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GENETICAL AND CHEMICAL STUDIES ON PUMPKINS (*Cucurbita moshata*).

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ABSTRACT

Two pumpkin varieties namely, Balady and White Libi were crossed. Parents, F_1, F_2 and backcrosses were used in this study. Mode of inheritance, nature of gene action, heritability and number of effective genes were estimated. The results showed that fruit weight was quantitatively inherited and over dominance was existed. Broad sense heritability was 32.7%, while narrow sense heritability was 29.4% and from one to three pairs of genes control this character. As for fruit shape index, a dominance to round fruit was existed and one pair of genes control the character. Broad sense heritability was 67.2%, while in narrow sense heritability was 138%. The results of chemical composition indicated that the fruit's rind was higher in protein and lipids than the flesh. The cultivar Libi was higher than the Balady in carbohydrate, protein and lipids. The F_1 showed the highest level of carbohydrates, while the backcross to Libi gave the highest level of protein and F_2 was higher in lipids.

INTRODUCTION

Genetic information on pumpkin could be obtained from wide intervarietal crosses, which need to be available before proceeding with the formulation of appropriate breeding strategies to develop and improve fruit quality. Hussain *et al*. (1974) showed that the watermelon cross between Clondike striped x Sugar baby gave the best improvement in fruit weight over mid parental values and superior parent.

Brar and Nandpuri (1975) studied the parents, F_1, F_2, BC_1 and BC_2 of three watermelon crosses. Average fruit weight showed considerable heterosis and partial dominance for high fruit weight in two crosses and over dominance in the third.

Warid and Abd El-Hafez (1976) stated that the segregation in the F_2 for watermelon. Cross Congo x Yellow skin was 1 elongate : 2 semi-elongate : 1 spherical. This character was controlled by one pair of genes.

Abd El-Hafez (1983) found all types of dominance in various F_1 hybrids from different combinations of eight watermelon cultivars. As for fruit shape, he mentioned that low shape x high shape index produced F_1 fruit of low shape.

Janakiram *et al*. (1992) in their studies on heterosis for quantitative characters in bottle gourd (*Lagenaria siceraria*) found significant heterosis over the better parent for 8 characters. The best performing hybrid for yield showed 58.1% heterosis over better parent.

Jaiswal *et al*. (1990) evaluated seven cultivars of bittergourd for protein, carbohydrate and vitamin C content. They found that the fruits of the cultivar Priya contained 2.32% protein, 8.07% carbohydrate and 112.2

mg/100gm vitamin C. They mentioned that a large variation was found in the chemical composition between the seven cultivars, suggesting that there is scope for *M. charantia* breeding for high yield and nutritive value.

Rao *et al*. (1990) mentioned that cucurbita maxima contained 1.27% lipids and 2.83% proteins. Lipids classes were separated by silicic acid column chromatography and quantified. Therefore, the object of this work was to study the genetic behaviour of some economic fruit characters of pumpkin.

MATERIALS AND METHODS

The study was carried out at El-Baramon Horticulture Station during three summer successive seasons, 1996, 1997 and 1998. A pure lines for six generations, from the cultivars improved and distributed by Vegetable Research Department. White Libi (P_1) and Balady (P_2) were used in this investigation. In 1996, crosses were made between White Libi and Balady pumpkin cultivars. The P_1, P_2 and F_1 seeds were cultivated on March 1997, selfing and backcross to both parents were made. The parents, F_1, F_2, BC_1 and BC_2 seeds were sown on March 1998. A randomized complete block design with a single row plot with four replicates for each of parents and F_1's population was performed. Twenty five replicates with one row for F_2, and ten replicates for BC_1 and BC_2 populations were used. The plot consisted of one row 4.0 meters long and 2.5 m. width, the spacing between plants was one meter. Cultural practices were carried out as recommended for this crop. The fruits were harvested at mature stage.

The recorded data were as follows:

a. Inheritance of fruit weight and fruit shape:

All harvested fruits obtained from the different genotypes were weighed and average fruit weight was calculated in Kg. by dividing the total weight on the fruits number. For quantitative characters, the phenotypic variance of segregated populations was partitioned into environmental and genetic components. The variance, of the two parents, F_1 generation provided the estimate of the environmental variance (Allard, 1960). The inheritable variance was devided into additive or fixable component "D" and dominance or non-fixable component "H". The F_2 variance was expressed as:

$$F_2 = \frac{1}{2} D + \frac{1}{4} H + E$$

The summed variance of the backcrosses was expressed as:-

$$(VBC_1 + VBC_2 = \frac{1}{2} D + \frac{1}{2} H + 2 E$$

Where:

D = Additive or fixable component.
H = Dominance or non-fixable component.
E = Environmental component.

