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Studies on the inheritance of some characters in pumpkins (*Cucurbita moschata* Poir.).

M.K. Hatem

Vegetables Breeding Dept. Hort. Res. Inst., Agricultural Research Center (ARC), Giza –Egypt

Abstract

These experiments were carried out at El-Kanater El-Khyreia, Horticulture Research Station of Hort. Res. Institute, during three successive summer seasons of 2012, 2013 and 2014. Two pumpkins, *Cucurbita moschata* Poir. viz., White Libi and Balady were used in studying the inheritance of average fruit weight, fruit shape index, flesh thickness, total carbohydrates, total soluble solids (TSS) and β carotene contents. In 2012 the two parents were planted in the field during summer season to produced the F_1 seeds. In summer season of 2013 the F_1 plants were selfed to produce the require F_2 seeds. In the third season, the four populations, i.e., P_1, P_2, F_1 and F_2, were evaluated . The estimated heritability values were 74.8% for average fruit weight, 82.5% for fruit shape index, 69.4% for flesh thickness, 76.3% for total carbohydrates, 66.6% for total soluble solids and 63.4% for β carotene content. Data obtained indicated that all characters are controlled by 2 – 5 pairs of gene. Complete dominance for high parent was found in total carbohydrates and complete dominance for the low parent was found in fruit shape index. Partial dominance for the high parent was found in average fruit weight, flesh thickness and β carotene content. Incomplete dominance was found in total soluble solids (TSS). Obtained high broad sense heritability for all studied attributes, lead to suggest that considerable improvement through breeding and selection could be achieved.

In conclusion, these results demonstrate the possibility of improving the breed specifications cultivar Balady by hybridization with cultivar white Libi leading to improved fruiting specifications for this product.

Key words: Pumpkin - Inheritance- Heritability - Heterosis - Potence ratio – Complete dominance- number of genes.

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.

Some authors have reported that pumpkin fruits have high medicinal values (**Jones 1996; Keles *et al*., 2001**; **Sentu and Debjani 2007**; **Abd El- Aziz** and **Abd El-Kalek 2011**). The different parts of plant have also been used as medicine in the developed world and the leaves are haemostatic, analgesic, and also used externally for treating burns. Traditionally, the pulp is used to relieve intestinal inflammation or enteritis dyspepsia and stomach disorders. Pumpkin is relatively high in energy and carbohydrates and good source of vitamins, especially high carotenoid pigments and minerals (**Bose and Som 1998**; **Tindall, 2001**). Pumpkin seed is as excellent source of protein and also has pharmacological activities such as anti-diabetic (**Li *et al*., 2003**), antifungal (**Wang and Ng, 2003**), antibacterial and anti-inflammation activities (**Fu *et al*., 2006**) and antioxidant effects (**Nkosi *et al*., 2006**).

The success of any crop improvement program depends, on the amount of genetic variability present in the population. Very few research works relating to variability of pumpkin accessions have been conducted in Egypt. So, intensive research efforts are needed in several areas particularly for selection of superior pumpkin genotypes. There is wide genetic variability among the existing pumpkin accessions (**Ferrial *et al*., 2003** and **2004**; **Aruah *et al*., 2010**; **Aliu *et al*., 2011**) and thus, the utilization of such variability in the crop's breeding programmes is possible. The breeding programs depend on the knowledge of key traits, genetic systems controlling their inheritance, genetic and the environmental factors that influence their expression. Presently, there is dearth of information about the genetic systems controlling their inheritance in the crop.

Fruit yield is a complex character that is determined by complex associations among several agronomic traits (**Chandra *et al*., 1990**; **Rao *et al*., 1990**).

Furthermore, very limited attempt has been made for genetic improvement of the crop. Heterosis or hybrid vigour can play a vital role in increasing the yield quality of pumpkin. It refers to the phenomenon in which F_1 hybrid obtained by crossing of two genetically dissimilar inbred lines or genotypes, shows increased or decreased vigour over the better parent or mid-parent value (**Pohlman, 1979**).

