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ESTIMATION OF HETEROSIS, INBREEDING DEPRESSION AND COMBINING ABILITY IN SNAP BEANS (*Phaseolus vulgaris*) USING LINE X TESTER ANALYSIS.

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ABSTRACT

The present study on using "Line x Tester analysis" was conducted to find out heterosis, inbreeding depression and combining ability on Snap Beans during years 1999 and 2000 autumn season. The variances due to genotypes were significant for all characters in both seasons except for vitamin C content in 1999. The highest percentage of heterosis over high parent for yield per plant was observed in the cross (2 x 6) in both seasons. Variety Serbo had high GCA for yield per plant in the two seasons. Estimates of heterosis, GCA (general combining ability) and SCA (specific combining ability) showed that the best combiners were Serbo and Helda, while the best combinations were (1 x 6), (2 x 5) and (2 x 6).

INTRODUCTION

For many years, exploitation of heterosis and combining ability to select the better general combiners and specific combinations had opened the way of crop improvement. In Snap Beans, there were several articles on studying heterosis and combining ability (Nienhuis and Singh, 1986; Singh *et al.*, 1992; Yadav and Harer 1994 and Oliveira *et al.*, 1996) most of them have not been utilized for commercial production. Using mating design like "Line x Testers analysis" was found suitable for studying both heterosis and combining ability to select suitable combiners and combinations to produce new bean variety (Dixit *et al.* 1980). In the current trial, "Line x Tester analysis" was employed to identify the best combiners and combinations beside the extent of heterosis.

MATERIALS AND METHODS

Three varieties of snap beans as females (Lines) namely Helda (climbing beans), Giza3 and HAB53 (bush type beans) were crossed with three males (Testers) namely HAB32, Bronco (bush type beans) and Serbo (climbing beans) selected on the basis of good adaptability and desirable horticultural characters. The seeds of these genetic resources were obtained from Vegetable Research Departments, Horticulture Research Institute. The seeds of 9 F_1 hybrids and F_2 generations along with the 6 parents were sown in two seasons of years 1999 and 2000 in a randomized block design with three replications at Kaha vegetable research station, Kaliobia governorate. Seed sowing was carried out on September 1999 and September 2000. Seeds were sown on ridges with dimensions of 60 cm wide and 4 m long. The distance between plants was 20 cm. Each replicate contained 24 plots. The area of each plot was 7.2 m^2 consisted of 60 plants. Furrow irrigation

was used and normal agricultural practices were adopted according to the recommendations of Ministry of Agriculture. Data were recorded on ten plants for 10 characters namely, number of days from planting to 50% flowering, number of days from planting to maturity, pod length, pod diameter, pod thickness, pod weight, protein content, vitamin C content, number of pods per plant and yield per plant. Data were statistically analyzed for the study of combining ability according to Singh and Chaudhary (1977).

RESULTS AND DISCUSSION

There were significant differences among genotypes in both 1999 and 2000 seasons for all traits except for vitamin C content in 1999 showing wide range of variability between the parents chosen for the trial (Table 1 a and b). In respect of males there were significant differences only in pod weight in both seasons and in yield per plant in 2000 season. While, in respect of females there were significant differences in number of days to 50% flowering in the first season, pod diameter in both seasons and pod weight in the second season. In addition, females x males showed significant differences in both seasons in number of days to 50% flowering, pod weight, pod thickness, pod diameter and number of pods per plant and in the first season for number of days to maturity, pod weight and yield per plant. These results were in line with those found by Raut *et al.* (1991) and Singh *et al.* (1992) on mung bean and common bean.

The magnitude of mean squares due to male were larger than female x male for number of days to 50% flowering, number of days to maturity, pod length, pod thickness, pod diameter, pod weight, protein content, vitamin C content and yield per plant in 1999 season while the magnitude of mean squares due to male were larger than female x male for pod length, pod diameter, pod weight and yield per plant in the second season indicating great diversity among males where these results were agreed with those had been recorded by Singh *et al.* (1992) on common bean.

