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STUDIES ON THE INHERITANCE OF SOME QUANTITATIVE AND QUALITATIVE TRAITS IN COWPEA II. GREEN POD QUALITY 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 for green pod morphological and chemical traits. Non-significant t^2 values were observed for the studied nine pod traits, but it was significant for sugars. And/also one parent (Kafr El-Sheikh) was found outside parabola for pod filling. Therefore, the analysis was retried on the base of 4x4 diallel. Results showed partial dominance for pod length, and complete dominance for pod diameter, pod filling, seed number/pod, DM, protein, carbohydrates, fiber and sugars, after testing the intersection point from origin. Both additive and non-additive gene action were involved in the inheritance of these traits, except D for carbohydrates and fibers, and H_1 and H_2 for protein and sugars. The expressions of these traits were mostly due to recessive genes, except dominant genes for pod diameter and carbohydrates. From heritability estimates and graphics (Wr/Vr), all the traits were highly affected by the environment and had low h^2 estimates (50% or less). On the other side, high h^2 were found for pod length (75%), for pod filling (67.5%) and sugars (74.4%). For heterosis over BP, few cases showed positive values, however the negative ones for fiber would be considered in following crosses; i.e., IT 86F x IT 93K (-18.6%), IT 86F x Kafr El-Sheik (-14.4%) and IT**

93K x Kafr El-Sheik (-17.9%). The best combiners for pod length, pod diameter, seed number and sugars were IT 86F and IT 93K, for pod filling, protein and carbohydrates were Dokki and Kaha, for DM was Kaha, and for fibers were IT 86F and Dokki.

Key words: Cowpea, heterosis, gca, sca, diallel, pod quality

INTRODUCTION

Green cowpea pods (*Vigna unguiculata* (L.) Walp.) is a summer legume crop and ranks second, after snap bean in summer of Egypt. Unfortunate, Immature pods yield of the cultivars in Egypt is somewhat low and its quality is highly affected by environmental conditions; i.e., low soil moisture, the pods are short and fibery (Yamaguchi, 1983). To overcome these drawbacks, developing good yielding and high quality cultivars may solve these problems.

A good understanding of the genetics of green pod morphological and chemical traits is the pre-request for planning a suitable breeding program. Damarany (1994a and c), Mehta and Zaveri (1997), HelaL (2000) and Tyagi *et al.* (2000) reported significant gca and sca, heterosis, moderate to high heritability, additive and non additive effect and presence of partial to over dominance in the inheritance of pod length and seed number per pod. Over dominance and heterosis was significantly positive for pod diameter. Damarany (1994a and b) and Hussein (1998) reported heterosis, ranged from -8.37 to 12.69%, high heritability and partial dominance for pod filling. Moreover, Subbiah (2003) reported positive association between DM and yield, and fiber had negative effect on green pod yield. Abo-Bakr *et al.* (1988) reported that total soluble sugars ranged from 2.14% for Cream-7 to 4.391% for Pusa Phalguni in cowpea fresh pods. Rodrigues *et al.* (1998) reported significant gca and sca for fiber content in *Phaseolus vulgaris* pods and the nonadditive effect was predominant for this trait. Onwuliri and Obu (2002) reported 56% carbohydrates and 20.5-31.7% for protein content in cowpea. Ponmarimmal and Das (1996) and Malarvizhi (2000) reported non additive gene action for crude protein content.

The purpose of this work (5x5 diallel technique) was to determine and compare the general and specific combining ability effects for establishing a few cultivars as tester parents for cowpea green pods; morphological and chemical traits. To study heterosis and genetic parameters that involved in the inheritance of these traits. Also, graphical analysis (Wr/Vr) and genetic components of variation are helpful methods 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., IT 86F, IT 93K, 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 F_1 seeds at the Experimental Farm, Faculty of Agriculture, Zagazig University. These cultivars were chosen because each possessed at least one or two of the characters to be studied. IT 86F had wide pod, high protein, high sugars and less fibers; IT 93K had long pod and medium in other pod quality traits; Kafr El-Sheikh had thin pod and high carbohydrates content; Dokki had thin pod, high protein and carbohydrates, and Kaha had short, thin pod, less seed number per pod, high DM and sugars content.

The 10 F_1 hybrids along with the 5 parents were planted, in a completely randomized block design with three replicates, on July 15th , 2003. The treatments in each replication consisted of 10 plants at the spacing of 30cm apart on one row of 3m long and 70cm wide.

Data recorded: A random sample of 10 green pods were taken from the 4th and 5th pickings (mid harvest season) to determine pod morphological traits, then dried at 70°C to determine the chemical contents of the pods. The morphological traits were pod length (cm), pod diameter (cm, using Calipare), pod filling (using Ramison's, 1978, method) and green seed number per pod. Chemical traits were DM (%), protein (using Bremner and Mulvaney, 1982 method; N values were multiplied by 6.25), fiber (by the method reported by SPA, 1943), carbohydrate (by Michel *et al.*, 1956, method) and sugars (using Forsee, 1938, method).

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 and 1955) and Hayman (1954a, 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 (BP) were also calculated (Mather and Jinkes, 1971).

RESULTS

1. Mean Performance of Pod Traits

Results of the analysis of variance for cowpea genotypes, derived from 5x5 diallel cross system regarding green pod traits, revealed highly significant variances of total genotypes, parents, and crosses (Tables 1 and 2) for pod morphological and chemical traits. Parents *vs* crosses variances were also highly significant for pod filling, dry matter, carbohydrates, and fiber contents, but it was insignificant for pod length, pod diameter, seed number per pod, protein content and total soluble sugars.

For mean pod morphological traits (Table 3), data illustrated that *cvs* IT 93K and Kaha gave the highest and the lowest values of pod length, pod diameter and seed number per pod, respectively, and vice versa for pod filling. In this respect, *cv* Kafr El-Sheikh showed intermediate values in all pod morphological traits. For crosses, the crosses showed highest mean values for pod length and pod diameter were IT 93K x Kafr El-Sheikh, for pod filling was Dokki x Kaha, and for seed number was IT 86F x IT 93K and Dokki x Kaha. On the other hand, the crosses showed the lowest values were Dokki x Kaha for both pod length and diameter, IT 93K x Kafr El-Sheikh for pod filling, and IT 86F and Kafr El-Sheikh x Kaha for seed number per pod.