The additive component was obtained by substituting the sum of backcrosses variance from 2 VF_2 as follows:-

$$2\,VF_2 - (VBC_1 + VBC_2) = (D + 1/2\,H + 2\,E) - (1/2\,D + 1/2\,H + 2\,E) = 1/2\,D$$

The dominance component (H) was obtained by subtracting the estimate of the additive component "D" in the formula for F_2 variance (Allard, 1960).

1. Degree and nature of dominance:

The procedure used to estimate the degree of dominance was as follows:-

$$\text{The ratio of P} = \frac{\overline{F}_1 - \overline{M.P.}}{\frac{1}{2}(\overline{P}2 - \overline{P}1)}$$

This is considered as a measure of relative potency of gene set (Smith, 1952).

Whereas:

F_1 = First generation mean.
P_1 = The mean of the smaller parent.
P_2 = The mean of the large parent.
$\overline{M.P.}$ = Mid parent value.

Relative potency of gene (P) was used to determine the nature of dominance and its direction, according to the formula given by Smith (1952), where:

1- When the difference between the parents was significant and $(\overline{F}_1 - \overline{M.P.})$ was not significant the absence of dominance was indicated.
2- Complete dominance is considered when potence ratio is equal or did not differ significantly from ±1.
3- Partial dominance is considered when potence ratio is between 0.1 and 1.0 but not equal to zero.
4- Over dominance (Heterosis) is considered if potence ratio exceeds ±1.0.

2. Heterosis:

Two measurements of heterosis, i.e. superiority of F_1 over mid parent (H_1), and superiority of F_1 over the better parent (H_2) were calculated using the formula reported by Ghaderi and Lower (1979) as follows:-

$$H_1 = 100\,\frac{(\overline{F}_1 - M)}{}$$

M

-

$$H_2 = 100\ \frac{(F_1 - P_1)}{P_1}$$

Where: M is the mean of the two parents and P_1 is the mean of the better parent. H_2 was estimated only for those traits which showed over dominance.

3. Heritability:

a. Heritability in broad sense was estimated using the formula reported by Burton (1951) as follows:-

$$H^2_b = \frac{VF_2 - VF_1}{VF_2} \times 100$$

Where:

H^2_b = Broad sense heritability.
VF_2 = Variance of F_2 generation.
VF_1 = Variance of F_1 generation.

b. Narrow sense heritability (H^2_n) was estimated using Warner (1952) equation as follows:-

$$h^2_n = \frac{2\ VF_2 - (VBC_1 + VBC_2)}{VF_2} \times 100$$

Where:-

H^2_n = Narrow sense heritability.
VF_2 = Variance of F_2 generation.
VF_1 = Variance of F_1 generation.
VBC_1 = Variance of backcross population to first parent.
VBC_2 = Variance of backcross population to second parent.

The number of effective factors controlling the measured trait were calculate using:

a. Weber's modified by Castle Wright Formula (1951).

Where:-

N = Number of effective factors.

b. The Wright formula (Wright, 1921):

$$N = \frac{0.25\,(0.75 - h + h^2)\,D^2}{S^2F_2 - S^2F_1}$$

Where:-

$$h = \frac{\bar{F}_1 - \bar{P}_1}{\bar{P}_2 - \bar{P}_1}$$

$D = \bar{P}_2 - \bar{P}_1$

$\bar{P}_1$ = Mean of the smaller parent.
P_2 = Mean of the larger parent.
F_1 = Mean of the F_1 generation.
S^2F_1 = Variance of the F_1 generation.
S^2F_2 = Variance of the F_2 generation.

c. Saki and Niles (1959):

$$N = \frac{[(P_1 - P_2) / 2]^2}{2\,\sigma^2 g}$$

$\sigma^2 g = VF_2 - VF_1$ (genetic variance).

b. Chemical composition:

The following compounds were determined in a sample of 8 fruits for every genotypes.

1. Total carbohydrates:

Total carbohydrates content was determined in skin and flesh for the parents and the populations according to the method of Montgomery (1961).

2. Total protein:

Total protein was determined according to the method of A.O.A.C. (1980).

3. Total lipids:

Total lipids were determined according to the method of A.O.A.C. (1980).

