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EVALUATION OF COWPEA PARENTAL AND HYBRID GENOTYPES FOR HETEROSIS AND INBREEDING DEPRESSION

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ABSTRACT

Five parental genotypes of cowpea (*Vigan sinensis* L), four F_1's and their F_2's were used to study their performances, heterotic effects, inbreeding depression and degree of dominance for eleven vegetative and yield characters.

The mean values of the five parental, four F_1's and F_2's genotypes indicated that in VR_4 (P_4), F_1 (VR_4 x VR_3) (P_4xP_3) and F_2 (P_4xP_3), the genes controlling almost all the studied characters are expressed as increasing genes for these characters either as a parental genotypic background or in combination with $P_3(VR_3)$ either in the F_1 and the F_2 of the cross (P_4xP_3).

Moreover, the F_1 (P_4xP_3) had the highest heterotic values over both the mid and the better-parent for pod weight, number of pods and seed weight per plant. In addition, the F_2 (P_4xP_3) had the highest mean values for eight characters out of eleven and had also a considerable high values for the other three characters.

This $F_2(P_4xP_3)$ also showed negative and significant inbreeding depression for seven characters out of the eleven in relation to the mid-parental values.

Significant degree of dominance values in nine characters out of the eleven were observed for both the F_2 (P_4xP_3) and $F_2(P_6xP_4)$. Meanwhile, each of $F_2(P_{30}xP_4)$ and $F_2(P_{30}xP_{14})$ showed significant degree of dominance values in eight out of the eleven characters. These results strongly suggest that $F_1(P_4xP_3)$ would have the potential to be used in cowpea breeding programs.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) is one of the most important legume crops in Egypt and many other tropical and subtropical countries in the world. Pod characters, (i.e. length, diameter and weight of pod and both number and weight of seed index) are considered the most important components affecting seed yield (Gad El-Hak *et al.*, 1988). Recently, there is an intensive efforts for improving, the cowpea productivity through breeding procedures which depended largely on the presence of genetic variations. The important task of the breeder is to utilize the genetic variation and its components which are important for crop improvement, (Poechlman and Barthakur, 1972). Different genetic parameters, i.e., heterosis, inbreeding depression and degree of dominance were suggested by Sangwan and Sangwan (2003), Anupam *et al.* (2003), Neema and Palanisamy (2004) and Vaithiyalingan (2004) to achieve this task.

The objective of the present investigation was to study the genetic performance of eleven vegetative, yield and quality characters in five parental cowpea genotypes and four F_{1s} and their F_2 progenies under sand soil conditions. The study extended to through some light on heterosis, degree of dominance and the inbreeding depression under the condition of these environment.

MATERIALS AND METHODS

A. Materials:

Five cowpea (*Vigna sinensis* L) parental genotypes, four F_1s and their F_2s were used in this study. The parental genotypes were the four virus resistant lines which were obtained from the Horticultural Crops Research Institute. They were VR3 as (P_3), VR4 as (P_4), VR_6 as (P_6) VR_{14} as (P_{14}) and the local variety Dokki 331 as (P_{30}). These genotypes were used to study heterosis, degree of dominance and inbreeding depression in eleven vegetative and yield characters. The study was achieved under the sand soil conditions of El-Kassassein Horticultural Research Station, Horticultural Crops Research Institute, ARC, during the seasons of 2001, 2002 and 2003.

B. Methods:

In March 2001, the five parental genotypes were sown, in the Experimental Farm, El-Kassassein Horticulture Research Station. The crosses P_4 x P_3, P_6 x P_4, P_{30} x P_4 and P_{30} x P_{14} were made. All the F_1 seeds of the four crosses were sown in March of 2002 to obtain the selfed F_2 seeds which were collected at the end of the season as single plant progenies. In March 2003, all genotypes including the parents, F_1 and F_2 generations were planted.

The parental, F_1 and F_2 seeds were sown for evaluation in a randomized complete blocks design with three replications under the drip irrigation system. Two seeds were sown in a single hill for each dripper. The drippers were 20 cm apart and the irrigation lines were 60 cm width. Each plot was 6 m^2. The agricultural treatments were similar for all entries under study.