For green pod chemical traits (Table 4), the parents revealed highest dry matter (DM), protein, carbohydrates, fiber and total soluble sugars of their pods were Kaha, Dokki, Dokki, IT 93K and Kaha, respectively. However, the lowest values of these traits were obtained form IT93K, IT 93K, Kaha, Kaha and Kafr El-Sheikh, respectively. The crosses among these cultivars that showed highest values of pod chemical traits were IT 93K x Kaha, IT 86F x Dokki, IT 93K x Dokki, IT 93K x Kaha and IT 86F x IT 93K, respectively. The lowest values of these traits were obtained from the crosses of IT 86F x IT 93K, IT 93K x Kafr El-Sheikh, IT 93K x Kaha, IT 86F x IT 93K, and Kafr El-Sheikh x Dokki, respectively.

Table 1: Mean squares resulted from 5 x 5 diallel analysis for cowpea green pod morphological traits

S. O. V.	d.f	Pod length (cm)	Pod diameter (cm)	Pod filling	Seed No./pod
Reps	2	19.42**	0.003$^{N.S}$	0.0018$^{N.S}$	2.367$^{N.S}$
Genotypes	14	211.14**	0.081**	0.0574**	9.330**
Parents	4	286.40**	0.081**	0.0402**	9.690**
Crosses	9	200.82**	0.089**	0.0599**	10.190**
P's vs crosses	1	2.98$^{N.S}$	0.007$^{N.S}$	0.1034**	0.144$^{N.S}$
Error	28	2.74	0.002	0.0008	0.949

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

Table 2: Mean squares resulted from 5x5 diallel analysis for cowpea green pod chemical traits

S. O. V.	d.f	Dry matter (%)	Protein (%)	Carbohydrate (%)	Fiber (Fresh wt. %)	T. S. Sugars (%)
Reps	2	0.36^{NS}	4.41^{NS}	7.60^{NS}	0.018^{NS}	3.50^{NS}
Genotypes	14	1.65**	15.20**	19.86*	0.138**	21.55**
Parents	4	1.77**	18.97**	21.60**	0.104**	31.48**
Crosses	9	1.45**	15.12**	20.09**	0.089**	19.04**
P's vs crosses	1	2.97**	0.80^{NS}	10.83**	0.719**	4.12^{NS}
Error	28	0.19	3.92	8.49	0.025	4.79

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

Table 3: Mean performance of green pod morphological traits for five parents cultivars of cowpea and their F_1 hybrids

Genotypes	Pod length (cm)	Pod diameter (cm)	Pod filling	Seed No./ pod
1. IT 86F	25.33	0.99	0.49	12.34
2. IT 93K	40.15	0.98	0.43	15.23
3. Kafr El-Sheikh-1	20.61	0.70	0.56	11.61
4. Dokki-331	20.67	0.79	0.61	12.51
5. Kaha-1	14.16	0.63	0.71	10.33
$P_1 \times P_2$	39.64	0.85	0.42	16.56
$P_1 \times P_3$	20.20	0.69	0.59	11.94
$P_1 \times P_4$	20.38	0.91	0.59	11.95
$P_1 \times P_5$	24.89	0.94	0.45	11.25
$P_2 \times P_3$	39.72	1.09	0.29	11.33
$P_2 \times P_4$	24.01	0.66	0.46	11.34
$P_2 \times P_5$	23.24	0.90	0.55	12.63
$P_3 \times P_4$	18.60	0.78	0.69	12.80
$P_3 \times P_5$	19.60	0.60	0.55	10.80
$P_4 \times P_5$	17.70	0.53	0.85	15.00
L.S.D at 5%	2.77	0.06	0.05	1.63

Table 4: Mean performance of chemical traits for five parent's cultivars of cowpea and their F_1 hybrids

genotypes	Dry matter (%)	Protein (%)	Carbohy-drate (%)	Fiber (fresh wt. %)	T. S. Sugar (%)
1. IT 86F	11.56	23.83	58.89	2.36	16.53
2. IT 93K	10.20	18.88	57.79	2.66	14.32
3. Kafr El-Sheikh-1	10.50	19.01	61.33	2.62	10.16
4. Dokki-331	10.93	23.83	64.00	2.32	11.66
5. Kaha-1	12.08	20.06	57.79	2.25	17.91
$P_1 \times P_2$	9.07	20.44	56.68	1.92	18.37
$P_1 \times P_3$	10.64	19.40	61.56	2.02	14.69
$P_1 \times P_4$	10.53	23.44	57.78	2.14	17.91
$P_1 \times P_5$	10.93	19.66	58.89	2.30	12.93
$P_2 \times P_3$	10.85	16.02	56.68	2.15	12.03
$P_2 \times P_4$	9.54	21.49	62.67	2.03	14.69
$P_2 \times P_5$	11.24	19.79	55.57	2.48	14.24
$P_3 \times P_4$	10.29	22.66	56.68	2.14	11.28
$P_3 \times P_5$	10.95	23.05	61.33	2.38	17.92
$P_4 \times P_5$	10.99	22.27	61.33	2.16	13.77
L.S.D at 5%	0.74	3.31	4.87	0.26	1.79

2. Combining Ability

Results of gca and sca variances (Tables 5 and 6) reflected highly significant values for all morphological and chemical traits of cowpea pods, except gca for DM, gca and sca for carbohydrates which were significant and gca for protein was insignificant. The expected mean squares for gca (σ^2_A) illustrated that, its values for pod length and protein content were larger than σ^2_D. The non additive portion (σ^2_D) for other traits was larger than that for the additive one (σ^2_A). It is interesting to mention that, the additive portion was negative and less than the non additive one for fiber content in the green pods, according to Griffing's approach (1956).

Mean performance of gca (Table 7), revealed that the best combiners for green pods morphological traits were IT 93K and Kafr El-Sheikh for pod length, IT 86F and IT 93K for pod diameter and seed number, and Dokki and Kaha for pod filling. The poorest combiners in this respect, were IT 86F and Dokki for pod length and diameter, respectively, IT 93K for pod filling, and Kafr El-Sheikh for seed number per pod. Moreover, the best combiners for chemical traits were Kaha and Kafr El-Sheikh for DM, Dokki and Kaha for protein, and IT 86F for total soluble sugars. The poorest combiners for these traits were IT 93K and IT 86F, IT 93K, and Kafr El-Sheikh, respectively. For fiber content, the best and the poorest combiners were IT 86F and Kaha, respectively, since the objective is to breed for low fibers content. For carbohydrates, there were insignificant differences among these cultivars. For sca, it was previously mentioned with mean performance for the genotypes (Tables 3 and 4).