Beside that, there were significant differences among F_1 and F_2 generations for all the studied characters in both seasons except for number of days to maturity in the second season, protein content and vitamin C content in both 1999 and 2000 seasons (Table 2 a and b). These records were in accordance with those had been reported on *Phaseolus spp* by Sayed (1998) on number of days to 50% flowering, pod weight and pod length. However, they were in contrast with his results on yield per plant, number of pods per plant, number of days to maturity, pod diameter, pod thickness. Meanwhile, the insignificant results of the present work concerning number of days to maturity and protein content were in line with the records of Sayed (1998) on *Phaseolus spp* and Singh and Saini (1985) on French bean.

The mean values of parents (female lines and male testers) are shown in Table (3) while the mean values of hybrids and heterosis over high parents are shown in Table (4 a and b). Out of 9 hybrids, 2 exceeded their high parents in number of days to 50% flowering [(3 x 5) and (2 x 4)], number of days to maturity [(3 x 5) and (2 x 4)], number of pods per plant [(2 x 4) and

Table (1a): Analysis of variance for genotypes for ten characters of 6 parents and 9 F_1 hybrids in snap beans during 1999 and 2000 seasons.

Source of variance	df	Mean sum of square									
		Number of days to 50% flowering		Number of days to maturity		Pod length (cm)		Pod thickness (cm)		Pod diameter (cm)	
		1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Genotype	14	42.498*	48.571*	112.756*	31.41*	24.945*	23.519*	0.015*	0.028*	0.255*	0.266*
Males (T)	2	17.444	7.259	42.926	19.843	21.811	23.033	0.018	0.0005	0.059	0.303
Females(L)	2	86.111*	7.148	188.482	12.509	38.746	32.38	0.025	0.026	0.559*	0.593*
T x L	4	12.222*	81.981*	33.426*	22.454	13.785*	10.77*	0.006*	0.015*	0.053*	0.076*
Error	28	3.398	9.414	3.584	10.682	0.244	0.858	0.0004	0.001	0.009	0.007

(*) significant at 5% level.

Table (1b): Analysis of variance for genotypes for ten characters of 6 parents and 9 F_1 hybrids in snap beans during 1999 and 2000 seasons.

Source of variance	df	Mean sum of square									
		Pod weight (g)		Protein content (%)		Vitamine C content (%)		Number of pods per plant		Yield per plant (g)	
		1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Genotypes	14	7.279*	9.107*	0.118*	0.096*	4.944	11.178*	152.803*	99.279*	4603.888*	5538.921*
Males (T)	2	21.343*	17.02*	0.073	0.059	5.293	6.824	70.778	12.037	11437.007	11435.827*
Females(L)	2	10.151	14.624*	0.201	0.032	0.066	3.778	302.333	220.037	152.914	554.805
T x L	4	1.596*	2.043	0.033	0.06	3.743	6.957	117.944*	89.037*	1672.448*	461.29
Error	28	0.248	1.554	0.034	0.032	11.308	3.67	10.046	10.865	322.205	973.68

(*) significant at 5% level.

Table (2a): Analysis of variance for F_1 and F_2 generations for ten characters in snap beans during 1999 and 2000 seasons.

Source of variance	df	Mean sum of square									
		Number of days to 50% flowering		Number of days to maturity		Pod length (cm)		Pod thickness (cm)		Pod diameter(cm)	
		1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Genotypes	17	33.21*	57.20*	72.41*	32.52	19.07*	15.97*	0.02*	0.02*	0.16*	0.20*
Error	34	4.91	14.01	2.94	19.35	0.27	1.63	0.001	0.002	0.01	0.01

(*) Significant at 5% level.

Table (2b): Analysis of variance for F_1 and F_2 generations for ten characters in snap beans during 1999 and 2000 seasons.

Source of variance	df	Mean sum of square									
		Pod weight (g)		Protein content %		Vitamin C content (%)		Number of pods per plant		Yield per plant (g)	
		1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Genotypes	17	6.85*	7.04*	0.09	0.05	4.77	5.42	123.66*	93.84*	3501.8*	2623.05*
Error	34	0.10	1.34	0.06	0.03	11.03	3.61	3.2	9.92	85.15	466.2

(*) Significant at 5% level.