Abd El-Rahman *et al*., (2000) showed that fruit weight was quantitatively inherited and over dominance was existed in pumpkin (*Cucurbita moschata*). They added that broad sense heritability was 32.7%, while narrow sense heritability was 29.4% and one to three pairs of gene control this character. As fruit shape index, dominance to round fruit was existed and one pair of genes control the trait. Broad sense heritability was 67.2%. They found that, chemical composition indicated that the fruit's rind was higher in protein and lipids than the flesh. Therefore, the object of this work was to study the genetic behavior of some economic fruit characters of pumpkin.

The heterotic effects and genetic components of variation for qualitative and quantitative characters were estimated in sweet gourd (*Cucurbita moschata* Duch. ex Poir). The phenotypic coefficients of variation were higher than genotypic one for all the character, indicating that the environment played a consider role on the expression of these characters. High heritability coupled with high genetic advance were found in parents and hybrid for number of fruits per plant, individual fruit weight and fruit yield suggesting that improvement would be effective through phenotypic selection (**Jahan *et al*., 2012**). They added that, both positive and negative heterosis was observed for different qualitative and quantitative characters in F_1 hybrids of sweet gourd. None of the hybrids exhibited maximum heterosis for all traits, but significant and desirable level of heterosis over mid-parents and better parent was obtained in several hybrids.

Sudhakar *et al*., (2010) found the improvement of traits like flesh thickness, total carotenoids and ascorbic acid, selections could be made, while fruit yield may be improved through hybridization programs.

Therefore, this study was carried out to plan efficient pumpkin breeding programs, also to have an understanding of its genetic and breeding systems, information on the character association in pumpkin.

Materials and Methods

This investigation was carried out at El-Kanater El-Khyreia Horticulture Research station Institute. In summer 2013 and 2014. The crosses were made between the parents P_1 (White Libi) and P_2 (Balady) to produce F_1 seeds. F_1 plants were selfed to produce the F_2 seeds. In summer season of 2014, the two parents (P_1 & P_2), F_1 and F_2 were evaluated in a randomized complete blocks design with three replicates. Each replicate included 15 plants of each P_1, P_2 and F_1 and 48 plants of F_2. All cultural practice were carried out according to the recommendation followed for pumpkin crop during the growing seasons. 4,6 and 7 of March

The parents, F_1 and F_2 seeds were sown on first March 2012, 2013 and 2014. The plot consisted of three row 5.0 meters long and 2.5m. for each row in P_1, P_2 and F_1 while 10 rows for F_2 plants, the spacing within plants was one meter. The fruits were harvested at ripe stage. Observation and measurements were recorded on an individual plant basis.

The recorded data were as follows:-

a) The average fruit weight was calculated in kg.

b) Fruit shape index, was calculated the ratio of the polar diameter by transverse diameter of the fruit.

c) Flesh thickness was calculated in cm. of the fruit.

d) Chemical composition:

1- Total carbohydrates:- Total carbohydrates content was determined in skin and flesh for the fruits parents, F_1 and F_2 populations according to the method of **Montgomery (1961)**.

2- Total soluble solids (TSS %) content: - The total soluble solids content (TSS) was determined by the hand refractometers.

3- β carotene content:- β carotene content for the flesh of the fruits according to **A.O.A.C. (1975)**.

Means, variances, and standard error were computed for each population. Population means were compared by least significant difference (L.S.D.) according to **Snedecor and Cochran (1973)**.

Various genetic parameters were estimated according to **Warner *et. al*., (1980)**.

1- Average degree of heterosis (ADH%):- Based on MP or mid-parents heterosis = $\bar{F}_1 - MP / MP * 100$

Based on HP or better parent heterosis= $\overline{F_1} - \overline{HP} / \overline{HP} * 100$

2- Potence ratio (P.R.) = $\bar{F}_1 - MP / \frac{1}{2}(\overline{P_2} - \overline{P_1})$

3- Inbreeding depression (I.D.%)= $(\overline{F_1} - \overline{F_2} / \overline{F_1}) * 100$

4- Environmental variance (E)= $VP_1 + VP_2 + VF_1 / 3$

5- Genetical variance (G)= $VF_2 - E$

6- Heritability:- Broad sence h_b^2 = $((VF_2 - VE) / VF_2) * 100$

7- The minimum number of genes:-

The numbers of effective factors controlling the measured trait were calculated using by:- **Castl and Wright formula (1921)** and **Burton (1951)**.

