the inheritance, for most of the traits. However, number of branches per plant, which represents non-additive type of gene action, was involved in determining the performance of top crosses progenies. These results support the findings of Kaw and Menon (1983), Cruz *et al*.(1987), Harer and Deshmukh (1991) and El-Hosary *et al*.(1994).

Values of gca effects "$\hat{g}i$" for individual lines (females) and testers (males) in each trait are presented in Table (3). The female line H30Z behaved as good combiner for all characters studied, except 100-seed weight, followed by line H75ZBC which behaved as good combiner for number of pods per plant, number of seeds per plant, 100-seed weight and seed yield per plant. On the other hand, female line H3Z expressed highly significant negative "$\hat{g}i$" effects for all the studied traits, except number of days to flowering. The male tester H5L23 gave the highest positive "$\hat{g}i$" effect than other testers, Gasoy 17 and Hartwig, for number of branches per plant, number of pods per plant, number of seeds per plant and seed yield per plant. Therefore, the tester H5L23 could be considered as an excellent tester in breeding for high yield potentiality. Specific combining ability effect of the top crosses "$\hat{S}ij$" was computed for all the studied traits as shown in Table (4).

The desirable inter- and intra-allelic interactions were represented by four top crosses (H3Z x Gasoy 17), (H30Z x Hartwig), (H73ZBC x Hartwig) and (H3Z x H5L23) for number of pods per plant, number of seeds per plant and seed yield per plant. Another three crosses; (H30Z x Gasoy 17), (H73ZBC x Gasoy 17) and (H75ZBC x H5L23) were superior for number of days to flowering. These results are in accordance with those obtained by El-Hady *et al*.(1991), El-Hosary *et al*.(1994) and Bastawisy *et al*.(1997).

The mean performance of the 19 genotypes is given in Table (5). Wide variations between parents and between their F_1 crosses for all the studied traits were observed. These variations might be primarily attributed to genetic diversity among parents for all the studied traits. The parental line H30Z behaved as the earliest for maturity (108 days). However, the parental tester Harwig was the latest one for maturity (143.33 days). The parental line H75ZBC was the highest for seed yield per plant (18.6 g) and 100-seed weight (17.29 g), but the parental tester Gasoy 17 was the lowest for these two traits (13.04 and 13.94 g) respectively. Results indicated that top cross (H75ZBC x H5L23) gave the highest value for number of branches per plant, number of pods per plant and number of seeds per plant (7.40, 356.27 and 792.5), respectively. However, the top cross (H73ZBC x Gasoy 17) had the lowest value for the same traits (5.20, 115.77 and 179.00), respectively. The top cross (H3Z x Hartwig) was the earliest for maturity date (124.67 days), however, the top cross (H30Z x Hartwig) was the latest (141.0 days). For seed yield per plant the top cross (H30Z x H5L23) gave the highest value (129.7 g), while the top cross (H73ZBC x Gasoy 17) had the lowest value (29.7 g). Heterosis expressed as the percentage deviation of F_1 mean performance from its mid and better parent values for all the studied traits, are presented in Table (6). For plant height, all top crosses exceeded positive highly significant to mid and better parents, except the top cross (H3Z x Gasoy 17) whereas exhibited highly significant negative heterosis for better parent value and insignificant for mid parent value. For number of branches per plant, all top crosses expressed highly significant positive heterotic effects relative to mid and better parent values. Concerning flowering and maturity dates, all top crosses expressed highly significant positive heterotic effects relative to better parent values, however, some top crosses exhibited significant negative and insignificant heterotic effects relative to mid parent values for flowering and maturity dates. Regarding yield and its components, all top crosses exhibited highly significant positive heterotic effects relative to mid and better parent values. The top cross (H30Z x H5L23) gave the highest value for these traits, followed by cross (H75ZBC x H5L23). For 100-seed weight, the four top crosses (H3Z x Gasoy 17), (H30Z x Gasoy 17), (H73ZBC x Gasoy 17) and (H75ZBC x Hartwig) showed significantly positive heterotic effects relative to mid and better parent values. While, top crosses (H3Z x Hartwig), (H30Z x Hartwig), (H73ZBC x Hartwig), (H3Z x H5L23) and (H30Z x H5L23) showed insignificant heterotic effects relative to mid and better parent values for 100-seed weight. Hence, it could be concluded that these top crosses offer possibility for improving seed yield in soybean. These findings revealed that a hybridization program based on these materials would be useful. Similar trend was obtained by Weber *et al*.(1970), Paschal and

Wilcox (1975), Halvankar and Patil (1992), Bastawisy *et al*.(1997) and Habeeb (1998).