Table (3): Mean values of the parents for ten characters during 1999 and 2000 seasons.

Genotype	Number of days to 50% flowering		Number of days to maturity		Pod length (cm)		Pod thickness (cm)		Pod diameter (cm)		Pod weight (g)		Protein content (%)		Vitamine C content (%)		Number of pods per plant		Yield per plant (g)	
	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Female(L):																				
Helda (1)	42	52	55	63	20	20	0.63	0.62	1.73	1.56	6.63	7.67	2.37	2.03	29.84	21.92	25	26	165.4	200.37
Giza3 (2)	35	53	47	65	13	14	0.85	0.88	0.93	0.86	3.08	3.67	2.11	2.03	27.27	21.92	10	14	31.95	51.17
HAB53 (3)	37	42	46	58	12	12	0.76	0.74	0.85	0.8	3.14	4.16	2.42	1.76	29.6	18.95	29	22	89.99	91.08
Male (T):																				
HAB32 (4)	42	53	58	66	14	15	0.8	0.86	0.83	0.8	3.92	3.67	2.07	1.71	26.45	18.42	17	18	68.39	69.33
Bronco (5)	46	50	64	65	15	15	0.7	0.61	0.76	0.67	2.6	2.77	2.03	2.04	25.68	22.00	22	23	56	62.37
Serbo (6)	36	48	45	60	10	9	0.68	0.61	0.77	0.76	3.26	2.23	2.14	1.8	27.9	19.45	25	26	80.39	58.06

Table (4a): Mean values and heterosis (H%) over high parent for ten characters of 9 F_1 generations during 1999 season.

Cross	Number of days to 50% flowering		Number of days to maturity		Pod length (cm)		Pod thickness (cm)		Pod diameter (cm)		Pod weight (g)		Protein content (%)		Vitamine C content (%)		Number of pods per plant		Yield per plant (g)	
	mean	H%	mean	H%	mean	H%	mean	H%	mean	H%	mean	H%	mean	H%	mean	H%	mean	H%	mean	H%
1 x 4	36	-14.17	51	-10.98	17.76	-12.42	0.8	0.5	1.05	-39.16	4.67	-29.65	2.59	9.33	26.14	-12.42	24	-1.35	113.8	-31.2
1 x 5	42	-8.03	62	-4.15	13.58	-33.02	0.71	1.19	1.13	-34.61	3.17	-52.26	2.54	7.22	28.78	-3.56	17	-31.08	53.83	-67.45
1 x 6	42	-1.57	52	-4.88	20.71	2.15	0.63	-6.84	1.47	-15.24	7.5	13.07	2.59	9.33	29.82	-0.08	18	-27.03	135.1	-18.32
2 x 4	37	-13.39	47	-17.92	12.29	-13.65	0.75	-11.43	0.84	-10.01	2.5	-36.22	2.51	18.9	28.23	3.55	26	51.92	65.5	-4.23
2 x 5	40	-12.41	49	-23.83	14.35	-3.67	0.74	-12.69	0.71	-23.1	2.57	-16.62	2.17	2.71	28.46	4.37	30	40	77.73	38.81
2 x 6	37	1.85	46	-2.11	13.32	-0.42	0.71	-17.15	0.76	-17.79	4	22.6	2.14	-0.07	27.86	-0.11	36	44.59	142.53	77.3
3 x 4	34	-7.21	48	-16.76	13.76	-3.36	0.85	6.67	0.83	-2.34	3.27	-16.67	2.48	2.36	27.69	-6.45	38	31.4	122.93	36.62
3 x 5	34	-26.28	46	-28.5	13.37	-10.28	0.77	2.2	0.74	-13.4	2.4	-38.78	2.42	0.0	27.6	-6.76	25	-13.95	59.57	-33.8
3 x 6	34	-9.01	46	0.73	16.31	30.8	0.81	7.63	0.83	-3.16	5.53	69.6	2.37	-2.34	28.94	-2.22	23	-19.77	127.33	41.51

Table (4b): Mean values and heterosis (H%) over high parent for ten characters of 9 F_1 generations during 2000 season.