Results and Discussion

Data of the studied characters for P_1, P_2, F_1 and F_2 populations of the cross " White Libi X Balady" are given in Table 1. The analysis of variance indicated that there were significant differences among the studied generations in all characters under study.

1- Average fruit weight:

The two parental cultivars (P_1) White Libi and (P_2) Balady showed significant difference in average fruit weight. Their means were 6.426and 3.71Kg., respectively. The White Libi line significantly exceeded Balady by about 2.716 kg.. The ADH%, based on the MP values was estimated as 15.36% in this cross, indicating dominance towards the high fruit parent. Partial dominance for the high fruit for average fruit weight was detected in these cross, since it showed significant negative ADH values in relation to high parents. These values were (-9.03%) for this cross. The estimated potence value (0.57) was in accordance with the suggested positive partial dominance and additive effects hypothesis (Table 1 & Fig. 1). Similar results were obtained by Jahan *et al*., 2012.

The F_1 frequency distribution was skewed towards the high parent, due to the partial dominance of the large fruit. Significant difference between the actual means of the F_1 and F_2 supporting the partial dominance of the high fruit weight.

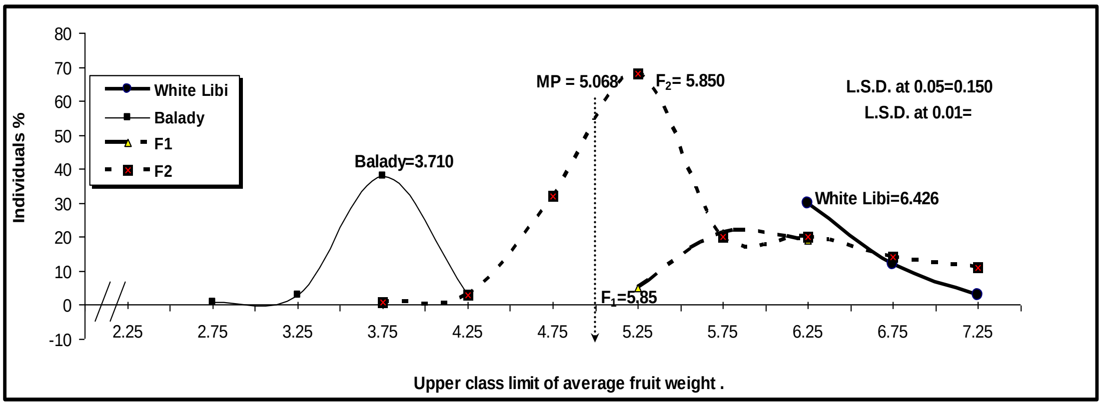
Variances of the non-segregating populations i.e., P_1, P_2 and F_1 were different, indicating that the environmental variance varies considerable among different genotypes (Table 1). However their variances were less than those of F_2, this indicates that their homogeneity was higher than that of F_2 populations which had greater variance.

Table 1. Estimates of genetic parameters for average fruit weight, shape index, flesh thickness, total carbohydrates, total soluble solids (TSS) and β carotene content.