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تقييم الهجن القمية للمحصول وبعض الصفات الزراعية الأخرى فى فول الصويا

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أجرى هذا البحث بمحطة إيتاى البارود للبحوث الزراعية فى المواسم الصيفية عامى ٢٠٠٠ و ٢٠٠١ بهدف دراسة قوة الهجين والقدرة على التآلف لمجموعة من الهجن القمية لمحصول فول الصويا بين ثلاثة كشافات هى: Gasoy 17, Hartwig and H5L23 إستخدمت كآباء وأربع سلالات هى: H3Z, H30Z, H73ZBC and H75ZBC إستخدمت كأمهات.

فى الموسم الزراعى عام ٢٠٠٠ تم عمل التهجينات القمية بين هذه الأباء والأمهات السابقين وتكون لدينا أثنى عشر هجين قمى.

فى الموسم الزراعى عام ٢٠٠١ تم تقييم الجيل الأول وآباء هذه الهجن. وشملت الدراسة صفات طول النبات وعدد فروع النبات وميعاد التزهير وميعاد النضج وعدد قرون النبات وعدد البذور فى النبات ووزن ١٠٠ بذرة ووزن بذور النبات. وكانت النتائج المتحصل عليها كالتالى:

- كان تباين الآباء وتباين الهجن القمية وتباين التفاعل بين الكشافات والسلالات معنوياً لكل الصفات المدروسة.
- ساهم تباين القدرة الخاصة على التآلف بدور كبير فى وراثة كل الصفات المدروسة عدا صفة عدد الفروع للنبات مما يعنى أن التباين الراجع للعوامل غير المضيفة كان مهماً فى وراثة جميع الصفات تحت الدراسة.
- أوضحت قيم القدرة العامة على التآلف أن الكشاف H5L23 أفضل من الكشافين Hartwig و Gasoy 17 وكذلك كانت أفضل الأمهات هى H30Z يليه H75ZBC وذلك لصفات وزن محصول النبات وعدد بذور النبات وعدد قرون النبات وعدد فروع النبات.
- أوضحت قيم القدرة الخاصة على التآلف أن الهجين (H30Z x Hartwig) والهجين (H73ZBC x Hartwig) أعطت قيم موجبة وعالية المعنوية لكل من وزن محصول النبات وعدد بذور النبات وعدد قرون النبات.
- إتضح من دراسة المتوسطات أن الهجين (H75ZBC x H5L23) كان أفضل الهجن القمية حيث أعطى أعلى قيمة لكل من صفات وزن بذور النبات (١١٩,٤جرام) وعدد بذور النبات (٧٩٢,٥) بذرة وعدد قرون للنبات (٣٥٩,٢) قرن وعدد فروع للنبات (٧,٤) فرع.
- كانت قيم قوة الهجين الخاصة بصفات وزن محصول النبات وعدد بذور النبات وعدد قرون النبات معنوية موجبة لمعظم الهجن القمية سواء مقارنة بمتوسط الأبوين أو مقارنة بالأب الأعلى قيمة.

Table (2): Analysis of variance for all the studied characters.

S.O.V	d.f	Plant height (cm)	No. of branches /plant	No. of days to flowering	No. of days to maturity	No. of pods /plant	No. of seeds /plant	100-seed weight (g)	Seed yield /plant (g)
Replications	2	2.33	0.33	1.42	0.69	58.7	82.54	0.44	3.30
Genotypes	18	365.22**	8.67**	139.65**	236.59**	22036.24**	168086.47**	3.63**	4899.17**
Parents	6	178.78**	0.58**	300.67**	516.64**	571.68**	1317.74**	3.88**	14.01
Crosses	11	164.24**	2.31**	59.28**	75.69**	19609.93**	129611.86**	3.17**	3450.24**
Lines (females)	3	454.81**	5.67**	58.10**	57.52**	15712.25**	83455.46**	2.34**	2068.34**
Testers (males)	2	112.14**	1.42**	127.09**	176.36*	57138.37**	425916.97**	9.14**	12956.04**
Line x tester	6	36.33**	0.92**	37.27**	51.21**	9049.29**	53921.70**	1.56**	972.59**
Parent vs. cross	1	3694.57**	127.27**	57.57**	326.34**	177513.03**	1591919.51**	7.26**	50148.26**
Error	36	3.02	0.11	1.05	2.15	45.35	211.04	0.17	10.13
δ^2 gca		5.52	0.06	0.83	1.06	455.56	3265.07	0.07	106.88
δ^2 sca		11.10	0.27	12.07	16.35	3001.31	17903.55	0.46	320.82

δ^2 gca and δ^2 sca refer to general and specific combining abilities, respectively.
*** and ** : Significant at 0.05 and 0.01 levels of probability, respectively.**

Table (3): General combining ability effect for all the studied characters.