Cross	Number of days to 50% flowering		Number of days to maturity		Pod length (cm)		Pod thickness (cm)		Pod diameter (cm)		Pod weight (g)		Protein content (%)		Vitamine C content (%)		Number of pods per plant		Yield per plant (g)	
	mean	H%	mean	H%	mean	H%	mean	H%	mean	H%	mean	H%	mean	H%	mean	H%	mean	H%	mean	H%
1 x 4	48	-9.43	61	-7.07	13.54	-31.53	0.59	-31.48	1.14	-27.4	4.35	-43.26	2.21	8.75	23.84	8.75	27	3.9	116.33	-41.94
1 x 5	48	-7.74	59	-10	15.32	-22.57	0.58	-6.9	0.99	-36.67	4.5	-41.3	2.03	-0.16	21.96	-0.17	18	-28.57	83.97	-58.09
1 x 6	42	-18.06	60	-4.23	19.98	0.99	0.68	8.99	1.62	3.77	8.42	9.87	2.23	9.66	24.04	9.65	18	-29.49	150.96	-24.66
2 x 4	42	-20.75	56	-15.66	12.21	-17.7	0.66	-24.83	0.74	-13.49	2.99	-18.48	1.88	-7.46	20.29	-7.46	25	34.55	73.44	5.92
2 x 5	47	-11.32	62	-4.1	14.09	-2.91	0.78	-11.17	0.76	-11.23	2.52	-31.21	2.19	7.36	23.62	7.36	34	50	85.12	36.48
2 x 6	51	-3.14	56	-13.7	12.24	-13.67	0.72	-17.71	0.78	-8.27	4.37	19.09	2.09	2.94	22.56	2.94	34	32.05	149.48	157.47
3 x 4	53	0.0	58	-12.63	11.88	-19.89	0.72	-18.36	0.75	-6.13	3.43	-17.38	2.11	20.25	22.79	20.25	26	18.46	87.37	-4.08
3 x 5	43	-14	62	-4.62	12.61	-13.09	0.63	-15.83	0.75	-6.54	3.47	-16.58	2.03	-0.31	21.93	-0.31	23	1.47	79.86	-12.32
3 x 6	47	-1.39	60	-0.56	15	22.73	0.61	-17.53	1.1	37.75	4.98	19.91	2.32	29.06	25.1	29.06	29	12.82	146.2	60.52

Table (5a): Mean values and inbreeding depression (ID%) for ten characters of 9 F_2 generations during 1999 season.

Cross	Number of days to 50% flowering		Number of days to maturity		Pod length (cm)		Pod thickness (cm)		Pod diameter (cm)		Pod weight (g)		Protein content (%)		Vitamine C content (%)		Number of pods per plant		Yield per plant (g)	
	mean	ID%	mean	ID%	mean	ID%	mean	ID%	mean	ID%	mean	ID%	mean	ID%	mean	ID%	mean	ID%	mean	ID%
1 x 4	33	-8.26	49	-4.71	17.51	-1.42	0.72	-10.32	0.94	-10.71	3.82	-18.11	2.55	-1.29	25.13	-3.85	23	-6.85	100.2	-11.95
1 x 5	40	-3.97	61	-1.76	11.58	-14.75	0.63	-10.54	1.05	-7.46	2.44	-22.9	2.25	-11.17	26.79	-.6.93	14	-18.14	25.4	-52.82
1 x 6	40	-3.00	51	-2.08	18.03	-12.97	0.62	-1.96	1.36	-7.42	6.22	-17.01	2.25	-12.89	27.81	-6.74	15	-18.52	122.94	-9.00
2 x 4	36	-2.96	45	-5.46	11.53	-6.17	0.67	-11.01	0.82	-2.47	1.95	-21.89	2.45	-2.11	25.81	-8.58	20	-23.73	57.84	-11.7
2 x 5	40	-0.63	46	-6.97	13.73	-4.38	0.73	-2.2	0.65	-9.14	2.43	-5.31	2.1	-3.17	27.47	-3.48	23	-23.63	60.85	-21.72
2 x 6	36	-1.36	46	-0.9	12.61	-5.38	0.68	-4.21	0.72	-5.52	3.59	-10.37	2.12	-0.94	27.72	-0.51	27	-25.47	99.35	-30.3
3 x 4	33	-3.16	47	-1.56	13.34	-3.02	0.83	-2.97	0.80	-3.48	3.15	-3.7	2.25	-9.41	25.73	-7.08	29	-24.12	91.95	-25.2
3 x 5	32	-4.21	46	-0.91	13.15	-1.66	0.67	-13.17	0.66	-10.31	2.38	-0.87	2.22	-8.26	26.02	-5.73	22	-10.47	52.33	-12.16
3 x 6	32	-4.21	45	-1.81	13.87	-14.94	0.77	-6.02	0.75	-8.79	4.37	-21.08	2.20	-7.05	27.09	-6.38	21	-7.98	106.26	-16.55