Ten plants from each entry over all replications were randomly chosen for measuring all the vegetative and yield characters. The vegetative characters recorded were: stem length (cm), number of leaves per plant and number of branches per plant. The total dry yield characters were weight of dry pods per plant (g.), number of dry pods per plant and dry seed weight per plant (g). Pod quality characters were average pod weight (g), number of seeds per pod, seeds weight per pod (g), pod length (cm) and weight of 100 dry seeds (g.).

C. Statistical Procedures:

An analysis of variance among the five parents, the four F_1's and the F_2 generations was applied to calculate the LSD values according to Snedecor and Cochran (1980). Heterosis was determined as a percent deviation of the F_1 value from either the mid-parental (MP) or the better-parental (BP) value according to Bhatt (1971). Significance of heterosis was determined according to Abou-Tour (1980).

Inbreeding depression (ID) was estimated from the comparisons between F_1 or parental values and their F_2 values. The degree of dominance estimates were calculated according to Peter and Frey (1966). Tests of significance of both genetic comparisons were made using the least significant difference (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

I. Performance of parental, F_1 hybrids and F_2 genotypes:

The results in Table 1, showed that P_4 has either the highest or the second highest for all the characters except for number of seeds per pod. Meanwhile, P_5 followed P_4 for five characters but it had the highest mean values for both pod length and dry weight of 100 seeds.

The mean values of the four F_1 hybrids, showed that the F_1 (P_4 x P_3) had the highest mean values for all the characters except for number of leaves per plant, number of branches per plant and dry weight of 100 seeds. It occupied the second order for stem length value. Meanwhile, the F_1 (P_6 x P_4) had the highest mean values for stem length, number of leaves per plant, and dry weight of 100 seeds. It also occupied the second order for number of branches per plant and weight of seeds per pod.

The mean values of F_2 generations showed that the F_2 (P_4 x P_3) had the highest mean values for all characters except for length of pod, dry weight of 100 seeds and stem length. Meanwhile, the F_2 (P_{30} x P_{14}) had the lowest values for all characters except for number of branches per plant, number of seeds per pod and length of pod. These results clearly suggested that in F_1 (P_4xP_3) and F_2 (P_4xP_3), the parent P_4 had most the genes controlling all the studied characters and expressed as an increasing genes for these characters either in the parental genotypic background or in combination with P_3 genetic background in the F_1 (P_4xP_3) and the F_2 (P_4xP_3).

Table 1: Mean values of some vegetative and yleld characters for cowpea parental, F_1 hybrids and F_2 genotypes.

Genotype	Stem length (cm)	No. leaves/ plant	No. bran-ches/ plant	Dry yield/plant			Pod characters				100 dry seeds wt. (g)
				Pods wt. (g)	No. pods	Seeds wt (g)	Weight (g)	No. seeds	Seeds wt (g)	Length (cm)	
Parental Genotypes											
P_3	34.0	30.0	3.3	47.70	15.33	31.04	3.11	14.2	2.02	12.0	14.0
P_4	111.7	95.7	8.0	103.68	40.67	82.36	2.55	11.0	2.03	13.7	17.3
P_6	35.3	23.3	3.3	58.37	32.33	38.25	1.80	8.07	1.18	8.0	13.7
P_{14}	43.0	38.3	6.0	68.03	37.0	46.95	1.90	10 83	1 31	13.7	14.9
P_{30}	69.7	76.3	4.3	85.83	35.0	54.43	2.47	11.37	1.58	14.7	18.5
F_1 hybrids genotypes											
F_1(P_4xP_3)	117.3	81.7	5.3	225.93	73.0	164.37	3.1	14 5	2.21	14.3	17.8
F_1 (P_6xP_4)	156.3	83.0	6	117.23	46.33	98.93	2.53	11.03	2.20	9.7	21 8
F_1(P_{30}xP_4)	72.3	68.3	4.7	140.37	54.0	105.1	2.6	11.67	1.95	13.5	19.8
F_1(P_{30}xP_{14})	37.7	31.3	8.3	91.03	40 3	71.02	2.33	12.1	1.82	13.3	17.5
F_2 genotypes											
F_2(P_4xP_3)	124.7	144.7	9.3	144.0	51.67	104.33	2.78	12.8	2.02	11.3	17.5
F_2 (P_6xP_4)	141.7	65.0	7.0	111.03	45.0	88.59	2.47	10.33	1.97	10.7	17.9
F_2(P_{30}xP_4)	62.0	63.3	5.3	106.6	44.33	91.25	2.50	10.43	1.62	12.7	18.93
F_2(P_{30}xP_{14})	60.33	32.7	5.7	75.82	39.67	66.65	1.97	11.87	1.47	15.7	16.9
LSD5%	6.65	7.25	1.3	20.23	6.94	16.62	0.19	1.06	0.21	1.68	0.85
LSD1%	9.02	9.82	1.7	27.42	9.41	22.53	0.25	1.44	0.28	2.27	1.15