Parent	Plant height (cm)	No. of branches/plant	No. of days to flowering	No. of days to maturity	No. of pods/plant	No. of seeds/plant	100-seed weight(g)	Seed yield /plant(g)
Line (female)								
H3Z	-9.89**	-0.85**	0.92**	-3.39**	-28.30**	-76.52**	-0.66**	-15.71**
H30Z	3.05**	0.22*	2.25**	2.72**	39.78**	90.56**	-0.15	14.43**
H73ZBC	6.66**	-0.36**	0.47	0.50	-43.08**	-89.67**	0.36*	-10.18**
H75ZBC	0.18	0.99**	-3.64**	0.17	31.60**	75.63**	0.45**	11.46**
S.E ($\hat{g}i - \hat{g}j$)	0.82	0.16	0.48	0.69	3.17	6.85	0.19	1.50
Tester (male)								
Gasoy 17	-3.34**	-0.39**	3.75**	2.74**	-51.57**	-175.93**	0.71**	-31.74**
Hartwig	2.66**	0.14	-2.08**	1.71**	-26.82**	-22.85**	0.26*	-2.23*
H5L23	0.68	0.25*	-1.67**	-4.45**	78.39**	198.78**	-0.97**	33.97**
S.E ($\hat{g}i - \hat{g}j$)	0.71	0.14	0.42	0.60	2.75	5.93	0.17	1.30

*** and ** : Significant at 0.05 and 0.01 levels of probability, respectively.**

Table (4): Specific combining ability effects for all the studied top-crosses.

Crosses	Plant height(cm)	No. of branches/plant	No. of days to flowering	No. of days to maturity	No. of pods/plant	No. of seeds/plant	100-seed weight(g)	Seed yield /plant(g)
H3Z x Gasoy 17	-0.02	0.49*	-0.75	0.64	34.04**	65.44**	-0.35	10.86**
H30Z x Gasoy 17	-1.56	-0.52**	3.58**	-2.47**	-52.54**	-125.05**	0.02	-20.68**
H73ZBC x Gasoy 17	-2.97**	0.03	2.36**	0.08	18.04**	-15.22	0.83**	-5.75**
H75ZBC x Gasoy 17	4.55**	-0.02	-5.2**	1.75*	-0.46	74.82**	-0.50*	15.55**
H3Z x Hartwig	0.22	0.19	0.42	-4.36**	-19.54**	-96.97**	0.03	-18.51**
H30Z x Hartwig	-0.66	0.54**	-1.58**	5.86**	28.82**	77.17**	-0.25	16.64**
H73ZBC x Hartwig	-0.07	-0.49*	-2.47**	1.41	45.08**	152.91**	-0.79**	14.14**
H75ZBC x Hartwig	0.52	-0.22	3.64*	-2.92**	-53.44**	-133.09**	1.01**	-12.27**
H3Z x H5L23	-0.2	-0.68**	0.33	3.72**	-14.50**	31.53**	0.32	7.65**
H30Z x H5L23	2.22*	-0.02	-2.00**	-3.39**	23.72**	47.88**	0.23	4.04*
H73ZBC x H5L23	3.04**	0.46*	0.11	-1.50	-63.12**	-137.69**	-0.03	-8.39**
H75ZBC x H5L23	-5.07**	0.24	1.56**	1.17	53.90**	58.27**	-0.51*	-3.28
S.E ($\hat{S}_{ij}$ - $\hat{S}_{kj}$)	1.42	0.27	0.84	1.20	5.50	11.86	0.34	2.59

*** and ** : Significant at 0.05 and 0.01 levels of probability, respectively.**

Table (5): The genotypes mean performance for all the studied traits.