Table (5b): Mean values and inbreeding depression (ID%) for ten characters of 9 F_2 generations during 2000 season.

Cross	Number of days to 50% flowering		Number of days to maturity		Pod length (cm)		Pod thickness (cm)		Pod diameter (cm)		Pod weight (g)		Protein content (%)		Vitamine C content (%)		Number of pods per plant		Yield per plant (g)	
	mean	ID%	mean	ID%	mean	ID%	mean	ID%	mean	ID%	mean	ID%	mean	ID%	mean	ID%	mean	ID%	mean	ID%
1 x 4	46	-4.51	59	-3.4	11.66	-13.89	0.52	-12.85	1.05	-7.17	3.69	-15.13	2.04	-7.69	22.01	-7.69	24	-8.75	103.41	-11.11
1 x 5	46	-3.67	56	-4.7	14.4	-5.97	0.56	-3.25	0.91	-8.24	3.88	-13.89	2.01	-1.09	21.72	-1.09	15	-17.73	72.08	-14.16
1 x 6	39	-8.86	60	-0.97	17.29	-13.46	0.65	-4.73	1.39	-14.25	6.69	-20.62	2.07	-6.97	22.36	-6.97	15	-20.46	137.27	-9.07
2 x 4	37	-13.1	51	-8.61	11.06	-9.42	0.56	-15.81	0.7	-5.83	2.46	-17.84	1.81	-3.93	19.49	-3.93	20	-17.57	58.9	-19.79
2 x 5	45	-4.79	61	-2.47	13.58	-3.62	0.76	-2.29	0.74	-2.06	2.18	-13.76	2.08	-4.72	22.5	-4.72	26	-23.28	70.94	-16.65
2 x 6	49	-5.03	52	-5.91	12.02	-1.81	0.71	-1.5	0.77	-1.43	3.66	-16.22	2.00	-4.16	21.63	-4.16	27	-21.12	102.05	-31.73
3 x 4	50	-4.87	56	-2.96	10.77	-9.38	0.67	-6.47	0.71	-5.09	2.87	-16.34	2.00	-5.17	21.62	-5.17	22	-15.58	74.46	-14.77
3 x 5	41	-5.62	62	-0.74	12.29	-2.52	0.53	-14.89	0.71	-5.34	3.20	-7.7	1.94	-4.43	20.96	-4.43	20	-11.59	68.88	-13.74
3 x 6	45	-4.93	56	-5.45	12.91	-13.94	0.57	-6.93	0.94	-14.69	4.09	-17.95	2.05	-11.75	22.15	-11.75	27	-9.38	110.39	-24.5

Table (6a): Estimates of general combining ability (GCA) for ten characters in snap beans during 1999 season.

