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STUDIES ON THE INHERITANCE OF SOME QUANTITATIVE AND QUALITATIVE TRAITS IN COWPEA I.GROWTH AND YEILD TRAITS

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ABSTRACT: **Five cowpea cultivars; viz., IT 86F, IT 93K, Kafr El-Sheikh-1, Dokki-331 and Kaha-1 were crossed in a diallel mating system, without reciprocals, and evaluated in summer season of 2003. Both general (gca) and specific (sca) combining ability were highly significant in the studied nine traits. The best combiners were IT 86F and IT 93K for plant height and green pod weight, Kaha for branch number, Dokki for leaf area, Kafr El-Sheikh for early green pod number and yield, Dokki and Kaha for total number of green pods per plant, and IT 93K and Dokki for plant yield. Some crosses showed heterosis over BP in growth traits; viz., IT 93K x Dokki (39.5%) or with Kaha (38.4%) for plant height, and IT 93K x Dokki (10.1%) for leaf area. A pronounced heterosis over BP was observed in IT 93K x Kafr El-Sheikh (148.8%; 189.9%) and Kafr El-Sheikh x Kaha (75.2%; 113.8%) for early pods number and early yield, respectively, and IT 86F x Dokki , Kafr El-Sheikh x Kaha and Dokki x Kaha (46.0, 46.5 and 46.3%, respectively) for total green pods yield. Additive (D) and non-additive had significant effect on all the nine traits, but D for early pod number and H_2 for early pod weight were insignificant. In all traits, H_1 was larger than D, and vice versa for plant height and pod weight in both early and total yield. From Wr/Vr graph and $(H_1/D)^{1/2}$, the traits showed over-dominance were leaf area, early yield, early pod number and total plant yield, and other traits showed complete dominance. Scattering pattern of array**

points suggested large genetic variability among the parents for each. From h^2 and Wr/Vr graph, results indicated predominant role played by genotypes x environment for leaf area, pod number and yield (early and total), but other traits were not so.

Key words: Cowpea, heterosis, growth, diallel and yield.

INTRODUTION

Vegetable cowpea (*Vigna unguiculata* (L.) Walp.) considered one of the most important leguminous crops in tropical and sub-tropical regions, especially in Africa and Asia. However, it came in the second rank, in summer of Egypt, after snap bean. Cowpea could grow well under a wide range of climatic and soil conditions, but it is quite sensitive to cold temperature. Immature pods from cowpea can share with snap bean, in summer. However, yielding ability of various cultivars cultivated in Egypt is somewhat low (3.537* ton/*fed*).

To improve yielding ability of cowpea green pods, a clear understanding of the genetics of yield traits is essential to select a suitable breeding methodology. Abo-Bakr *et al.* (1988), Gad El-Hak *et al.* (1988), Thiyagarajan (1989), Roquib and Patnik (1990), Sawant *et al.* (1994) and Hussein (1998) reported significant gca and sca, heterosis, high heritability estimates, additive and non additive effects, and presence of partial dominance in the inheritance of plant height and branch number. Helal (2000) came to similar conclusions, in this respect. Complete and over dominance were reported for leaf area by Sawarkar *et al.* (1999) and Helal (2000), respectively. Moreover, Metwally *et al.* (1998) revealed that leaf area in cowpea was cultivar dependent.

For early and total yield, significant gca and sca, additive and non additive, heterosis, and high heritability estimates, respectively for pod weight and moderate and low heritability estimates, respectively, for pod number and yield were reported by Gad El-Hak *et al.* (1988), Singh and Dabas (1992), Umaharan *et al.* (1997), Hussein (1998), Rahman and Saad (2000) and Subbiah *et al.* (2003).

The objectives of this study (5x5 diallel cross system) were to determine and compare the general and specific combining ability effects for establishing a few cultivars as tester parents for

*Ministry of Agric., Cairo, Egypt (2002) growth, and early and total green pods yield traits. To study heterosis and genetic parameters, that involved in the inheritance of these traits. And/also, graphical analysis (Wr/Vr) and genetic components of variation are helpful method to decipher an all genetic picture of these characters and will help in choosing appropriate breeding schemes for achieving maximum progress in development of varieties in short time.

MATERIALS AND METHODS

Five inbred lines of cowpea (Vigna unguiculata (L.) Walp.); viz., IT86F, IT93K, Kafr El-Sheikh-1, Dokki-331, and Kaha-1 were crossed in a diallel mating system (5x5 diallel), without reciprocals. Hand pollination was done according to Mayers (1994), to produce F1 seeds, at the Experimental Farm, Faculty of Agriculture, Zagazig University. These cultivars were chosen because each one possessed at least one or two of the characters to be studied. The former two *cvs* had tall plants, high pod weight and high yield. The later three *cvs* had short plants, low pod weight, high pod number per plant. Moreover, IT86F and Dokki were the earliest cultivars. In addition, Kaha had more branches, but Kafr El-Sheikh was the poorest yielder one.

The 10 F1 hybrids along with the 5 parents were planted, in a completely randomized block design with three replicates, on July 15th, 2003. The treatment in each replicate consisted of 10 plants, at the spacing of 30cm apart on one row of 3m long and 70cm wide.

The observations were recorded for: (1) Plant growth traits measured on every plant, at the end of the season; i.e., branch number and leaf area (estimated according to Metwally *et al.*, 1998) which calculated for the fourth upper leaf; except plant height which was measured at 60 days. (2) Early green pods per plant and its components; and (3) Total green pods per plant and its components.

Statistical analysis: Data were subjected to the analysis of variance according to Snedecor and Cochran (1967). Gca and sca were calculated using method 2 model II proposed by Griffing (1956). The diallel cross technique given by Jinkes and Hayman (1953), Jinkes (1954, 1955) and

Hayman (1954 a, b; 1957; 1958), using Mather (1949) concept of D and H components of variation were followed. The second degree statistical variance and covariance were used for preparing two-quarter graphics(Wr/Vr). Heterosis over (MP), relative heterosis, and over better parent (BP), heterobeltoisis, were also calculated (Mather and Jinkes, 1971).