Genotypes	Plant height(cm)	No. of branches/plant	No. of days to flowering	No. of days to maturity	No. of pods/plant	No. of seeds/plant	100-seed weight (g)	Seed yield /plant(g)
H3Z	82.73	3.33	38.00	116.33	92.10	119.40	15.31	16.45
H30Z	74.97	2.43	33.67	108.00	81.37	123.33	16.07	15.89
H73ZBC	91.50	2.43	37.00	120.67	71.87	145.27	15.42	18.11
H75ZBC	85.20	2.80	37.67	119.67	89.17	127.13	17.29	18.60
Gasoy 17	98.53	3.00	61.00	140.67	59.50	94.00	13.94	13.04
Hartwig	93.17	3.40	50.67	143.33	84.77	95.60	16.63	15.57
H5L23	85.87	2.33	50.00	131.67	58.13	88.83	14.74	13.19
H3Z x Gasoy 17	90.87	5.17	50.00	130.67	146.57	272.80	16.08	40.78
H30Z x Gasoy 17	102.27	5.23	55.67	133.67	128.07	249.40	16.96	39.38
H73ZBC x Gasoy 17	104.47	5.20	52.67	134.00	115.77	179.00	18.28	29.70
H75ZBC x Gasoy 17	105.50	6.50	41.00	135.33	172.87	434.33	17.03	72.65
H3Z x Hartwig	97.10	5.40	45.33	124.67	117.73	263.47	16.00	40.94
H30Z x Hartwig	109.17	6.80	44.67	141.00	234.17	604.70	16.24	106.18
H73ZBC x Hartwig	113.37	5.20	42.00	134.33	187.57	500.20	16.19	79.07
H75ZBC x Hartwig	107.47	6.83	44.00	129.67	142.83	379.50	18.08	74.30
H3Z x H5L23	94.70	4.63	45.67	126.67	227.97	613.60	15.07	103.17
H30Z x H5L23	110.07	6.37	44.67	125.67	334.27	797.03	15.47	129.70
H73ZBC x H5L23	114.50	6.27	45.00	125.33	164.60	431.23	15.72	92.67
H75ZBC x H5L23	99.90	7.40	42.33	127.67	356.27	792.50	15.34	119.40
$L.S.D_{0.05}$	2.87	0.55	1.69	2.42	11.12	23.96	0.68	5.25
$L.S.D_{0.01}$	3.83	0.73	2.26	3.23	14.85	32.03	0.91	7.02

Table (6): Percentage values of heterotic effects relative to mid (M.P) and better (B.P) parents for all the studied traits.

Crosses	Plant height		No. of branches/ plant		No. of days to flowering		No. of days to maturity		No. of pods /plant		No. of seeds /plant		100-seed weight		Seed yield /plant	
	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P
H3Z x Gasoy 17	0.26	-7.77**	63.09**	55.26**	1.01	31.58**	1.69*	12.33**	93.36**	59.14**	155.67**	128.48**	9.91**	5.03*	176.57**	147.90**
H30Z x Gasoy 17	18.58**	4.40**	92.28**	74.33**	17.55**	65.34**	7.51**	23.77**	81.81**	57.39**	129.51**	102.22**	12.99**	5.54*	172.24**	147.83**
H73ZBC x Gasoy 17	9.95**	6.03**	91.18**	73.33**	7.49**	42.35**	2.55**	11.05**	76.24**	61.08**	49.62**	23.22**	24.52**	18.55**	90.69**	63.99**
H75ZBC x Gasoy 17	14.84**	7.07**	124.14**	116.67**	-16.90**	8.84**	3.96**	13.09**	132.54**	93.68**	292.81**	241.64**	9.03**	-1.50	359.23**	290.59**
H3Z x Hartwig	10.40**	4.22**	60.24**	58.82**	2.23	19.29**	-3.97**	7.17**	33.12**	27.83**	146.02**	120.66**	0.19	-3.79	155.72**	148.88**
H30Z x Hartwig	29.86**	17.17**	132.88**	100.00**	5.93**	32.67**	12.20**	30.56**	181.89**	176.24**	452.39**	390.31**	-0.67	-2.35	275.02**	268.22**
H73ZBC x Hartwig	22.78**	21.68**	78.08**	52.94**	-4.20*	13.51**	1.77*	11.32**	139.49**	121.27**	315.31**	244.32**	1.00	-2.65	369.54**	366.61**
H75ZBC x Hartwig	20.50**	15.35**	120.32**	100.88**	-0.38	16.80**	-1.39	8.36**	64.23**	60.18**	240.76**	198.51**	6.60**	4.57*	334.88**	299.46**
H3Z x H5L23	12.34**	10.28**	77.74**	39.04**	-3.80*	20.18**	2.15*	8.89**	203.47**	147.52**	489.38**	413.90**	0.27	-1.57	596.15**	527.17**
H30Z x H5L23	36.87**	28.18**	167.65**	162.14**	6.76**	32.67**	4.87**	16.36**	379.24**	310.80**	651.35**	546.26**	0.39	-3.73	792.02**	716.24**
H73ZBC x H5L23	29.10**	25.14**	163.44**	158.02**	3.45*	21.62**	-0.67	3.86**	155.19**	129.02**	268.42**	196.85**	4.24*	1.95	492.14**	411.71**
كلنا نبايع مبارك Sk	16.79**	16.34**	187.94**	164.29**	-3.44*	12.37**	1.59	6.69**	383.73**	299.54**	633.93**	523.38**	-4.24*	-11.28**	651.18**	541.94**

*** and **: Significant at 5% and 1% level of probability, respectively.**