RESULTS AND DISCUSSION

A.1. Average fruit weight:

The frequency distribution of the average fruit weight per plant for the P_1, P_2, F_1, F_2, BC_1 and BC_2 generations is presented in Table (1). The F_2 fruits occupied all classes and the continous distribution curve for it (Fig. 1) indicates that this character inherited quantitively.

Regarding nature of dominance, it is obvious from Table (1) that the F_1 mean was 4.23 kg and the mid parent was 3.22 kg. Results of backcrosses show that BC_1 was 3.97 kg and BC_2 was 3.35 kg. These obtained results suggested a case of over dominance. Another evidence of over dominance can be noticed from Table (2), where the potency ratio was 4.12. A case of over dominance for average fruit weight was previously reported by Hussain *et al*. (1974) and Brar and Nandpuri (1975) in watermelon. Number of effective factors conditioning the average fruit weight character was found to be 0.227 by Wright formula, 2.178 by Burton and 0.227 by Sakai and Niles (1959). This indicated that the minimum number of genes controlling this character was estimated as 1-3 pairs of genes.

The value of heritability was 32.66% in broad sense compared with 29.36% in narrow sense, this could be attributed to that most of the genetic variance was additive or fexable component.

Estimating heterosis, it was found to be (H_1 = 31.36%) and (H_2 = 22.25%) by the formula of Ghaderi and Lower (1979).

A.2. Fruit shape:

The shape index is the ratio of the polar diameter by transverse diameter of the fruit. The frequency distribution of the fruit shape index for the P_1, P_2, F_1, F_2, BC_1 and BC_2 is presented in Table (3) and Fig. (2). The mean of F_1 population was 0.86 which lied near the round parent (0.93), suggesting dominance of round fruit. The number of effective factors conditioning the fruit shape character was found to be 0.156 by Wright's formula, 0.366 by Burton formula and 0.156 by Sakai and Niles method. This result indicated that this character controlled by one pair of genes. The result was in agreement with that of Warid and Abd El-Hafez (1976).

The value of heritability was 67.2% in broad sense and 138% in narrow sense heritability (Table 4).

Table 2. Dominance, number of effective factors, heritability and heterosis for fruit weight (kg) in the cross Libi x Balady pumpkins.

Statistic	Estimation values Libi x Balady
Dominance:	
Potence ratio	4.12
Number of effective factors:	
Wright formula	0.227
Burton formula	2.178
Sakai and Niles method	0.227
Heritability:	
Broad sense heritability (Alard, 1960)	32.664%
Narrow sense heritability (Warner, 1952)	29.356%
Heterosis:	
H_1	31.36%
H_2	22.25%

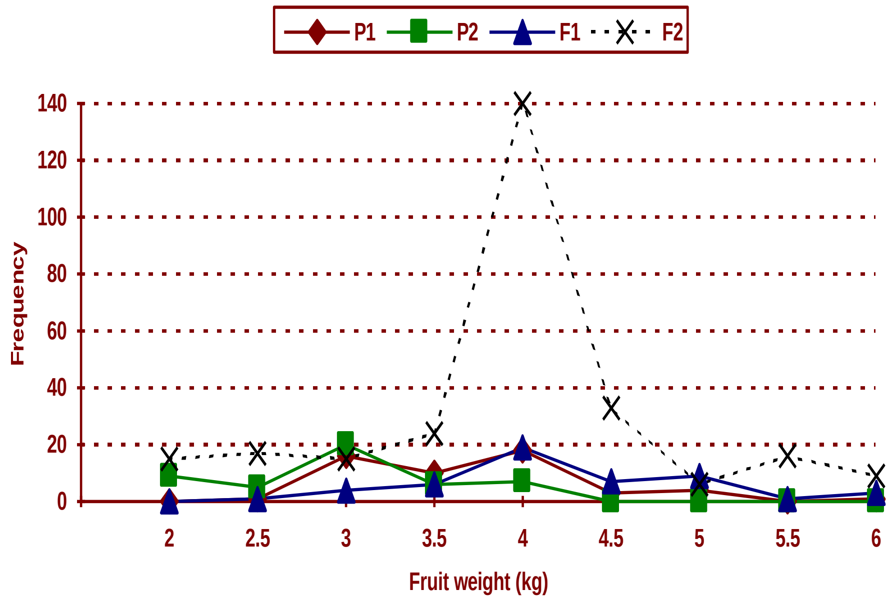

Fig. 1. Frequency distribution of fruit weight for P_1, P_2, F_1 and F_2 of the cross Libi x Balady.

Table 4. Dominance, heritability and number of effective factors, and for fruit shape index in the cross Libi x Balady pumpkins.