RESULTS

The analysis of variance of 5x5 diallel cross system for growth, and early and total green pods yield and their components were run on the basis of individual plant data. Mean performance of the genotypes produced from diallel cross system were compared. Gca, sca, heterosis and genetic parameters were calculated to assess the genetic architecture of the parental cultivars and the inheritance of the aforementioned traits of cowpea, that to help breeder for planning breeding program when dealing with snap green pods yield of this crop.

1. Mean Performance

Conventional analysis of variance (Tables 1 and 2) showed highly significant mean squares for genotypes (total), parents, crosses and parents *vs* crosses for growth traits (plant height, branch number per plant and the 4th leaf area), early and total green pods yield traits per plant (pod weight, pod number per plant and green pods weight per plant), except parents *vs* crosses for plant height and branch number which were significant.

Table 1: Mean squares resulted from the analysis of 5x5 diallel for cowpea growth traits in summer season of 2003

S. O. V.	d.f	Pl. ht. (cm)	Br. No.	4th L. area (cm^2)
Reps	2	659.17*	3.41**	94.06^{NS}
Genotypes	14	2987.77**	3.17**	2471.04**
Parents	4	6691.22**	2.51**	4609.64**
Crosses	9	1614.78**	3.45**	1539.67**
P's *vs* crosses	1	530.94*	3.22*	2298.94**
Error	28	194.68	0.46	194.33

$^{NS, *}$ and **: Insignificant at 5 % level of probability, significant at 5% level of probability and highly significant at 1% level of probability, respectively.

Table 2: Mean squares resulted from 5x5-diallel analysis for cowpea early and total yield traits in summer season of 2003

S. O. V.	d.f	Early yield			Total yield		
		Pod wt. (g)	Pod No.	Yield (g)	Pod wt. (g)	Pod No.	Yield (g)
Reps	2	0.03^{NS}	14.14^{NS}	90.81^{*}	0.01^{NS}	32.64^{*}	562.31^{**}
Genotypes	14	5.56^{**}	115.01^{**}	1180.93^{**}	3.22^{**}	289.64^{**}	2328.76^{**}
Parents	4	11.57^{**}	64.08^{**}	290.80^{**}	5.99^{**}	176.63^{**}	811.14^{**}
Crosses	9	3.33^{**}	127.37^{**}	1335.39^{**}	2.32^{**}	231.04^{**}	1058.61^{**}
P's vs crosses	1	1.53^{**}	207.48^{**}	3351.31^{**}	0.20^{**}	1395.01^{**}	19830.59^{**}
Error	28	0.10	6.52	26.46	0.02	8.33	110.55

^{NS}, * and **: Insignificant at 5 % level of probability, significant at 5% level of probability and highly significant at 1% level of zprobability, respectively.

Table 3: Mean performance of the genotypes resulted from 5x5 diallel cross system for growth,and early and total green pods yield traits in summer season of 2003

Genotypes	Growth traits			Early green pods yield			Total green pods yield		
	Pl. ht. (cm)	Br. No.	4^{th} L. area (cm^2)	Pod wt. (g)	Pod No.	Yield (g)	Pod wgt. (g)	Pod No.	Yield (g)
1. IT 86F	98.55	2.71	140.70	6.87	5.86	40.26	5.49	21.84	119.90
2. IT 93K	120.25	4.35	223.16	6.74	4.65	31.36	5.93	21.32	126.43
3. Kafr El-Sheikh	28.06	3.34	185.86	3.41	8.19	27.93	3.23	26.28	84.88
4. Dokki-331	35.88	3.92	150.41	3.94	13.54	53.35	3.69	30.74	113.43
5. Kaha-1	13.02	5.13	125.94	2.63	15.03	39.53	2.74	39.95	109.46
$P_1 \times P_2$	71.75	4.33	176.46	6.63	4.42	29.32	5.74	24.92	143.04
$P_1 \times P_3$	31.78	3.58	142.07	4.24	10.69	45.34	4.80	27.37	131.16
$P_1 \times P_4$	40.67	3.58	165.54	4.70	15.26	71.71	4.40	39.68	174.59
$P_1 \times P_5$	77.22	5.81	145.43	4.72	10.37	50.63	3.24	40.48	131.16
$P_2 \times P_3$	57.28	3.55	165.45	4.61	20.38	93.95	4.88	36.17	176.51
$P_2 \times P_4$	94.67	5.17	158.11	3.69	13.04	48.10	4.16	42.12	178.51
$P_2 \times P_5$	54.33	6.15	100.59	4.95	9.96	49.28	3.46	46.12	159.58
$P_3 \times P_4$	27.42	3.17	173.62	3.30	9.65	31.83	3.53	38.59	136.22
$P_3 \times P_5$	29.33	4.92	128.30	3.21	26.33	84.52	3.14	51.07	160.36
$P_4 \times P_5$	34.42	5.28	153.96	3.21	19.98	64.73	3.26	51.00	166.26
L.S.D at 5%	23.33	1.13	23.31	0.52	5.12	8.60	0.26	4.82	17.50

For growth traits (Table 3), parental means reflected a wide range in each trait. The cultivars that showed lowest values were IT 86F in branch number (2.71 branches), and Kaha in plant height (13.02 cm) and the 4th leaf area (125.94 cm^2). The cultivars that showed highest values in these traits were Kaha for branch number (5.13 branches) and IT 93K for both the plant height (120.25 cm) and the 4^{th} leaf area (223.16 cm^2). F_1-hybrids reflected the parental range, however it was higher than the highest parent in branch number; i.e., 5.28, 5.81 and 6.15, when Kaha was crossed with each of Dokki, IT86F and IT93K, respectively. The highest values for F_1-hybrids in plant height (94.67 cm) did not reach to high parent of the cross IT 93K x Dokki, and Kafr El-Sheikh x Dokki (173.62 cm^2) and IT 86F x IT 93K (176.46 cm^2) for leaf area.