II. Heterosis over Mid- and Better-Parental Values:

Significant heterosis over the mid-parental values was observed for almost all characters over the four hybrids. However, the highest heterotic effects was obtained for total dry yield; weight of pods per plant, number of pods per plant and seeds yield per plant which was observed for the F_1 hybrid P_4xP_3, although it had the second highest heterotic values for stem length, weight of pod and weight of 100 dry seeds. The F_1 hybrid P_6xP_4 was the highest for pod weight, number of seeds per pod, weight of seeds per pod and weight of 100 dry seeds, while it was the second highest for seeds yield per plant as soon in Table 2. Meanwhile, the highest and significant heterotic values of number of leaves per plant and number of branches per plant were observed for the F_1 hybrid $P_{30}xP_{14}$ as present in Table 2.

Heterosis over the better-parental value, which is presented in Table 3 the F_1 hybrid (P_4xP_3) had the highest positive heterosis over the respective, better-parental value for weight of pods per plant, number of pods per plant and seeds yield per plant. In addition, the F_1 hybrid (P_6xP_4) showed the highest positive and significant heterosis over better-parental values for both weight of 100 dry seeds and stem length.

Heterosis relative to the mid- and better parental values which are presented in Tables 2 and 3 showed that the F_1 hybrids P_4xP_3 is considered the most promising hybrid for yield characters and it might be of great value in future breeding programs.

In general, crosses showing significant and highly significant differences among the parental genotypes which were observed for all characters, indicated the presence of wide variability. Similar results were reported by Sangwan and Sangwan (2003), Joseph and Santhoshkumar (2000), Anupam *et al.* (2003), Sawale *et al.* (2003), Neema and Palanisamy (2004) and Vaithiyalingan (2004).

III. Inbreeding Depression (ID) in F_2 generations:

Both significant and highly significant values of inbreeding depression for the F2 values from their respective F1 were observed for almost all the eleven characters. This indicated the presence of dominance in controlling the expression of these characters, which in turn, leads to the loss in their performance through inbreeding depression as soon in Table 4. The F_1 (P_4xP_3) had the highest and significant inbreeding depression for six out of the eleven characters which were: number of leaves per plant, number of branches per plant, weight of pods per plant, number of pods per plant, weight of seeds per plant and number of seeds per pod. However, insignificant of values inbreeding depression were also observed for $F_1(P_4xP_3)$ for length of pod and weight of 100 dry seeds. Moreover, insignificant inbreeding depression values were also, observed in seven out the eleven characters of F_2 ($P_{30}xP_{14}$).

Inbreeding depression in F_2 values from their mid-parental values showed both significant and highly significant inbreeding depression in the F_2 (P_4xP_3) from its respective mid-parental values for almost all the studied quantitative characters.

Table 2: Heterosis (%) over mid-parental values in eleven vegetative, and yield characters for four cowpea crosses.