3. Heterosis

Results of Table 8 show that MP heterosis had negative and positive signs. However, for BP heterosis, all the crosses revealed negative heterosis in all pod morphological and chemical traits. Therefore, the pod traits did not reach to better parent. A few exceptions were observed in pod diameter, pod filling, seed number, DM, protein, fibers, and sugars. The crosses which showed respected heterosis in these traits were IT 93K x Kafr El-Sheikh (11.22%), Kafr El-Sheikh x Dokki (13.7%) and Dokki x Kaha (16.2%), IT 86F x IT 93K (8.7%) and Dokki x Kaha

(19.9%), IT 93K x Kafr El- Sheikh (3.3%), Kafr El-Sheikh x Kaha (14.9%), IT 93K x Kafr El-Sheikh (-17.9%) and IT86F x IT93K (-18.6%), and IT 86F x IT 93K (11.1%), respectively. For carbohydrates, it is not worthy to mention those having positive heterosis.

Table 5: Mean squares for gca and sca resulted from 5x5 diallel analysis for cowpea green pod morphological traits

S. O. V.	d.f	Pod length (cm)	Pod Diameter (cm)	Pod filling	Seed No. /pod
Genotypes	14	211.140**	0.0806 **	0.0574**	9.33**
gca	4	192.827**	0.0450 **	0.0416**	3.66**
sca	10	21.401**	0.0196 **	0.0102**	2.89**
Error	28	0.913	0.0006	0.0003	0.32
σ^2 gca		24.490	0.0036	0.0045	0.11
σ^2 A		48.979	0.0072	0.0089	0.22
σ^2 D		20.488	0.0135	0.0100	2.57

** : Significant at 1% level of probability.

Table 6: Mean squares of gca and sca resulted from 5x5 diallel analysis for cowpea green pod chemical traits

S. O. V.	d.f	Dry matter (%)	Protein (%)	Carbodydrates (%)	Fiber (fresh wt. %)	T. S. sugar (%)
Genotypes	14	1.65**	15.20**	19.86**	0.138**	21.55**
gca	4	0.98*	11.11**	7.75*	0.026**	11.09**
sca	10	0.38**	2.65 N.S	6.17*	0.054**	5.62**
Error	28	0.06	1.31	2.83	0.008	1.60
σ^2 gca		0.09	1.21	0.23	-0.004	0.78
σ^2 A		0.17	2.42	0.45	-0.008	1.56
σ^2 D		0.31	1.34	3.34	0.046	4.02

NS, * and **: Insignificant at 5%, significant at 5% and 1% level of probability, respectively.

Table 7: Mean values of general (gca) combining ability for green pod morphological and chemical traits of 5x5 diallel of cowpea

Genotypes	Green pod morphological traits				Green pod chemical traits				
	Pod length (cm)	Pod diameter (cm)	Pod filling	Seed number /pod	Dry matter (%)	Protein (%)	Carbohy -drate (%)	Fiber (fresh wt. %)	T. S. sugar (%)
IT 86F	12.12	0.85	0.51	13.93	10.29	20.74	58.73	2.10	15.98
IT 93K	31.65	0.87	0.43	12.97	10.18	19.44	57.90	2.15	14.83
Kafr El-Sheikh-1	24.53	0.79	0.53	11.72	10.68	20.28	59.06	2.17	13.98
Dokki-331	20.65	0.72	0.65	12.77	10.34	22.46	59.62	2.12	14.41
Kaha-1	21.36	0.74	0.60	12.42	11.03	21.19	59.28	2.33	14.72
±S. E.	7.05	0.07	0.08	1.05	0.35	1.12	0.65	0.09	0.75

Table 8: Heterosis over mid (MP) and better (BP) parent for green pod morphological traits of cowpea F_1s hybrids

cross	Pod length(cm)		Pod diameter (cm)		Pod filling		Seed No. /pod	
	MP	BP	MP	BP	MP	BP	MP	BP
P_1 x P_2	21.1	- 1.3	-15.88	-14.14	- 7.42	-13.81	20.1	8.7
P_1 x P_3	-12.1	-20.3	-18.34	-30.30	13.30	5.71	- 0.3	- 3.2
P_1 x P_4	-11.4	-19.5	2.25	- 8.08	7.71	- 2.98	- 3.8	- 4.5
P_1 x P_5	26.1	- 1.7	16.05	-18.18	-25.60	-38.08	- 0.8	- 8.8
P_2 x P_3	30.7	- 1.1	29.76	11.22	-41.56	-48.39	-15.6	-25.6
P_2 x P_4	-21.1	-12.0	-25.42	-32.65	-10.83	-23.80	-18.2	-25.5
P_2 x P_5	-14.4	-42.1	11.80	- 8.16	- 4.75	-24.38	- 1.2	-17.1
P_3 x P_4	- 9.9	-10.0	4.70	- 1.27	18.11	13.72	6.1	2.3
P_3 x P_5	12.7	- 4.9	- 9.77	-14.29	-14.57	-24.52	- 1.6	- 7.0
P_4 x P_5	1.6	-14.4	-25.35	-32.91	27.04	16.16	31.4	19.9
LSD at 5%	2.4	2.7	0.06	0.07	0.04	0.05	1.4	1.6

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.