For early and total green pod yield (Table 3), the cultivars showed highest pod weight were IT 86F and IT 93K and high number of pods per plant were Kaha and Dokki, as components of early yield and total yield per plant. The lowest values in the aforementioned traits were obtained from Kaha for pod weight and from IT93K for pod number per plant. For early and total plant yield, the earliest parent was Dokki and the highest productive one was IT 93K, but Kafr El-Sheikh had the lowest early yield and individual plant yield. F_1-hybrids gave pod weight per pod not exceeded the parental values on early and total yield base. The crosses which gave highest number of pods and early yield, and exceeded the parental values, were IT 93K x Kafr El-Sheikh and Kafr El-Sheikh x Kaha. The crosses that showed highest total yield per plant, more than the parental values, were IT 93K x Dokki, IT 93K x Kafr El-Sheikh and IT 86F x Dokki.

2. Combining Ability

Results of the analysis of variance (Table 4), according to Griffing (1956), reflected highly significant mean squares due to gca and sca for the studied nine traits, except sca for branch number, which was significant. It also reflected that, gca was larger than sca in most cases, except that for early yield per plant and total green pods yield per plant. However, the additive portion (σ^2_A) was less than the non-additive one (σ^2_D), except that for plant height, branch number and

Table 4: Mean squares of general (gca) and specific (sca) combining ability for 5x5 diallel analysis of cowpea growth, and early and total yield traits

S. O. V.	d.f.	Growth traits			Early yield traits			Total yield traits		
		Pl. ht. (cm)	Br. No.	4^{th} L. area (cm^2)	Pod wt. (g)	Pod No.	Yield (g)	Pod wt. (g)	Pod No.	Yield (g)
Geno. (s)	14	2987.77**	3.17**	2471.04**	5.56**	115.01**	1180.93**	3.220**	289.64**	2328.76**
gca	4	2686.81**	2.57**	1311.60**	5.78**	52.52**	77.75**	3.356**	189.58**	430.45**
sca	10	319.57**	0.45*	628.51**	0.28**	32.66**	520.00**	0.161**	63.53**	914.58**
Error	28	64.89	0.15	64.78	0.03	2.17	8.82	0.008	2.77	36.85
σ^2 gca		338.18	0.30	97.58	0.79	2.84	- 63.18	0.456	18.01	- 69.16
σ^2_A		676.36	0.61	195.17	1.57	5.67	-126.36	0.912	36.01	- 138.32
σ^2_D		254.68	0.30	563.73	0.25	30.49	511.18	0.153	60.76	877.73

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

Table 5: Mean values of general combining ability (gca) for 5x5 diallel analysis of cowpea growth, and early and total yield traits

Genotypes	Growth traits			Early yield traits			Total yield traits		
	Pl. ht. (cm)	Br. No.	4^{th} L. area (cm^2)	Pod wt. (g)	Pod No.	Yield (g)	Pod wt. (g)	Pod No.	Yield (g)
IT 86F	55.36	4.33	157.40	5.07	10.19	48.75	4.55	33.11	144.99
IT 93K	69.51	4.80	147.90	4.97	11.95	54.80	4.56	37.53	164.35
Kafr El-Sheikh-1	36.45	3.81	150.11	3.84	16.76	63.67	4.09	38.30	151.20
Dokki -331	49.30	4.30	162.81	3.73	14.48	54.09	3.84	43.05	163.95
Kaha -1	48.83	5.55	132.01	4.03	16.66	26.29	3.28	47.17	154.32
+ S.E	12.01	0.66	11.74	0.64	2.90	14.05	0.54	5.41	8.36

pod weight per pod (in early and total yield).

For mean values of gca (Table 5), data illustrated that the best combiners for plant height were *cvs* IT93K and IT86F, for branch number were *cvs* Kaha and IT 93K, for leaf area per leaf were *cvs* Dokki and IT 86F. On the other hand, the poor combiners for these growth traits were *cv* Kafr El-Sheikh for plant height and branch number, and Kaha for the 4th leaf area. Other genotypes, in this respect, had had medium values of gca.

For mean gca of early and total green pods yield traits (Table 5), the cultivars which showed highest values of mean gca and being the best combiners for pod weight per pod were *cvs* IT 86F and IT 93K in early and total yield, for pod number per plant were Kafr El-Sheikh and Kaha in early pod number and *cv* Kaha and Dokki in total pod number, for early yield was Kafr El-Sheikh, and for total yield were *cvs* IT 93K and Dokki. The poor combiners for pod weight were *cv* Dokki in early yield and Kaha in total yield, for pod number was *cv* IT86F, in early and total pods, for early yield was *cv* Kaha, and for total yield was IT 86F. Medium types were also observed.

For mean sca crosses performance, it was previously mentioned in mean performance of the first portion (Table 3).

3. Heterosis

Results of heterosis for growth traits (Table 6) showed, generally, positive and negative values, when calculated from mid-parental values (MP) and from better parent (BP). Plant height revealed equal number of positive and negative values from MP, but only one cross; namely, Kafr El-Sheikh x Kaha had plant height near to higher parent of this cross. For branch number most of the obtained values were higher than MP value, but four crosses showed heterobeltiosis (BP); i.e., IT93K x Kaha, IT93K x Dokki, IT 86F x Kafr El-Sheikh and IT86F x Kaha. For leaf area, MP heterosis reflected negative and positive heterosis, but only three crosses showed positive values for BP heterosis and the highest heterobeltiosis were observed on cross IT86F x Dokki.

Table 6: Heterosis over mid (MP) and better (BP) parent for growth traits of cowpea F_1s hybrids

Crosses	Plant ht. (cm)		Branch No.		4^{th} Leaf area	
	MP	BP	MP	BP	MP	BP
P_1 x P_2	-34.4	-40.3	22.7	- 0.5	- 3.0	-20.9
P_1 x P_3	-49.8	-67.8	16.6	4.4	-13.0	-23.6
P_1 x P_4	39.5	-58.7	7.8	- 8.7	13.7	10.1
P_1 x P_5	38.4	-21.7	48.2	13.3	9.1	3.4
P_2 x P_3	-22.8	-52.4	- 8.7	-18.4	-23.5	-29.9
P_2 x P_4	21.3	-21.3	24.9	18.9	-15.4	-29.2
P_2 x P_5	-18.5	-54.8	29.8	19.9	-43.0	-54.9
P_3 x P_4	-14.2	-23.6	-13.9	-19.1	3.3	- 6.6
P_3 x P_5	42.8	4.5	15.4	- 3.7	-17.7	-31.0
P_4 x P_5	40.8	- 4.1	16.6	2.9	11.4	2.4
LSD at 5%	20.2	23.3	1.0	1.1	20.2	23.3

P_1, P_2, P_3, P_4 and P_5: IT 86F, IT 93K, Kafr El-Sheikh-1, Dokki-331 and Kaha-1, respectively.