Sr.no.	parents	Number of days to 50% flowering	Number of days to maturity	Pod length (cm)	Pod thickness (cm)	Pod diameter (cm)	Pod weight (g)	Protein content (%)	Vitamine C content (%)	Number of pods per plant	Yield per plant (g)
	Female (L)										
1	Helda	2.78	5.26	2.3	-0.04	0.29	1.16	0.15	0.08	-6.56	1.1
2	Giza3	0.56	-2.19	-1.73	-0.02	-0.16	-0.93	-0.15	0.02	4.44	-4.56
3	HAB53	-3.33	-3.07	-0.57	0.06	-0.13	-0.22	0.001	-0.09	2.11	3.46
	Male (T)										
4	HAB32	-1.44	-0.85	-0.45	0.05	-0.02	-0.48	0.1	-0.82	3.11	0.93
5	Bronco	1.33	2.48	-1.28	-0.01	-0.07	-1.24	-0.05	0.11	-2.33	-36.1
6	Serbo	0.11	-1.63	1.73	-0.04	0.09	1.72	-0.06	0.71	-0.78	35.17
C.D. at 5%		1.71	1.75	0.46	0.02	0.09	0.46	0.17	3.11	2.93	16.61

Table (6b): Estimates of general combining ability (GCA) for ten characters in snap beans during 2000 season.

Sr.no.	parents	Number of days to 50% flowering	Number of days to maturity	Pod length (cm)	Pod thickness (cm)	Pod diameter (cm)	Pod weight (g)	Protein content (%)	Vitamine C content (%)	Number of pods per plant	Yield per plant (g)
	Female (L)										
1	Helda	-0.85	0.81	2.18	-0.05	0.29	1.42	0.03	0.38	-4.93	9.01
2	Giza3	-0.07	-1.35	-1.25	0.06	-0.2	-1.04	-0.07	-0.75	4.96	-5.4
3	HAB53	0.93	0.54	-0.93	-0.01	-0.09	-0.38	0.03	0.37	-0.04	-3.61
	Male (T)										
4	HAB32	0.81	-1.02	-1.55	-0.01	-0.08	-0.75	-0.06	-0.6	-0.37	-15.7
5	Bronco	-0.96	1.7	-0.09	-0.001	-0.13	-0.84	-0.04	-0.4	-0.93	-25.1
6	Serbo	0.15	-0.69	1.64	0.01	0.21	1.59	0.09	1	1.3	40.8
C.D. at 5%		2.84	3.02	0.86	0.03	0.08	1.15	0.16	1.78	3.05	28.87

Table (7a): Estimates of specific combining ability (SCA) for ten characters in snap beans during 1999 season.

Cross	Number of days to 50% flowering	Number of days to maturity	Pod length (cm)	Pod thickness (cm)	Pod diameter (cm)	Pod weight (g)	Protein content (%)	Vitamine C content (%)	Number of pods per plant	Yield per plant (g)
1 x 4	-2.22	-2.81	0.86	0.04	-0.14	0.03	-0.09	-1.29	1.44	11.96
1 x 5	0.67	4.19	-2.49	0.006	-0.02	-0.7	0.01	0.43	-0.44	-10.97
1 x 6	1.56	-1.37	1.63	-0.05	0.16	0.67	0.07	0.87	-1.00	-0.99
2 x 4	0.33	0.63	-0.58	-0.03	0.09	-0.04	0.13	0.86	-7.56	-30.69
2 x 5	0.89	-1.04	2.31	0.02	0.01	0.79	-0.06	0.16	1.89	18.58
2 x 6	-1.22	0.41	-1.73	0.01	-0.1	-0.74	-0.08	-1.03	5.67	12.1
3 x 4	1.89	2.19	-0.27	-0.01	0.06	0.01	-0.05	0.43	6.11	18.73
3 x 5	-1.56	-3.15	0.17	-0.03	0.01	-0.09	0.05	-0.59	-1.44	-7.61
3 x 6	-0.33	0.96	0.1	0.04	-0.06	0.08	0.001	0.16	-4.67	-11.12
C.D. at 5%	2.18	2.24	0.58	0.02	0.11	0.59	0.22	3.98	3.75	21.22

Table (7b): Estimates of specific combining ability (SCA) for ten characters in snap beans during 2000 season.