Statistic	Estimation values Libi x Balady
Dominance:	
Potence ratio	1.68
Number of effective factors:	
Wright formula	0.156
Burton formula	0.366
Sakai and Niles method	0.156
Heritability:	
Broad sense heritability (Burton, 1951)	67.164%
Narrow sense heritability (Warner, 1952)	138.806%

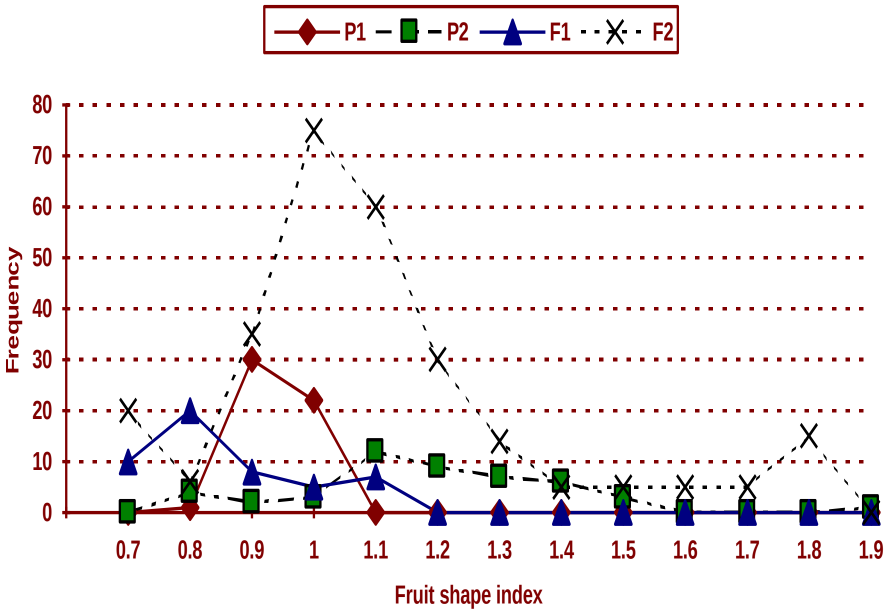

Fig. 2. Frequency distribution on fruit shape index for for P_1, P_2, F_1 and F_2 of the cross Libi x Balady.

B. Chemical composition:

Total carbohydrates protein and lipids were estimated in pumpkin's flesh and rind for the two parents, F_1, F_2, BC_1 and BC_2. Results are shown in Table (5) and Fig. (3). It is clear that the fruit's rind are rich in protein and lipids than the flesh in all the population. The flesh was higher in carbohydrate content for parents and F_1. The F_1 showed a significant difference in its carbohydrate contents than the two parents and the backcrosses, which gave 17.116 gm/100gm fresh flesh, while P_1 and P_2

gave 16.661 and 16.060 gm, respectively. As for protein, the Libi cultivar showed the highest content (1.477gm) than Balady, F_1, F_2, and BC_2. On the other hand, backcross to Libi gave the highest protein content (1.694 gm /100gram). The total lipids in Libi cultivar was higher than the Balady, F_1, and BC_1 with a significant difference between them. The F_2 gave the highest lipids contents.

Table 5. Total carbohydrate, protein and total lipids in the rind and flesh pumpkin for the P_1, P_2, F_1, F_2, BC_1 and BC_2 population (gm/100gm).

Population	Total carbohydrate		Total protein		Total lipids	
	Rind	Flesh	Rind	Flesh	Rind	Flesh
P_1	14.030	16.661	2.310	1.477	1.540	0.395
P_2	14.854	16.060	2.340	1.028	2.190	0.371
F_1	15.330	17.116	1.610	0.882	1.950	0.294
F_2	15.560	15.150	1.660	1.389	1.950	0.546
BC_1	14.840	14.158	2.670	1.694	1.410	0.305
BC_2	14.430	14.921	2.350	1.220	2.160	0.455
L.S.D.						
0.05	0.117	0.026	0.065	0.070	0.111	0.014
0.01	0.166	0.037	0.092	0.100	0.158	0.008

From the mentioned results it can be concluded that the pumpkins rind and flesh are rich in carbohydrate, protein and lipids. Breeding programe cam improve the quality of the Balady cultivar through producing hybrids or selection especially fruit quality and nutritive value.

The results of chemical composition are in agreement with that of Rao *et al*. (1990). Jaiswal *et al*. (1990) mentioned that bittergourd fruit contained 2.32% protein and 8.07% carbohydrate. They mentioned also that breeding can improve the cultivars for yield and nutritive value.