Table 9: Heterosis over mid (MP) and better (BP) parent for green pod chemical traits of cowpea F_1s hybrids

cross	Dry matter (%)		Protein (%)		Carbohydrate (%)		Fiber fresh weight (%)		T. S. sugar (%)	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
P_1 x P_2	-16.6	-21.5	- 4.3	-14.2	-2.9	- 3.8	-23.5	-18.6	19.1	11.1
P_1 x P_3	- 3.5	- 8.0	- 9.4	-18.6	2.4	0.4	-18.9	-14.4	10.0	-11.3
P_1 x P_4	- 6.4	- 8.9	- 1.6	- 1.6	-6.0	- 9.7	- 8.6	- 7.8	27.0	8.4
P_1 x P_5	- 7.5	- 9.5	- 9.6	-17.5	0.9	0.0	-43.3	2.2	-24.9	-27.8
P_2 x P_3	4.8	3.3	-15.5	-15.7	-4.8	- 7.6	-18.6	-17.9	- 1.7	-16.0
P_2 x P_4	- 9.7	-12.7	0.6	- 9.5	2.9	- 2.1	-18.5	-12.5	13.1	2.6
P_2 x P_5	0.9	- 7.0	1.7	- 1.3	-3.8	0.0	0.8	10.2	-11.7	-20.5
P_3 x P_4	- 4.0	- 5.9	5.8	- 4.9	-9.6	-11.9	2.2	- 7.8	3.4	- 3.3
P_3 x P_5	- 3.0	- 9.4	18.0	14.9	3.0	0.0	- 2.5	- 5.8	27.6	0.1
P_4 x P_5	- 4.5	- 9.0	1.5	- 6.5	0.7	- 4.2	- 5.7	4.0	- 6.9	-23.1
L.S.D 5%	0.6	0.7	2.9	3.3	4.2	4.9	0.2	0.3	3.2	3.7

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.

4.Genetic Parameters and Ratios

Data in Tables 10 and 11 reflected insignificant t^2 for all pod morphological and chemical traits, indicating the validity of the assumptions of diallel analysis, except sugars, which had highly significant. The additive genetic component (D) was significant and highly significant for all pod traits, except carbohydrates and fibers, which were insignificant. Concerning H_1 and H_2, these two dominant components reflected, also, highly significant values for all traits, except both H_1 and H_2 for pod filling and protein and H_2 for DM were insignificant. Dominant effect (h_2) was insignificant for all pod traits, except DM, carbohydrates and fibers. In this respect, F component was insignificant, but it was negative for pod length, pod diameter, pod filling and protein, and positive for other traits, indicating that most of the expression coming from dominant and recessive alleles, respectively.

For Genetic ratios (Tables 10 and 11), the values of $(H_1/D)^{1/2}$ were less than one for pod length and more than one for other traits, indicating partial and over dominance, but it was round one (0.94) for pod length, indicating complete dominance in the inheritance of this traits. Asymmetrical gene distribution ($H_2/4H_1$) was observed in all pod traits, except carbohydrates which showed maximum gene ratio (0.25). The group of genes (h_2/H_2) that controlling pod traits were all less than one, except DM and fiber, which were more than 3 and 7 pairs, respectively. Correlation coefficient (r) was positive for pod length, pod filling, seed number, DM, protein and fiber, and it was negative for pod diameter, carbohydrates and sugars, indicating dominant and recessive alleles in controlling these traits, respectively. Heritability (h^2) was higher than 50% for pod length and pod filling, and less than 50% for other traits.

For Wr/Vr graph (Figs. 1-11), the graphs showed that the regression line intersects Wr near to the origin, but when tested the intersection portion (α) from 0 point it was not differ from 0 for pod diameter, pod filling, seed number, DM, protein, carbohydrates and fiber, and significant from 0 for pod length and sugars (below origin). These results indicated presence of complete dominance, partial dominance, and over dominance in the inheritance of these traits, respectively. Two interesting cases were also observed with pod filling and

Table 10: Estimates of components of genetic variations and genetic ratios in 5x5 diallel for cowpea green pod morphological traits

Parameter	Pod length (cm)	Pod diameter (cm)	Pod filling	Seed No./pod
D	$94.15^{**} \pm 11.77$	$0.026^{**} \pm 0.007$	$0.0131^{**} \pm 0.0055$	$2.89^{**} \pm 1.28$
H_1	$82.99^{**} \pm 31.79$	$0.796^{**} \pm 0.019$	$0.0274^{NS} \pm 0.0147$	$11.02^{**} \pm 3.45$
H_2	$74.78^{**} \pm 28.83$	$0.076^{**} \pm 0.017$	$0.0200^{NS} \pm 0.0134$	$10.39^{**} \pm 3.13$
h_2	$4.04^{N.S} \pm 19.47$	$0.007^{N.S} \pm 0.012$	$0.0040^{NS} \pm 0.0091$	$0.09^{NS} \pm 2.11$
F	$-17.26^{N.S} \pm 29.41$	$-0.004^{N.S} \pm 0.176$	$-0.0094^{NS} \pm 0.0137$	$1.78^{NS} \pm 3.19$
E	$1.28^{N.S} \pm 4.81$	$0.001^{N.S} \pm 0.003$	$0.0003^{NS} \pm 0.0022$	$0.35^{NS} \pm 0.52$
$(H_1/D)^{1/2}$	0.94	1.64	1.45	1.96
$H_2/4H_1$	0.23	0.24	0.18	0.24
h_2/H_2	0.05	0.09	0.20	0.01
r	0.50	- 0.97	0.82	0.35
t^2	3.07^{NS}	0.17^{NS}	2.63^{NS}	0.03^{NS}
h^2 (n. s.)	75.00	46.30	73.84	22.80

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

Table 11: Estimates of components of genetic variations and genetic ratios in 5x5 diallel for cowpea green pod chemical traits

Parameter	Dry matter (%)	Protein (%)	Carbohydrate (%)	Fiber fresh wt. (%)	T. S. Sugar (%)
D	0.53 * ± 0.25	5.00 * ± 2.01	4.38 N.S ± 3.15	0.026 N.S ± 0.026	8.92 ** ± 2.70
H_1	1.33 * ± 0.69	7.82 N.S ± 5.43	17.61 ** ± 8.52	0.177 ** ± 0.069	19.01 ** ± 7.30
H_2	1:15 N.S ± 0.61	6.98 N.S ± 4.93	17.36 ** ± 7.73	0.136 ** ± 0.062	17.98 ** ± 6.16
h_2	4.25 * ± 0.41	0.31 N.S ± 3.33	12.12 ** ± 5.22	0.928 ** ± 0.042	4.67 N.S ± 4.47
F	0.18 NS ± 0.62	- 0.46 N.S ± 5.03	1.53 N.S ± 7.88	0.050 N.S ± 0.064	5.32 N.S ± 6.75
E	0.06 N.S ± 0.10	1.32 N.S ± 0.82	2.81 * ± 1.29	0.008 N.S ± 0.010	1.57 N.S ± 1.10
$(H_1/D)^{1/2}$	1.59	1.25	2.01	2.616	1.46
$H_2/4H_1$	0.22	0.22	0.25	0.192	0.24
h_2/H_2	3.71	0.04	0.70	7.443	0.26
r	0.25	0.29	- 0.18	0.849	- 0.95
t^2	1.30 N.S	0.41 N.S	0.42 N.S	0.829 N.S	11.20 **
h^2 (n. s.)	43.60	50.70	17.82	16.80%	27.62

NS, * and **: insignificant and significant at 5% and 1% level of probability, respectively.