Concerning heterosis for early and total yield per plant (Table 7), pod weight per pod, in both yield traits, showed positive and negative values for relative heterosis (MP), but all crosses had negative values when calculated on BP base. Early pod number and early yield had negative and positive values on the base of MP and BP, but the numbers of positive heterotic hybrids were more than the negative ones. The best crosses showed high heterotic values in early yield approached 189.9 and 113.8% for the crosses of IT93K x Kafr El-Sheikh and Kafr El-Sheikh x Kaha, respectively. On the other hand, all the crosses had positive MP and BP for pod number and yield per plant. The crosses illustrated highest heterotic percentage in pod number were IT 93K x Kafr El-Sheikh and Kafr El-Sheikh x Kaha, and in

Table 7: Heterosis over mid (MP) and better (BP) parent for early yield and total yield traits of cowpea F_1s hybrids

cross	Pod wt.		Pod No.		Yield (gm)	
	MP	BP	MP	BP	MP	BP
			Early yield			
$P_1 \times P_2$	- 2.6	- 3.5	- 16.0	- 24.6	-18.1	- 27.2
$P_1 \times P_3$	-17.5	-38.3	52.0	30.5	33.0	12.6
$P_1 \times P_4$	-13.1	-31.6	57.3	12.7	53.2	34.4
$P_1 \times P_5$	- 0.6	-31.3	- 0.8	- 31.0	26.9	25.8
$P_2 \times P_3$	- 9.3	-31.6	217.5	148.8	201.7	189.9
$P_2 \times P_4$	-30.9	-45.3	43.3	- 3.7	13.6	- 9.9
$P_2 \times P_5$	5.5	-26.6	1.2	- 33.7	39.0	24.7
$P_3 \times P_4$	-10.3	-16.2	- 11.2	- 28.7	- 21.7	- 40.4
$P_3 \times P_5$	6.3	- 5.9	126.8	75.2	150.6	113.8
$P_4 \times P_5$	- 1.5	-17.8	39.8	32.9	39.4	21.3
LSD 5%	0.5	0.5	4.4	5.1	7.5	8.6
			Total yield			
$P_1 \times P_2$	0.5	- 3.2	15.5	14.1	15.1	11.0
$P_1 \times P_3$	10.9	-20.6	13.8	4.2	28.7	10.0
$P_1 \times P_4$	- 4.1	-19.9	50.9	29.1	49.7	46.0
$P_1 \times P_5$	-21.3	-41.0	31.0	1.3	14.5	9.7
$P_2 \times P_3$	0.7	-17.7	52.0	37.6	65.2	37.0
$P_2 \times P_4$	-13.5	-29.8	81.1	39.6	47.4	38.7
$P_2 \times P_5$	-20.2	-41.7	50.5	15.4	33.9	23.9
$P_3 \times P_4$	2.0	- 4.3	35.4	25.5	37.6	20.2
$P_3 \times P_5$	5.6	- 2.8	54.2	27.8	65.1	46.5
$P_4 \times P_5$	1.4	-11.7	44.3	27.7	49.0	46.3
L.S.D 5%	0.2	0.3	2.2	4.8	15.2	17.5

P_1, P_2, P_3, P_4 and P_5: IT 86F, IT 93K, Kafr El-Sheikh-1, Dokki-331 and Kaha-1, respectively.

yield per plant were IT 93K x Kafr El-Sheikh, IT 93K x Dokki (both more than 37%, heterobeltiosis), IT86F x Dokki, Kafr El-Sheikh x Kaha, and Dokki x Kaha (had more than 46% heterobeltiosis).

4. Genetic Components and Genetic Ratios

Results in (Tables 8 and 9) reflected highly significant D, H_1, H_2, h_2 and F for all growth, early yield, and plant yield traits, except D value (insignificant) for pod number in early yield, H_2 value (insignificant) for pod weight in early yield, and F value (insignificant) for leaf area, pod number and early yield, average pod weight and total yield per plant. For E component, it had insignificant values for all the studied traits, except in branch number per plant, which was significant. The additive components (D) was larger than each of two dominant component (H_1 and H_2) for plant height and pod weight (in early yield and in total yield), but the dominant components (H_1 and H_2) were larger than D component for the other traits. F component was positive for all the studied traits, except that for branch number and total pods number per plant, which were negative.

For genetic ratios (Tables 8 and 9), the degree of dominance $(H1/D)^{1/2}$ values were less than one for plant height (0.74) for pod weight (0.53), and for early pods and for total pods (0.58)), while it was larger than unity for branch number (1.40), leaf area (1.44) and pod number (for early pods yield, 2.74 and total pods yield, 1.80) and yield (for early, 4.74 and total plant yield, 3.38). Moreover, Wr/Vr graph (Figs. 1-9) reflected that the regression line intersected Wr above, below, above, above, below, negative slop, above, below and below the origin, respectively for the nine traits. However, testing the intersecting points from 0 (origin), it was insignificant for plant height, branch number, early and total pod weight and pod number in early yield, indicating complete dominance in the inheritance of these traits. While, it was significant from 0 for leaf area, pod number, early yield and total yield, indicating over dominance predominate in the inheritance of these traits; however, it was over dominance towards recessive parents for early yield.

Gene frequency, as indicated by $(H_2/4H_1)$ had values, of all cases, less than 0.25 (maximum gene frequency), however total yield per plant and pod number in early yield had 0.24 value. The group of genes that control each character (h_2/H_2) and showing dominance indicated 2 groups of dominant genes for leaf area, more than 2 groups for pod weight and pod number of early pods and early yield, more than 5 groups for branch number, and 10-11 groups for total number of pods and pods yield per plant. While plant height and average pod weight had one group of dominant genes.

Heritability (h^2 ns) was higher than 50% for plant height, branch number, leaf area, early pod weight, total pod weight, and pod number, and less than 50% for early pod number and yield and total yield.