Generally, it could be concluded that improvement of Balady pumpkin fruits can be obtained through crossing between this cultivar and The White Libi cultivar.

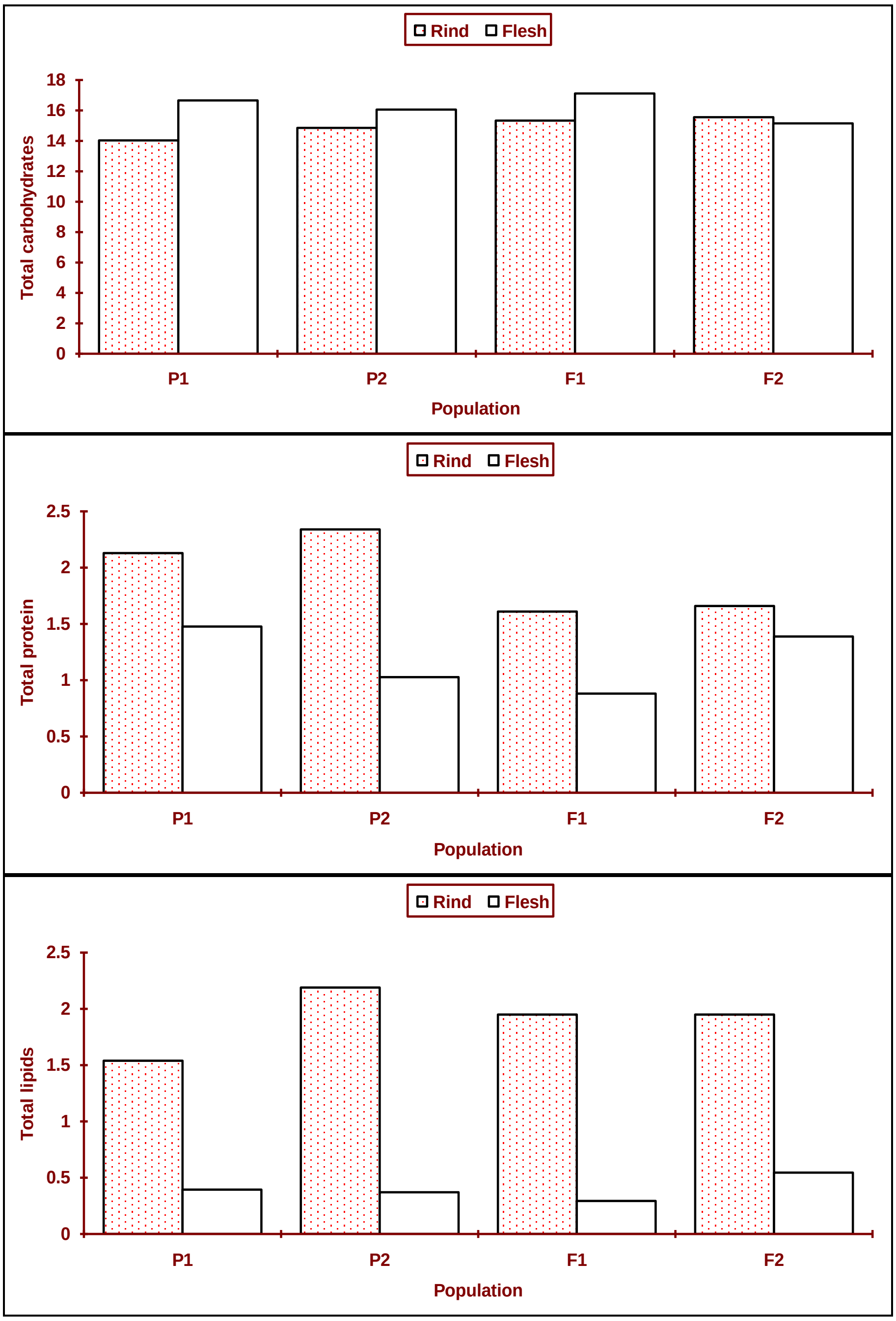

Fig. 3. Total carbohydrate, protein and total lipids (gm/100gm) in the rind and flesh pumpkins for P_1, P_2, F_1 and F_2

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دراسات وراثية وكيماوية على القرع العسلى (كيوكربيتا موشوتا)0