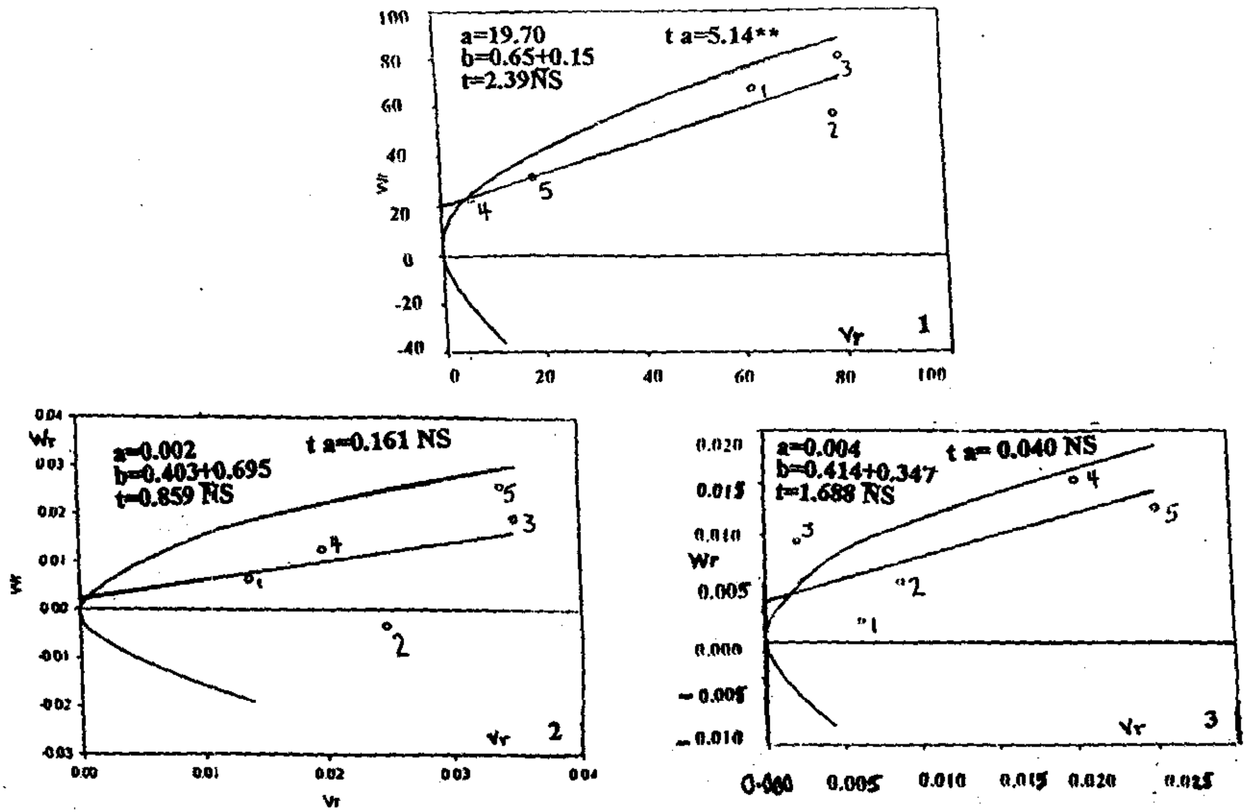

Fig. 1-3: Wr/Vr graph; 1. Pod length, 2. Pod diameter, and 3. Pod filling

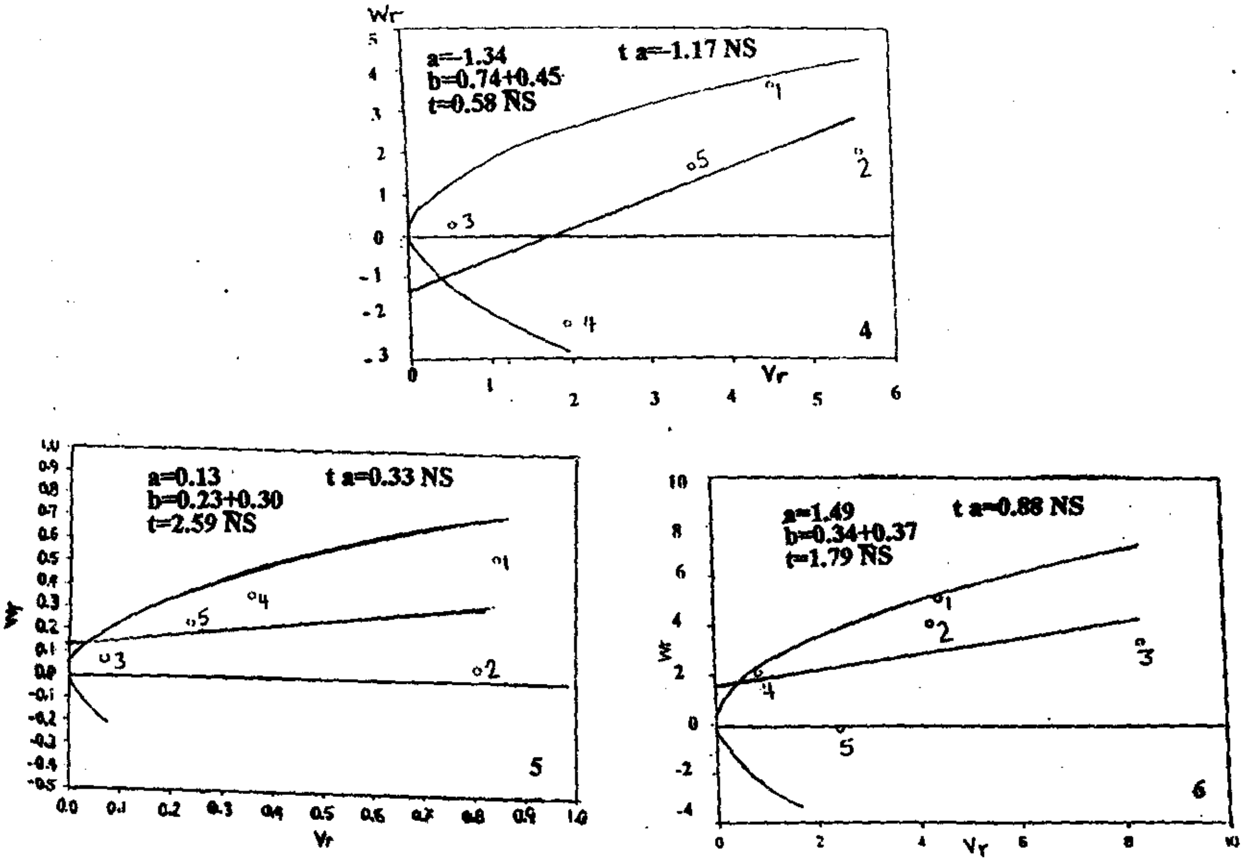

Fig. 4-6: Wr/Vr graph; 4. Seed number per pod, 5. Dry matter, and 6. Protein

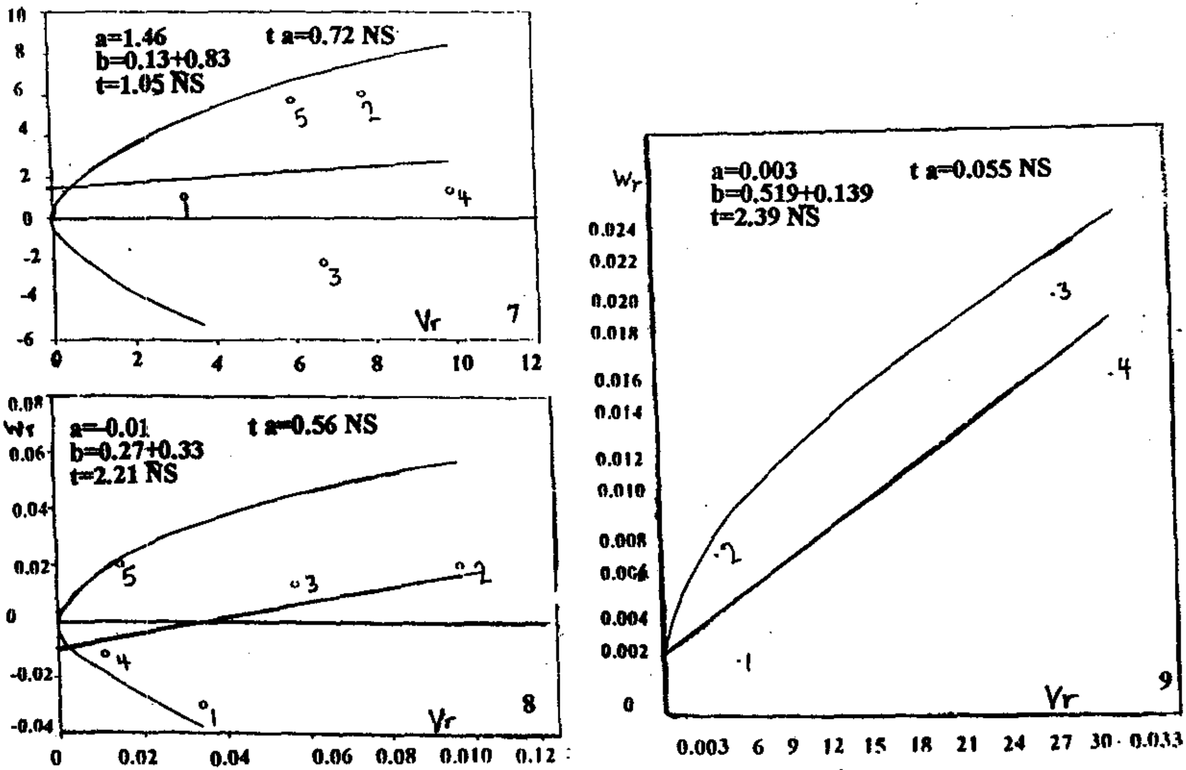

Fig. 7-9: Wr/Vr graph; 7. Carbohydrate, 8. Fiber, and 9. Pod filling 4x4

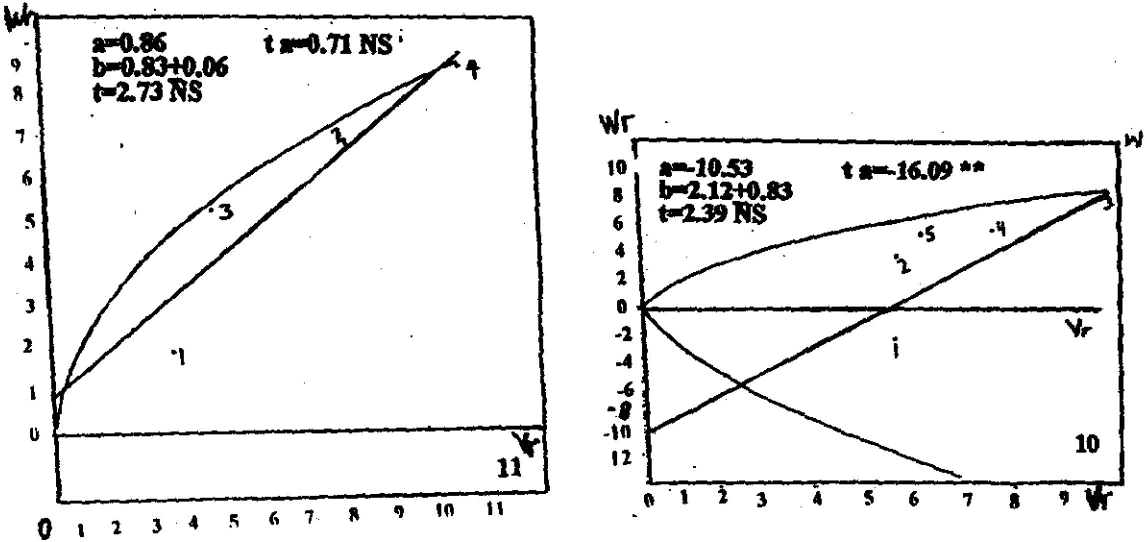

Fig. 10-11: Wr/Vr graph; 10. T.S. Sugars and 11. T.S. Sugars 4x4

sugars, where one of the parental cultivars lies outside the parabola (Kafr El-Sheikh) and t^2 was significant, respectively. By attempting and removing one parent from each and retrying the analysis, it becomes normal (Figs 10 and 11). The two graphs showed that the intersection point was above origin for both trait, but insignificant from 0 point (origin), indicating complete dominance for both the traits.