Table 8: Estimates of the genetic components of variations and genetic ratios in 5x5 diallel of cowpea growth traits

Parameter	Pl. ht. (cm)	Br. No.	L. area (cm^2)
D	$2155.19^{**} \pm 138.47$	$0.62^{**} \pm 0.10$	$1471.77^{**} \pm 364.80$
H_1	$1166.77^{**} \pm 373.96$	$1.22^{**} \pm 0.27$	$3059.68^{**} \pm 985.18$
H_2	$949.21^{**} \pm 339.18$	$0.88^{**} \pm 0.24$	$1085.54^{NS} \pm 893.57$
h_2	$627.46^{**} \pm 229.00$	$5.24^{**} \pm 0.16$	$2901.17^{**} \pm 603.30$
F	$1070.52^{**} \pm 354.90$	$-0.81^{**} \pm 0.25$	$1608.99^{NS} \pm 911.27$
E	$75.22^{NS} \pm 56.53$	$0.22^{**} \pm 0.04$	$64.77^{NS} \pm 148.93$
$(H_1/D)^{1/2}$	0.74	1.40	1.44
$H_2/4H_1$	0.20	0.18	0.09
h_2/H_2	0.66	5.92	2.67
r	0.39	-0.76	0.93
t^2	0.04^{NS}	0.09^{NS}	0.02^{NS}
h^2 % (n.s.)	67.57	66.80	73.21

$^{NS, *}$ and **: Insignificant at 5 % level of probability, significant at 5% level of probability and highly significant at 1% level of probability.

Table 9: Estimates of the genetic components of variations and genetic ratios in 5x5 diallel for cowpea yield and its components (early and total)

Parameter	Early yield traits			Total yield traits		
	Pod wt. (g)	Pod No.[1]	Yield (g)	Pod wt. (g)	Pod No.	Yield (g)
D	$3.82^{**} \pm 1.17$	$14.90^{NS} \pm 16.94$	$86.67^{**} \pm 293.05$	$1.99^{**} \pm 0.22$	$55.65^{**} \pm 8.25$	$223.47^{**} \pm 108.66$
H_1	$1.05^{**} \pm 0.47$	$111.46^{*} \pm 48.53$	$1950.57^{**} \pm 791.41$	$0.68^{**} \pm 0.22$	$180.23^{**} \pm 22.29$	$2553.76^{**} \pm 293.44$
H_2	$0.82^{NS} \pm 0.42$	$105.86^{*} \pm 45.45$	$1779.72^{**} \pm 717.81$	$0.53^{**} \pm 0.20$	$160.97^{**} \pm 20.22$	$2404.91^{**} \pm 266.15$
h_2	$1.90^{**} \pm 0.29$	$156.78^{**} \pm 31.74$	$4282.84^{**} \pm 484.64$	$0.30^{**} \pm 0.13$	$1781.67^{*} \pm 13.65$	$25353.66^{**} \pm 179.70$
F	$0.90^{**} \pm 0.43$	$9.09^{NS} \pm 43.52$	$187.53^{NS} \pm 730.07$	$0.21^{NS} \pm 0.20$	$-57.92^{**} \pm 20.62$	$103.80^{NS} \pm 271.43$
E	$0.03^{NS} \pm 0.07$	$0.61^{NS} \pm 7.58$	$10.25^{NS} \pm 119.64$	$0.01^{NS} \pm 0.03$	$3.31^{NS} \pm 3.37$	$46.89^{NS} \pm 44.36$
$(H_1/D)^{1/2}$	0.53	2.74	4.74	0.58	1.80	3.38
$H_2/4H_1$	0.20	0.24	0.23	0.20	0.22	0.24
h_2/H_2	2.32	1.48	2.41	0.57	11.07	10.54
r	0.68	- 0.88	- 0.08	0.80	- 0.92	- 0.93
t^2	0.00004^{NS}	0.23^{NS}	0.48^{NS}	0.0004^{NS}	0.02^{NS}	0.02^{NS}
h^2 % (n.s.)	87.01	17.40	7.14	88.00	60.40	17.20

$^{NS,\ *}$ and **: Insignificant at 5 % level of probability, significant at 5% level of probability and highly significant at 1% level of probability, respectively.

[1] Calculated on the base of four parents; IT 86F, IT 93K, Kafr El-Sheikh-1 and Dokki-331, since t^2 was significant in 5x5 diallel.