F_1 Hybrid	Stem length (cm)	No. leaves/ plant	No. branches/ plant	Dry yield/plant			Pod characters				100 dry seeds wt. (g)
				Pods wt. (g)	No. pods	Seeds wt (g)	Weight (g)	No. seeds	Seeds wt (g)	Length (cm)	
$F_1(P_4xP_3)$	61.02	29.10	6.10**	198.5	160.71	189.89	9.54	15.08	8.64	11.28	13.74
$F_1(P_6xP_4)$	112.65	39.50	6.20	44.68**	26.93	64.05	16.32	15.68	37.07	10.60	40.65
$F_1(P_{30}xP_4)$	20.29	20.58*	23.58	72.75*	42.73	53.67	5.05	4.34	8.033	4.93	10.62
$F_1(P_{30}xP_{14})$	33.10	45.38	61.17*	18.33	11.94	40.11	6.64	9.01	25.95	6.33	4.79

*,**; Significant it 5% and 1% levels, respectively.

Table 3: Heterosis (%) over better-parantal values in vegetative, and yield characters of four cowpea crosses.

F_1 Hybrid	Stem length (cm)	No. leaves/ plant	No. bran-ches/ plant	Dry yield/plant			Pod characters				100 dry seeds wt. (g)
				Pods wt. (g)	No. pods	Seeds wt (g)	Weight (g)	No. seeds	Seeds wt (g)	Length (cm)	
$F_1(P_4xP_3)$	5.01	-14.63	-33.75 **	117.911 **	79.493**	99.58*	-0.32	2.11	8.37	4.38	2.90
$F_1(P_6xP_4)$	39.93**	-14.27 *	-25.00	13.09*	13.92*	20.12*	-0.78	0.27	8.37	-29.20**	26.01**
$F_1(P_{30}xP_4)$	-35.27 **	-28.63 **	-41.25*	35.39	32.78*	27.61	1.96	2.64	-3.94	-8.16	7.03*
$F_1(P_{30}xP_{14})$	-45.91 **	-58.98 **	38.33*	6.06	8.92	30.48	-5.67	6.42	15.19	-9.52	-5.41

,**; Significant lt 5% and 1% levels, respectively.

Table 4: Inbreeding depression (ID) in F_2 mean values of eleven quantitative characters from their F_1 values in four cowpea hybrids.

F_2 genotypes	Stem length (cm)	No. leaves/ plant	No. branches/ plant	Dry yield/plant			Pod characters				100 dry seeds wt. (g)
				Pods wt. (g)	No. pods	Seeds wt (g)	Weight (g)	No. seeds	Seeds wt (g)	Length (cm)	
$F_2(P_4xP_3)$	-6.31	-77.11	-75.47	36.26	29.22	36.53	10.32	11.73	8.18	20.98	1.69
$F_2(P_6xP_4)$	9.34	21.69	-16.68	5.29	2.87	10.45	2.37	6.35	-10.46	-10.31	17.89**
$F_2(P_{30}xP_4)$	14.25	7.32	-12.77	24.06	17.91	13.18	3.85	10.63	16.92	5.93	4.39
$F_2(P_{30}xP_{14})$	-59.95	-4.47	31.33	16.71	1.56	6.15	15.45	1.90	19.23	-18.05	3.43

*,**; Significant at 5% and 1% levels, respectively.

Table 5: Inbreeding depression (ID) in F_2 mean values of eleven quantitative characters from their mid-parental values in four cowpea bybrids.

F_2 genotypes	Stem length (cm)	No. leaves/ plant	No. branches/ plant	Dry yield/plant			Pod characters				100 dry seeds wt. (g)
				Pods wt. (g)	No. pods	Seeds wt (g)	Weight (g)	No. seeds	Seeds wt (g)	Length (cm)	
$F_2(P_4xP_3)$	-71.17	-130.23	-64.60	-90.25	-84.54	-84.00	1.77	-1.59	0.25	12.06	-11.82**
$F_2(P_6xP_4)$	-92.79	-9.24	-23.89	-37.03	-23.29	-46.90	-13.56	-8.34	-22.74	1.38	-15.48
$F_2(P_{30}xP_4)$	31.64	26.40	13.82	-31.19	-17.17	-33.92	-1.01	6.75	10.25	10.56	-5.75
$F_2(P_{30}xP_{14})$	-7.01	42.932	-10.68	1.44	-10.19	-31.49	9.84	-6.94	-1.73	-10.56	-1.20

*,**; Significant at 5% and 1% levels, respectively.