The graphs showed also that the dominant parents were Dokki and Kaha, IT 86F, IT 86F and IT93K (Fig. 10), Kafr El-Sheikh, Kafr El-Sheikh, Dokki, IT 86F, Dokki and Kaha, IT 86F (Fig. 11), for the studied nine traits, respectively. The recessive parents were Kafr El-Sheikh and IT93K, Kaha and Kafr El-Sheikh, Kaha, IT93K, IT 86F, Kafr El-Sheikh, Dokki, IT93K, Dokki and Kaha, Kafr El-Sheikh (Fig. 10), and Dokki (Fig. 11), respectively with the studied traits.

DISCUSSION

For improving cowpea green pods quality, morphological and chemical traits, genetical studies are required for pre-planning a breeding program. Thin pod, long or short, high DM, high protein, high sugars, and low fiber contents should be manipulated in breeding program for developing high pod quality cultivars.

Mean gca and sca performances: Results of the analysis of variance reflected significant and highly significant mean squares due to parents and crosses for the studied nine pod traits. While, parent *vs* crosses was highly significant only for pod filling, DM, carbohydrates and fiber contents in pod. Mean squares for gca and sca were also significant and highly significant for all pod traits, except sca for protein (insignificant), gca for DM (%), and sca and gca for carbohydrates. Mean gca for the parents, should be manipulated according to the objective of the study. Therefore, high gca for some traits (e.g. fiber) may be not the best combiner for such traits. High gca values were observed for IT 93K and Kafr El-Sheikh for pod length, IT 86F and IT 93K for pod diameter, seed number and sugars, and Dokki and Kaha for pod filling, DM, protein and fibers. Low gca values were observed for IT 86F in pod length, Dokki and Kaha for pod diameter, IT 93K and IT 86F for pod filling, DM, protein and fiber, and Kafr El-Sheikh for seed number and sugars. Therefore, there is a high correspondence among the general performances of the parental cultivars (Tables 3 and

4) and their general combining ability values. But according to the objective of this work, thin pod, high and moderate DM, high protein, moderate sugars, were observed for Dokki and Kaha, and low fiber was observed for IT 86F and Dokki, would be considered as best combiners for these traits. Highly significant gca and sca effects indicating both additive and non additive gene effect were reported by Mehta and Zaveri (1997) and Umaharan *et al.* (1997) for pod length, Rodrigues *et al.* (1998) for pod diameter and fiber content in *Phaseolus vulgaris* pods, Thiyagarajan (1989); Dobhal and Rana (1997) and Hussein (1998) for seed number per pod, Bastian *et al.* (2000) for DM. Hazra *et al.* (1996) found only gca variance was significant for seed protein content. While, Ponmarimmal and Das (1996) and Malarvizhi (2000) reported that protein was influenced by non additive gene action.

Accordingly, the best crosses showed thin pods, moderate DM, high protein, high carbohydrates, moderate fibers and moderate sugars were Kafr El-Sheikh x Dokki and Dokki x Kaha. Also, there were some crosses showed long pod, wide pod, high seed number, high DM, high protein, high carbohydrates, low fiber and high sugars contents; i.e., IT 86F x IT 93K and IT 93K x Kafr El-Sheikh, IT 93K x Kafr El-Sheikh, IT 86F x IT 93K, IT 93K x Kaha, IT 86F x Dokki and Kafr El-Sheikh x Kaha, IT 86F x Kafr El-Sheikh and IT 93K x Dokki, IT 86F x IT 93K or Kafr El-Sheikh and IT 93K x Dokki, and IT 86F x IT 93K, IT 86F x Dokki and Kafr El-Sheikh x Kaha, respectively. So that, crosses of both IT cultivar with the other three ones were the best specific combinations. Those crosses involved, high x high, low x high or low x low general combiners. For heterosis, it was not found pronounced in those traits regarding heterobeltiosis, but highly pronounced negative heterobeltiosis were observed for the above-mentioned three crosses for fibers (IT 86F x IT 93K, IT 93K x Kafr El-Sheikh and IT 86F x Kafr El-Sheikh). Such crosses may show transgressive segregants for low fiber contents in advanced generations. Helal (2000) reported significant positive heterosis over MP and BP for pod length, pod diameter and seed number per pod, and Kheradnam *et al.* (1975), Ojomo (1974), Zaveri *et al.* (1983), Abo-Bakr *et al.* (1988) and Damarany (1994c) for pod filling.

Genetic components and graphical analysis: Results showed that D portion was mostly less than H_1

and H_2, except that for pod length which showed, more or less, equal values for D and H_1. For F, r and $H_2/4H_1$; F, it is not significant for the studied nine traits and asymmetrical gene distribution among the parents was observed, except for carbohydrates which showed maximum gene distribution (0.25). The F sign was negative for pod length, pod diameter, pod filling and protein, and positive for others, indicating that most of the expression coming from the effect of dominant and recessive alleles, respectively. Irrespective of their increasing or decreasing effect. For r-values, it indicated that the traits controlled by dominant genes were pod diameter, carbohydrates and sugars, while other traits were under control of recessive genes. The number of genes that exhibited dominance (h_2/H_2) were less than one, however it was more than 3 and 7 pairs for DM and fibers contents, respectively. Partial dominance reported by Umaharan *et al.* (1997) for pod length and for pod filling by Damarany (1994 c), and for seed number per pod by Shaker (1980) and Abo-Bakr *et al.* (1988). However, over dominance for pod diameter reported by Helal (2000). No records were found for chemical traits about genetic components in cowpea green pods.