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يعتبر القرع العسلى من محاصيل الخضر ذات القيمة الغذائية المرتفعة والصنف البلدى المنتشر فى الزراعة المصرية غير منتظم فى الشكل وفى سمك اللحم بالإضافة لمحتواه القليل من الكربوهيدرات والبروتين والليبيدات0 وفى هذا البحث تم التهجين بين سلالات مرباه ذاتيا من الصنف الليبى المنتظم الشكل والسميك اللحم والغنى بالكربوهيدرات والبروتين والليبيدات والصنف البلدى وتم الحصول على الجيل الأول والجيل الثانى والتهجين الرجعى للأب الليبى والأب البلدى0

إستخدمت الأباء والأجيال الإنعزالية لدراسة وراثة صفة وزن الثمار وشكل الثمرة فى القرع العسلى حيث تم قياس نظام التوارث ، طبيعة السيادة ، معامل التوريث وعدد أزواج العوامل الوراثية المتحكمة فى الصفات المذكورة0

كما تم تحليل لحم الثمار والقشرة كيماويا لتقدير الكربوهيدرات والبروتين والليبيدات فى الأباء والأجيال الإنعزالية المختلفة وتتلخص النتائج فيما يلى:-

- وزن الثمرة: تورث هذه الصفة كمياً ، وجود سيادة فائقة تجاه الأب الأكبر وزنا "الليبى" ، معامل التوريث فى المعنى الواسع 32.7% وفى المعنى الضيق 29.4% ويتحكم فى هذه الصفة من 2-3 زوج من العوامل الوراثية0
- وراثة معامل شكل الثمرة: وجود سيادة فائقة تجاه الأب المستدير "الليبى" ويتحكم فى هذه الصفة زوج واحد من العوامل الوراثية ، معامل التوريث فى المعنى الواسع 67.2 وفى المعنى الضيق 0%138
- التحليل الكيماوى لثمار القرع العسلى: أوضحت أن القشرة كانت أعلى فى المحتوى من البروتين والليبيدات عن اللحم فى كل من الصنفين والأجيال الإنعزالية0 الصنف الليبى كان أعلى فى المحتوى من الكربوهيدرات والبروتين والليبيدات عن الصنف البلدى0 كان الجيل الأول أعلى فى الكربوهيدرات وكان التلقيح الرجعى للأب الليبى أعلى فى البروتين وكان الجيل الثانى أعلى فى الليبيدات0

وبصفة عامة توضح هذه النتائج إمكانية تحسين مواصفات الصنف البلدى من القرع العسلى عن طريق التهجين بينه وبين الصنف الليبى للعمل على تحسين مواصفات ثماره وزيادة محتواه من الكربوهيدرات ، البروتين والليبيدات0

Table 1. Frequency distribution for fruit weight in kg of P_1, P_2, F_1, F_2, BC_1 and BC_2 populations for the cross Libi x Balady.

Population	Class center									Total	Mean	$S\bar{x}$	S^2	CV%
	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0					
P_1	-	1	16	10	18	3	4	-	1	53	3.46	±0.096	0.486	18.740
P_2	9	5	20	6	7	-	-	-	-	47	2.97	±0.093	0.407	21.481
F_1	-	1	4	6	19	7	9	1	3	50	4.23	±0.111	0.614	18.524
F_2	15	17	15	24	140	33	6	16	9	275	3.93	±0.052	0.746	21.973
BC_1	-	-	4	9	23	13	11	5	-	65	4.25	±0.081	0.431	15.433
BC_2	3	3	17	19	13	1	-	-	-	56	3.35	±0.119	0.842	28.873

Mid parent value = 3.22.

Table 3. Frequency distribution for fruit shape index of P_1, P_2, F_1, F_2, BC_1 and BC_2 populations for the cross Libi x Balady.

Population	Class center													Total	Mean	$S\bar{x}$	S^2	CV%
	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9					
P_1	--	1	30	22	--	--	--	--	--	--	--	--	--	53	0.94	±0.007	0.003	5.662
P_2	--	4	2	3	12	9	7	6	3	--	--	--	1	47	1.19	±0.031	0.046	18.071
F_1	10	20	8	5	7	--	--	--	--	--	--	--	--	50	0.86	±0.019	0.017	15.277
F_2	20	6	35	75	60	30	14	5	5	5	5	15	--	275	1.10	±0.016	0.067	23.472
BC_1	3	8	32	12	10	--	--	-	--	--	--	--	--	65	0.93	±0.013	0.011	11.047
BC_2	1	3	10	20	10	4	3	3	2	--	--	--	--	56	1.05	±0.023	0.030	16.485

Mid parent value = 1.07