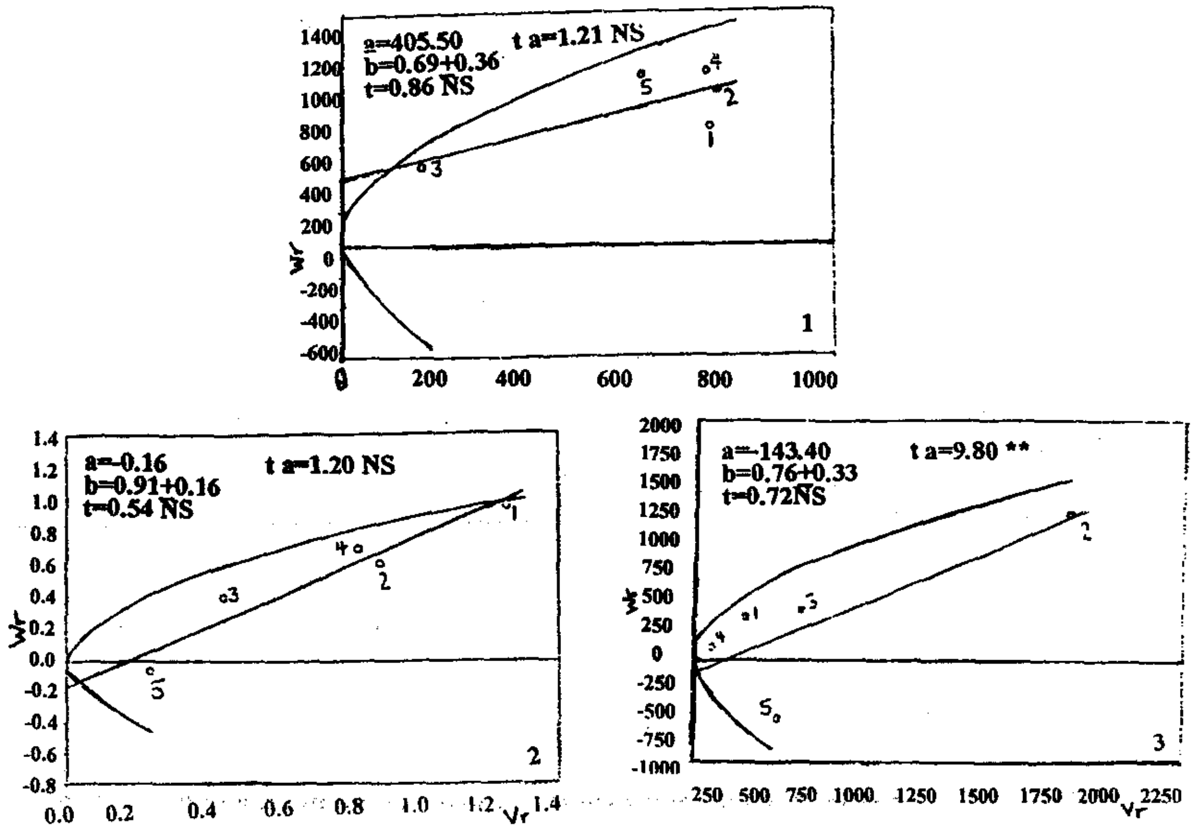

Fig. 1-3: Wr/Vr graph; 1. Plant height, 2. Branch number per plant, and 3. 4th leaf area

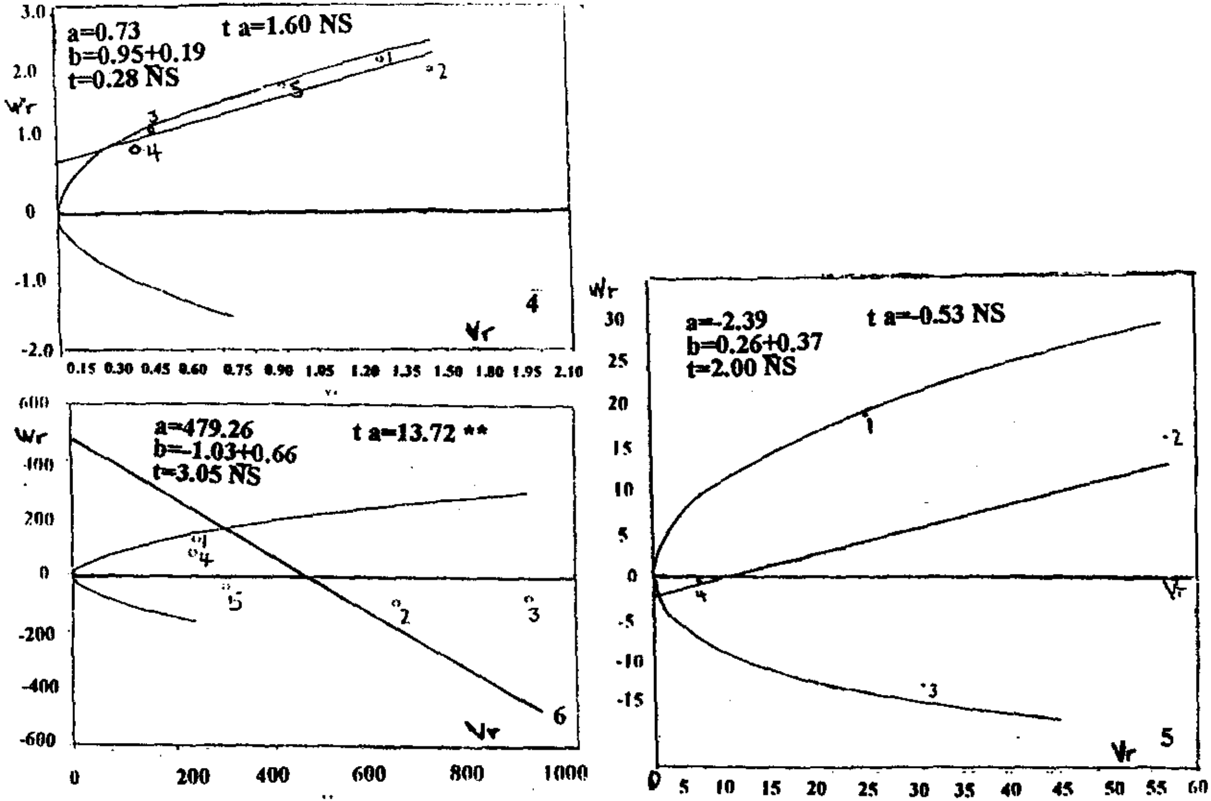

Fig. 4-6: Wr/Vr graph; 4. Early pod weight, 5. Early pod number, and 6. Early yield