Graphical analysis (Figs. 1, 2, 4, 5, 6, 7, 8, 9, and 11) reflected that, the regression lines cuts Wr near to the origin for 7 traits, indicating presence of partial or complete dominance. While, it cuts Wr below the origin for seed number per pod and fibers contents, indicating over dominance in controlling both the traits. But when tested the intersected point from the origin, it was only significant for pod length, and others were insignificant, indicating presence of partial and complete dominance, respectively. It was also showed that the dominant parents were Dokki and Kaha, IT 86F, IT 86F and IT 93K, Kafr El-Sheikh, Kafr El-Sheikh, Dokki and Kaha, IT 86F, Dokki and Kafr El-Sheikh and IT 86F, and IT 86F for the nine traits, respectively. The recessive parents were IT 86F, IT 93K and Kafr El-Sheikh, Kafr El-Sheikh and Kaha, Dokki, Kaha, IT 86F and IT 93K, IT 86F and IT 93K, Kafr El-Sheikh, Dokki, IT 93K, and Dokki for the aforementioned traits, respectively. It is interest to indicate that, most of the expression coming from the recessive parent in pod length, pod diameter, pod filling, DM(%), moreover the most expression coming from the dominant parent in seed number, protein, fiber, and sugars. Also graphs reflected that, pod diameter, seed number, DM (%), protein, carbohydrates, fiber and sugars were highly affected by environment, which indicated by the large distance between the parabola limit and regression line. Less distance was observed with pod length and pod filling, indicating a little role of the environment on these traits. These results should be considered with the estimates in narrow sense heritability. The percentages values of h^2 (Tables 10 and 11) were 75.0 for pod length, 46.3 for pod diameter, 73.84 for pod filling, 22.8 for seed number, 43.6 for DM(%), 50.7 for protein, 17.82 for carbohydrates, 16.8 for fibers and 27.62% for sugars in pods. Retrying Hayman's approach with 4x4 diallel for pod filling and sugars (Table 12), the data cleared that D was highly significant for both traits, and H_1 and H_2 were significant for pod filling and insignificant for sugars. Therefore, the additive gene action was more important for both traits than non-additive one. And also h^2 was high for pod filling (67.54%) and the situation was changed for sugars (74.41%), but it was for sugars (5x5) about 27.62%.

Table 12: Estimates of components of genetic variations and genetic ratios in 4x4 diallel of cowpea

Parameter	Pod filling	T. S. sugars (%)
D	0.0177^{**} ±0.0061	6.41^{**} ±0.97
H_1	0.0376^{*} ±0.0175	4.50^{NS} ±2.78
H_2	0.0326^{*} ±0.0164	3.94^{NS} ±2.61
h_2	0.0009^{NS} ±0.0110	24.62^{**} ±1.82
F	-0.0121^{NS} ±0.0157	-7.89^{**} ±2.54
E	0.0002^{NS} ±0.0027	1.57^{**} ±0.43
$(H_1/D)^{1/2}$	1.46	0.84
$H_2/4H_1$	0.22	0.22
h_2/H_2	0.03	6.25
r	0.90	- 0.34
t^2	3.85	0.14
h^2 (n. s.) %	67.54	74.41

NS, * and **: insignificant and significant at 5% and 1% level of probability, respectively.

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دراسة توارث بعض الصفات الكمية والبسيطة في اللوبيا
٢- صفات الجودة للقرون الخضراء

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هجنت خمسة أصناف من اللوبيا هي IT 86F و IT 93K وكفر الشيخ -١ ودقي – ٣٣١ وقها -١ بنظام الدى أليل (بدون الهجن العكسية)، وتم تقييم الآباء وهجنها خلال صيف ٢٠٠٣ لدراسة الصفات المورفولوجية والكيماوية للقرون الخضراء. كانت قيمة t^2 غير معنوية لجميع الصفات التسع المدروسة عدا محتوى القرون الخضراء من السكريات فقد كانت قيمة t^2 معنوية و وقع كفر الشيخ -١ خارج حدود السيادة في صفة امتلاء القرن لذا تم إعادة التحليل لهاتين الصفتين على أساس نظام داي أليل ٤x٤ فأصبحت الصفتان طبيعيتين.

وأظهرت النتائج ما يلي:

سيادة جزئية لطول القرن، و سيادة تامة لقطر القرن و امتلائه و عدد البذور بالقرن، والنسبة المئوية لكل من المادة الجافة، والبروتين، والكربوهيدرات، والألياف والسكريات الكلية وذلك بعد اختبار معنوية α بالنسبة لنقطة الأصل.

اشتركت الإضافة والسيادة في وراثة جميع الصفات عدا الكربوهيدرات والألياف فقد تحكمت فيهما الإضافة فقط، أما مكونا السيادة H_1 و H_2 فتحكما في وراثة البروتين والسكريات، و التعبير عن هذه الصفات يرجع معظمه إلى الجينات المتنحية، ولكنه يرجع إلى الجينات السائدة في صفتي قطر القرن والكربوهيدرات.

من خلال درجة التوريث بمعناها الضيق والرسم البياني V_r / W_r أتضح أن كل الصفات كانت عالية التأثر بالبيئة ومنخفضة في درجة توريثها (٥٠% فاقل)، وفي المقابل كانت درجة التوريث عالية في صفات طول القرن (٧٥%)، وامتلاء القرن (٦٧,٥%)، والسكريات (٧٤,٤ %) على أساس نظام داي أليل ٤x٤.

بالنسبة لقوة الهجين المحسوبة على أساس الأب المفضل للصفة، قليل من الحالات اظهرت قيما موجبة، ولكن القيم السالبة بالنسبة للألياف أخذت في الاعتبار في هجن IT 93 K x IT 86F (- ١٦,٨%) و كفر الشيخ x IT 86F (- ١٤,٤%) أو كفر الشيخ x IT 93K (- ١٧,٩%).

الأبوان المفضلان بالنسبة لطول القرن وقطر القرن وعدد البذور بالقرن وللسكريات كانا IT 86F وIT 93K ، أما بالنسبة لامتلاء القرن ومحتواه من كل من البروتين و الكربوهيدرات فكان الصنفان دقي وقها، وللمادة الجافة فكان الصنف قها، وللنسبة المئوية للألياف فكان الصنفان IT 86F ودقي.