cross	Number of days to 50% flowering	Number of days to maturity	Pod length (cm)	Pod thickness (cm)	Pod diameter (cm)	Pod weight (g)	Protein content (%)	Vitamine C content (%)	Number of pods per plant	Yield per plant (g)
1 x 4	1.19	2.3	-1.18	-0.02	-0.03	-0.66	0.11	1.16	5.93	14.95
1 x 5	2.63	-3.26	-0.87	-0.04	-0.13	-0.42	-0.09	-0.92	-1.85	-8.02
1 x 6	-3.81	0.96	2.05	0.05	0.16	1.08	-0.02	-0.24	-4.07	-6.93
2 x 4	-5.59	-1.2	0.91	-0.05	0.06	0.44	-0.11	-1.27	-5.96	-13.54
2 x 5	1.19	2.74	1.33	0.06	0.12	0.07	0.17	1.86	3.93	7.54
2 x 6	4.41	-1.54	-2.25	-0.01	-0.19	-0.51	-0.05	-0.59	2.04	6.01
3 x 4	4.41	-1.09	0.27	0.07	-0.03	0.22	0.01	0.11	0.04	-1.41
3 x 5	-3.81	0.52	-0.46	-0.03	0.01	0.35	-0.09	-0.94	-2.07	0.48
3 x 6	-0.59	0.57	0.19	-0.05	0.02	-0.56	0.08	0.83	2.04	0.93
C.D. at 5%	3.63	3.86	1.1	0.04	0.1	1.47	0.21	2.27	3.9	36.9

(2 x 5)], pod thickness [(1 x 4) and (2 x 6)], pod diameter [(1 x 4) and (1 x 5)], protein content [(2 x 4) and (3 x 6)] and vitamin C content [(2 x 5) and (3 x 6)]. The range of increase in hybrids was between (-26.28: -1.39%), (-28.5: -0.5%), (1.47: 51.92%), (-31.48: -6.84%), (-39.16: -2.34%), (2.36: 29.06%) and (2.94: 29.06%) for the same previous mentioned characters respectively. The results presented in Table (4 a and b) indicated also that one out of 9 hybrids exhibited an increase in pod length (3 x 6), pod weight (3 x 6) and yield per plant (2 x 6) over their high parents. The increase varied from 0.99% to 30.8% for pod length, 9.87% to 69.6% for pod weight and 5.92% to 157.47% for yield per plant over high parent.

The highest percentage of heterosis over high parent was observed in the cross (3 x 5) for number of days to 50% flowering and number of days to maturity during the first season; the cross (2 x 4) for number of days to 50% flowering, number of days to maturity during the second season, number of pods per plant and protein content during the first season; the cross (3 x 6) for pod length, pod weight in both two seasons, protein content and vitamin C content in the second season; the cross (2 x 5) for number of pods per plant in the second season and vitamin C content in the first season; the cross (2 x 6) for yield per plant in both seasons and for pod thickness in the first season; the cross (1 x 4) for pod diameter in the first season and pod thickness in the second season and the cross (1 x 5) for pod diameter in the second season. The most promising crosses were (2 x 5) and (2 x 6) which could be involved in an advanced breeding program to produce the seeds of F_2 generation and the subsequent generations to select the most promising offsprings to produce a new local variety with desirable horticultural characters suitable for local and export markets. These findings were similar to those reported on french bean by Singh and Saini (1985) that recorded high heterosis in 11 of 21 F_1 over high parent in protein content. While, on mung bean Patil *et al.* (1992) recorded high heterosis in number of pods per plant, yield per plant and pod weight. In addition to that Link *et al.* (1996) on faba bean showed high heterosis in yield per plant, number of days to 50% flowering, number of days to maturity, pod thickness, pod length and pod diameter. While, on faba bean Schill *et al.* (1998) and Abdelmula *et al.* (1999) recorded high heterosis in yield per plant. On the other hand, Aher *et al.* (2000) recorded similar results on mung bean in yield per plant, pod length, pod diameter and pod thickness.