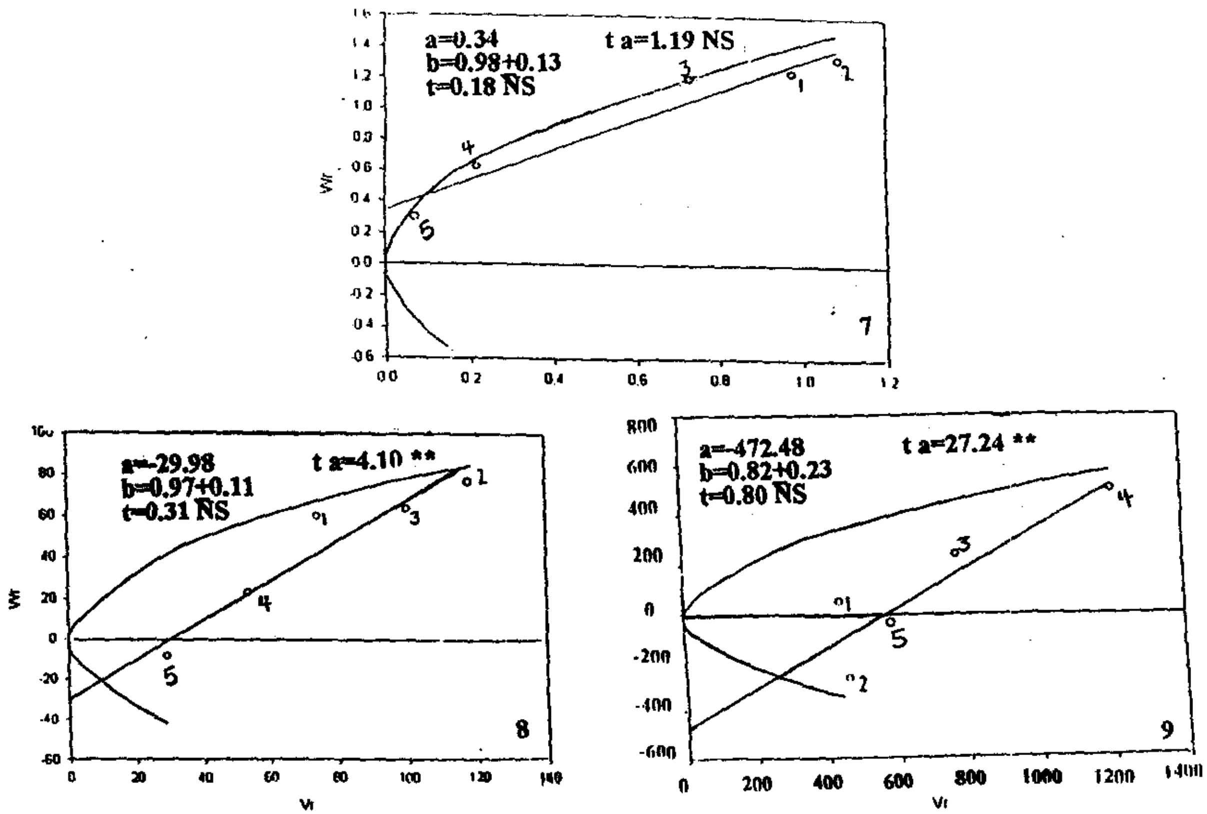

Fig. 7-9: Wr/Vr graph; 7. Pod weight, 8. Total pod number, and 9. Total yield

DISCUSSION

The results of mean performance, and gca and sca reflected highly significant mean squares due to parents, crosses and parents *vs* crosses, gca and sca in all studied traits; i.e., leaf area per leaf, early pod weight per pod, early pod number, early yield, average pod weight, pod number per plant, and total green pods yield per plant. In two cases of parents *vs* crosses, plant height and branch number per plant, were significant. Moreover, sca was significant for branch number per plant, early yield, and individual plant yield. Therefore, the five parents; i.e., IT 86F, IT 93K, Kafr El-Sheikh-1, Dokki-331 and Kaha-1 involved in 5x5 diallel cross system had sufficient diversity in aforementioned traits.

Combining ability effects: Present results illustrated presence of high correspondence among the general performance of the parental cultivars in plant height, branch number, early pod weight per pod, early pod number and all traits of green pod yield per plant. Other traits; i.e., leaf area, early pod number and early yield, did not reflect this general agreement. Therefore, a particular tester cultivar could not be used to evaluate all the studied characters with the same efficiency. In this respect, Metwally *et al*. (1998) illustrated that leaf area was mainly cultivar dependent.

In this assessment, the cultivars showed high mean gca were IT93K and IT86F for plant height, pod weight per pod (for early and total yield), IT93K and Kaha for branch number, Kafr El-Sheikh and Kaha for early pod number, Dokki and Kaha for total pod number per plant, and IT93K and Dokki for total plant green pods yield. Those cultivars had also high mean values of each trait. The best general combiners for leaf area were IT 86F and Dokki (had medium values of their mean performances), for early yield per plant were Kafr El-Sheikh and Kaha (had low and medium mean performances, respectively), Tables 3 and 5. So that, the choice of the tester parent, in the particular character, should be based on its progeny performance. This parameter (gca) indicated, mostly, additive variance ($\sigma^2 g = 1/2\sigma^2_A$). Plant breeder could exploit this portion of total the genetic variance to select a pure line (individual selection) from the advanced segregating generations to develop high performed lines, especially in self pollinated crops, as of *Vigna unguiculata*.

For sca and heterosis: Both the parameters reflected the per se behavior of the parental cultivars when crossed each other, and also reflected the role of non additive gene action on offspring of a cross. In this respect, MP heterosis (relative heterosis), is mostly and conveniently used in biometrical studies, while BP heterosis (heterobeltiosis) is a useful measure when breeding deals with economic traits. Heterosis measured on the base of BP is of interest, and to get heterotic cross, the non additive portion should be higher than the additive portion, even though the later portion should have significant value. Theoretically, the traits had higher σ^2_A than σ^2_D (Table 4) would show partial dominance or complete dominance, and heterosis (BP) may not found. In this respect, σ^2_A was larger than σ^2_D for plant height, branch number, pod weight (in early and total yield), had also mean sca performance for all the crosses less than the BP of each cross, and had, often, negative BP heterosis. The best crosses (with indication for gca) were IT 93K (high gca) x Kaha (high gca) and IT 93K (high gca) x Dokki (mid gca) for branch number, IT 86F (high gca) x Dokki (high gca) for leaf area, IT 93K (low gca) x Kafr El-Sheikh (high gca) and Kafr El-Sheikh (high gca) x Kaha (high gca) for early pod number and early yield, and were IT 93K (low gca) x Dokki (high gca), Kafr El-Sheikh (mid-gca) x Kaha (mid-gca) and Dokki (high gca) x Kaha (mid-gca). Significant gca and sca were also reported for plant height and yield of cowpea by Abo-Bakr *et al.* (1988), Gad El-Hak *et al.* (1988), Roquib and Patnik (1990), Hussein (1998) and Subbiah *et al.* (2003).

These results illustrated that, BP heterosis were observed in crosses having parents with gca of high x high, mid x high and high x low, mid x mid and low x low, especially in early and total yield, indicating that the heterosis did not reflect the gca of the parents involved in the cross, but it due to parents per se performance. Heterosis in plant yield reached 113-189% for early yield and higher than 46% for total plant yield, in the aforementioned crosses. From these results, transgressive segregants would be expected in the progeny of these crosses.