In addition, F_2 (P_4xP_3) showed the highest and significant inbreeding depression for number of leaves per plant, number of branches per plant, weight of dry pods per plant, number pods per plant and weight of seeds per plant. Meanwhile, the highest significant negative inbreeding depression was observed in the $F_2(P_6xP_4)$ for stem length, weight of pod, weight of seeds per pod and weight of 100 dry seeds. In addition, the $F_2(P_6xP_4)$ had the second highest and significant inbreeding depression for weight of pods per plant and number of pods per plant. However, the F_2 ($P_{30}xP_{14}$) had the significant inbreeding depression values for weight of seeds per plant, number of seeds per pods and length of pod as appeared in Table 5.

In Tables 4 and 5, the inbreeding depression (ID) in four cowpea hybrids showed that the cross (P_4xP_3) had significant, negative and positive ID values from their respective F_1 values for stem length, number of branches per plant, number of leaves, number of pods, weight of pods per plant, seeds weight per plant, number of seeds per pod, weight of seeds per pod and mean pod weight, 100-seeds weight. However, significant negative ID values in cross (P_4xP_3) were observed from their respective mid-parental values for seven out of the eleven characters (Table 5). Similar results were reported by Sawale *et al.* (2003), Joseph and Santhoshkumar (2000), Rij-Kumar, *et al.* (2000), Pal *et al.* (2003), and Anupam-Singh, *et al.* (2003). Meanwhile, insignificant ID from F_1 values for pod length was reported by Cheralu, *et al.* (2002).

IV. Degree of Dominance In Relation to Performance of either F_1 or the Mid-Parental Value:

In Table 6, degree of dominance values based on F_1 performance for eleven vegetative and yield characters of four F_2 cowpea hybrids, showed highly significant or even significant values in nine out of eleven characters in both the $F_2(P_4xP_3)$ and $F_2(P_6xP_4)$. However, insignificant degree of dominance values were observed for number of branches per plant and length of pod. Meanwhile, each of F_2 ($P_{30}xP_4$) and $F_2(P_{30}xP_{14})$ showed significant degree of dominance values in eight out of the eleven characters.

Based on the differences from mid-parental values, data in Table 7 showed that the highest and significant degree of dominance values for both number of leaves per plant and number of branches per plant were observed in the cross P_4xP_3. Meanwhile, the highest significant positive degree of dominance for number of pods per plant, weight of seeds per plant, number of seeds per pod and length of pod were found in the cross ($P_{30}xP_{14}$).

It worthy to mention that the parent VR_4 (P_4) and its F_1 (P_4xP_3) and F_2 (P_4xP_3) were found to have the highest performance or even the second highest for almost all the eleven characters Table 1. Moreover, the $F_1(P_4xP_3)$ had the highest heterosis either over mid or better-parental values for the three dry yield characters i.e. pod weight, number of pods and seed weight per plant Tables 2 and 3. In addition, the $F_2(P_4xP_3)$ had the highest mean values for eight out of the eleven characters and had a considerable high values for the other three characters Table 1, while it showed negative and significant inbreeding depression for seven out of the eleven characters in relation to the mid-parental values.

Table 6: Degree of dominance based on the differences from F_1 performance for eleven vegetative and yield characters of four F_1 cowpea hybrids.

F_1 Hybrid	Stem length (cm)	No. leaves/ plant	No. branches/ plant	Dry yield/plant			Pod characters				100 dry seeds wt. (g)
				Pods wt. (g)	No. pods	Seeds wt. (g)	Weight (g)	No. seeds	Seeds wt (g)	Length (cm)	
$F_1(P_4xP_3)$	1.14	0.57	-0.15	5.37	3.55	4.20	0.96	1.19	35.0	1.71	1.30
$F_1\ (P_6xP_4)$	2.17	0.65	0.15	1.60	2.36	1.75	0.95	1.02	1.40	-0.40	3.50
$F_1(P_{30}xP_4)$	-0.88	-1.82	-0.78	2.64	5.70	2.63	1.67	2.62	0.64	-1.4	3.17
$F_1(P_{30}xP_{14})$	-1.40	-1.39	3.706*	1.58	4.3	5.44	0.51	3.70	2.78	-1.8	0.44

*,** Significant at 5% and 1% levels, respectively.