The mean values of F_2 generation and inbreeding depression are shown in Table (5 a and b). Data showed negative low inbreeding depression for all studied characters and ranged from –52.82% to –0.5%. The highest value was for the cross (2 x 6) for vitamin C content in 1999 season while the lowest was for the cross (1 x 5) for yield per plant in 1999 season. The cross (2 x 6) had the most highest values for the most of the studied characters, namely for number of days to maturity, protein content and vitamin C content in 1999 season and for pod length, pod thickness and pod diameter in 2000 season. However, the reduction in performance due to increased homozygosity in the F_2 resulted from inbreeding. These results were in accordance to those had been recorded on bush bean by Gutierrez and Singh (1985) that found significant differences among F_2 generation for all

traits (yield and yield components) on bush beans. Also, the presented data were in line with those reported on mung bean by Naidu and Satyanarayana (1993) that reported low inbreeding depression for yield and yield components on mungbean.

GCA effects of the female parents (Lines) and the male parents (Testers) are shown in Table (6 a and b). Out of the three male parents, the variety Serbo had high GCA for most of the characters namely pod length, pod thickness, pod diameter, pod weight, number of pods per plant, yield per plant, protein content and vitamin C content. Among the female parents, the variety Helda had highest GCA for most characters namely number of days to 50% flowering, number of days to maturity, pod length, pod diameter, pod weight, yield per plant and protein content. These results were in line with those recorded by Saxena and Sharma (1992) on mung bean, Singh *et al.* (1992), Vizgarra *et al.* (1992) and White *et al.* (1994) on common bean.

The estimates of SCA effects (Table 7 a and b) revealed that out of 9 crosses 5 had positive SCA effects for all characters. Estimates of SCA showed that the best combinations were (3 x 4) for number of days to 50% flowering, pod thickness, number of pods per plant and yield per plant; (2 x 5) for number of days to maturity, pod length, pod weight, protein content and vitamin C content and (1 x 6) for pod length, pod diameter, pod weight and vitamin C content and that was in agreement with similar records by Saxena and Sharma (1992) on mung bean, Singh *et al.* (1992) and Vizgarra *et al.* (1992) on common bean. Data in Table (7 a and b) indicated that no cross combination was consistently good for all the studied characters which were similar to results which have been recorded by Dixit *et al.* (1980) on tomato.

The cross (1 x 6) which was the best combination for the most studied characters, its SCA effect was related to GCA effects of its parents. Moreover, that previous mentioned cross included both its parents with high GCA effects for almost all the studied characters. It could be, therefore, concluded that high GCA can be exploited as indicator in selection of desirable parents of the current trial for conducting crosses that can be involved in advanced generations in a selecting program for improving the local varieties. Also, in breeding program, some criteria such as the parents with desirable characteristics, high heterosis, high GCA and SCA effects are obviously essential and that was in accordance with the results of Dixit *et al.* (1980) on tomato. The best cross combinations which fulfilled most of the aspects mentioned above were (1 x 6), (2 x 5) and (2 x 6). Therefore, these crosses that revealed desirable attributes can be exploited in future breeding program and would be highly useful.

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تقدير قوة الهجين و التدهور الراجع للتربية الذاتية و القدرة على التآلف فى الفاصوليا باستخدام تحليل (Line x Tester).

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أجريت هذه الدراسة على محصول الفاصوليا لتقدير قوة الهجين و التدهور الراجع إلى التربية الذاتية و القدرة على التآلف و ذلك خلال السنوات ١٩٩٩ و ٢٠٠٠ فى الموسم النيلى. و قد وجد أن التباين الراجع للتراكيب الوراثية كان معنويا لكل الصفات فى كلا السنتين باستثناء صفة محتوى فيتامين ج فى عام ١٩٩٩. و قد كانت أعلى نسبة فى قوة الهجين متمثلة فى صفة محصول النبات من القرون الطازجة الخضراء و ذلك فى الهجين (٢ ×٦) فى كلا السنتين. و قد اظهر الصنف سربو أعلى قيمة فى القدرة العامة على التآلف بالنسبة لمحصول النبات من القرون الطازجة الخضراء فى السنتين. و قد أظهرت الدراسة نتيجة لتقدير قوة الهجين و القدرة على التآلف أن افضل الأصناف كانت الصنف سربو و هيلدا و أن افضل الهجن هم (١×٦) و (٢×٥) و (٢×٦).