Genetic parameters: From the analysis of diallel and testing the hypothesis (Tables 8 and 9), non-significant t^2 values for all studied traits in this work supported the assumptions underlying this analysis, except early pod number (t^2, significant). Estimates of D (additive gene action) was larger than H_1 and H_2 (dominant components), indicating the role of additive in inheritance of plant height and pod weight (in early and total plant yield). On the other side, the two dominant components were larger than the additive one for branch number, leaf area, early pod number, and early and total plant yield (pod number and yield), indicating the predominant of non additive portion in the inheritance of these traits. Such results are in agreement with combining ability estimates. These results were also indicated by Thiyagarajan (1989), Singh and Dabas (1992), Sawant *et al.* (1994), Umaharan *et al.* (1997) and Rahman and Saad (2000).

The degree of dominance $(H_1/D)^{1/2}$ values and intersection points of Wr after testing from 0 point, indicating complete dominance for plant height, branch number, pod weight (both in early and total yield) and total green pods yield, and over dominance for leaf area, yield and pod number in early yield and total yield. Complete dominance and over dominance were reported for leaf area by Sawarkar *et al.* (1999) and Helal (2000), respectively.

For gene frequency $(H_2/4H_1)$, it indicated asymmetrical gene distribution, except pod number (early yield) and total plant yield (0.24) which is near to maximum gene frequency. Considering these results, value of F and r, since the genes frequencies were less than 0.25, indicating that most of the expressions of traits were came from dominant alleles, except branch number and total pods number, but r-values indicated dominant genes for early pod number and yield in early and total yield, and recessive for others, irrespective of their effect.

From Wr/Vr graph analysis (Fig. 1-9), it confirmed the above results. The parents had most dominant genes for plant height was Kafr El-Sheikh, Kaha for branch number, Dokki for leaf area, Dokki for early pod weight and number, Dokki and Kafr El-Sheikh for early yield, Kaha for average pod weight and pod number (total), and IT86F, IT93K and Kaha for total green pods yield. The parents had most recessive genes were IT93K, IT86F and Dokki for plant height, IT86F for branch number, IT93K for leaf area, IT93K for pod weight and pod number (early and total), Kafr El-Sheikh for early yield and Dokki for total green pods yield.

It is interest to note that, all growth traits and pod weight, the environment had little effect, since the distance between the regression line and parbola limit was small. While, it was large for pod number and yield (early and total), so they highly affected by the environments. Other interesting point is for early yield, the regression slope was negative, the arrays of parents for Wr-Vr (which =1/2D-1/2H) all are negative, indicating the additive portion is negative and dominance is positive, and the expression (r, negative) is dominant. So, it could be conclude that dominance was ambidirictional in this trait. It also confirmed the heritability estimates. Heritability estimates were 67.57, 66.80, 73.21, 87.01, 17.40, 7.14, 88.00, 60.40, and 17.20% for the studied nine traits, respectively. Similar estimates were also reported by Abo-Bakr *et al.* (1988), Gad El-Hak *et al.* (1988), Thiyagarajan (1989), Roquib and Patnik (1990), Sawant *et al.* (1994) and Hussein (1998) for plant height and branch number.

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دراسة توارث بعض الصفات الكمية والبسيطة في اللوبيا
١- صفات النمو والمحصول

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هجنت خمسة أصناف من اللوبيا هى: IT 93K وIT 86F وكفر الشيخ -١و دقى- ٣٣١ وقها-١ بنظام الداي أليل (بدون الهجن العكسية)، وتم تقييم الآباء وهجنها خلال صيف ٢٠٠٣. أظهرت كلا من القدرة العامة والخاصة على التآلف معنوية عالية في التسع صفات المدروسة ، والآباء التى أظهرت قدرة عامة على التآلف هى IT 93K, IT 86F بالنسبة لارتفاع النبات ومتوسط وزن القرن الأخضر، وقها بالنسبة لعدد الفروع، ودقى بالنسبة للمساحة الورقية، وكفر الشيخ بالنسبة لعدد القرون الخضراء المبكرة والمحصول المبكر، ودقى وقها بالنسبة للعدد الكلى للقرون الخضراء للنبات، وIT93K ودقي بالنسبة لمحصول النبات الكلى.

أظهرت بعض الهجن قوة هجين متفوقة على الأب الأفضل للصفة لكلاً من صفات النمو الخضرى في هجين دقى x كل من IT 93K (٣٩,٥%) أو x قها (٣٨,٤%) لصفة ارتفاع النبات، وهجين دقى x IT 93K بالنسبة للمساحة الورقية، كما ظهرت قوة الهجين المحسوبة على أساس الأب الأفضل للصفة بالنسبة لعدد القرون المبكر والمحصول المبكر فى هجين IT93K x كفر الشيخ، و كفر الشيخ x قها، وأظهرت الهجن IT86F x دقى وكفر الشيخ x قها أو دقى x قها أعلى قوة هجين فى المحصول الكلى من القرون الخضراء.

كانت مكونات الإضافة والسيادة معنوية التأثير في التسع صفات المدروسة، ولكن الإضافة كانت غير معنوية بالنسبة لعدد القرون الخضراء المبكرة وكذلك مكون السيادة (H_2) لمتوسط وزن القرن الأخضر المبكر، وفي التسع صفات كان مكون السيادة أكبر من مكون الإضافة ووجد العكس في صفة ارتفاع النبات، ووزن القرن في كل من المحصول المبكر والمحصول الكلى للنبات.

من خلال الأشكال البيانية W_r/V_r و درجة السيادة $(H_1/D)^{1/2}$، (بدا تأثير السيادة الفائقة واضحا في توارث صفة المساحة الورقية، وعدد القرون المبكرة، والمحصول المبكر، و المحصول الكلى، و كانت باقي الصفات تحت تأثير السيادة التامة، ومن خلال درجة التوريث بمعناها الضيق والرسم البياني لعب تفاعل البيئة مع الأصناف دوراً كبيراً في توارث صفات عدد القرون والمحصول(المبكر والكلى)، بينما لم تتأثر باقي الصفات بالتفاعل.