Table 7: Degree of dominance, based on the differences from mid-parental values, for eleven vegetative and yield characters of four cowpea hybrids.

F2 Hybrid Genotypes	Stem length (cm)	No. leaves/ plant	No. branches/ plant	Dry yield/plant			Pod characters				100 dry seeds wt. (g)
				Pods wt. (g)	No. pods	Seeds wt. (g)	Weight (g)	No. seeds	Seeds wt (g)	Length (cm)	
$F_2(P_4xP_3)$	2.67	4.98	3.1	4.88	3.74	3.71	-0.36	0.25	-2.0	-3.65	2.24
$F_2\ (P_6xP_4)$	3.57	0.30	1.15	2.65	4.08	2.57	1.57	1.09	1.72	-0.11	2.67
$F_2(P_{30}xP_4)$	-2.74	-4.68	-.92	2.26	4.58	3.27	0.67	-8.16	-1.64	-6.0	3.43
$F_2(P_{30}xP_{14})$	0.59*	-2.59	1.29	-025	7.34	8.54	-1.51	5.70	0.37	6.0	0.22

*,**; Significant it 5% and 1% levels, respectively.

These results strongly suggest that the F_1 (P_4xP_3) had the potential to be used in cowpea breeding programs.

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تقييم التراكيب الوراثية لآباء وهجين اللوبيا لقوة الهجين والانخفاض الناتج عن التربية الداخلية

سوزان عباس سويدان
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تم تقييم خمسة تراكيب وراثية أبوية من اللوبيا (فجنا سيننسيس) وأربع هجن منها (F1)واجيالهم الثانية (F_2) لدراسة أداء تلك الآباء وقوة الهجين والانخفاض الناتج عن التربية الداخلية ودرجة السيادة لإحدى عشرة صفة من الصفات الخضرية والمحصولية.

أشارت متوسطات القيم للآباء الخمسة والجيل الأول والثاني أن الأب (P_4)VR_4 المشارك في الهجين $F_1(P_4xP_3)$ والجيل الثاني له $F_2(P_4xP_3)$ أن الجينات التي يحملها تقريبا كل الصفات المدروسة حيث قد عبرت عن نفسها كجينات زيادة في الصفات الإحدى عشر سواء كانت في الخلفية الوراثية للأب P_4 أو مع توليفة لآباء آخرين مثل P_3 سواء في الجيل الأول أو الجيل الثاني (P_4xP_3).

علاوة على ذلك فإن الهجين $F_1(P_4xP_3)$ كان له أعلى قيم قوة هجين سواء بالنسبة لمتوسط الأبوين أو بالنسبة لقيمة الأب الأعلى في الصفات الثلاث للمحصول الجاف وهي وزن القرن وعدد القرون في النبات ووزن البذور في النبات، بالإضافة إلى ذلك فإن الجيل الثاني $F_2(P_4xP_3)$ لنفس الهجين أظهر أعلى متوسطات لقيم ثمان صفات من الإحدى عشرة صفة موضع الدراسة كما أنه تميز بقيم متوسطات عالية بصورة ملحوظة بالنسبة لبقية الصفات الثلاث الأخرى. كما أظهر أيضا قيم معنوية سالبة لسبعة من الإحدى عشرة صفة وذلك في قيم الانحدار الناتج عن التربية الداخلية بالنسبة للقيم المتوسطة للأبوين لكل صفة.

لوحظ وجود قيم عالية المعنوية لدرجة السيادة وذلك لتسع صفات من بين الإحدى عشرة صفة وذلك للهجينين $F_2(P_4xP_3)$ و $F_2(P_8xP_4)$ بينما أظهر كل من الهجينين $F_2(P_{30}xP_{14})$ ، $F_2(P_{30}xP_4)$ قيما معنوية لدرجة السيادة لثمان صفات من الإحدى عشرة صفة، وتقترح هذه الدراسة بقوة أن الهجين $F_1(P_4xP_3)$ يعتبر ذو قيمة عالية عند استخدامه مستقبلا في برامج التربية للوبيا.