Characters Parameters	Average fruit weightkg	Fruit shape index	Flesh thickness cm	Total carbohydrates%	Total soluble solids (TSS).%	β carotene content
Mean (P_1)	6.426±0.05	0.91±0.01	5.89±0.07	17.18±0.01	10.78±0.09	9.21±0.10
Mean (P_2)	3.71±0.05	1.31±0.01	3.38±0.06	15.49±0.04	8.13±0.06	14.35±0.14
Mean (MP)	5.07	1.11	4.64	16.33	9.45	11.78
Mean (F_1)	5.85±0.05	0.93±0.01	5.09±0.05	17.19±0.2	9.53±0.09	13.78±0.08
Mean (F_2)	5.266±0.05	0.93±0.01	5.26±0.06	17.19±0.02	9.66±0.09	13.77±0.07
S^2 (P_1)	0.134	0.0004	0.228	0.001	0.397	0.455
S^2 (P_2)	0.101	0.0005	0.097	0.069	0.164	0.893
S^2 (F_1)	0.126	0.003	0.116	0.026	0.375	0.274
S^2 (F_2)	0.477	0.017	0.480	0.140	0.934	1.472
ADH %						
MP	15.36**	-16.33**	9.87**	5.23**	0.85	16.97**
HP	-9.03**	-29.24**	-13.62**	0.04	-11.55**	-3.97**
Potense ratio (P.R.)	0.57	-0.90	0.36	1.01	0.06	0.78
Inbreeding depression (ID)%	9.92	-15.61	-3.37	9.31	-1.326	7.36
Environmental variance.	0.12	0.01	0.15	0.03	0.312	0.54
Genetical Variance	0.36	0.02	0.33	0.11	0.622	0.93
Heritability (h_b^2) %.	74.76	82.49	69.36	76.28	66.56	63.39
No. of gene.						
1-Castle & Wright.	2.63	1.57	2.17	3.16	1.57	3.75
2- Burton.	5.31	2.20	5.07	4.71	4.53	3.58

P_1 = White Libi and P_2 = Balady .

Fig. 1: Distribution of average fruit weight (Kg.) in parental lines, F_1 and F_2 plants for the cross (White Libi x Balady).



The distribution of the F_2 plants for this cross stretched over a wide range as weight of fruit scale. About 60.00% of the F_2 plants for this cross was covered the range exhibited by the high parent (White Libi) and F_1 populations. The remaining F_2 plants (40%) covered the range exhibited by the recessive parent (Balady) and F_1 plants.

The minimum number of genes was estimated as 2.63 and 5.31 according to Castle & Wright and Burton formulae, respectively. The broad sense heritability (h_b^2) was estimated as 74.76%. The BSH obtained indicates that average fruit weight is controlled by many genes and accordingly affected by environmental factors. These results are agree with those of Abd El-Rahman *et al*., (2000) who found that fruit weight was quantitatively inherited with over dominance effects existed in pumpkin.

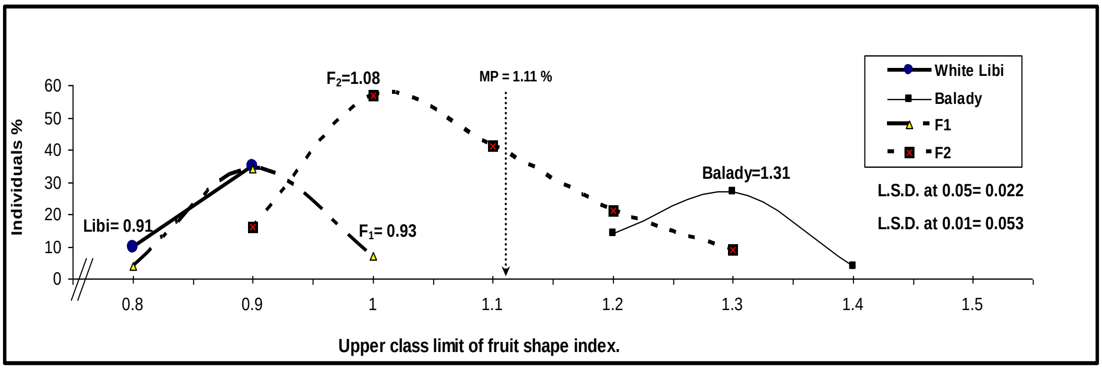
It could be concluded that the average fruit weight is controlled by more than two pairs of gene with mostly additive gene actions and partial dominance for the high weight.

2- Fruit shape index:

The two parental lines (P_1) White Libi and (P_2) Balady showed significant difference in fruit shape index. The White Balady line significantly exceeded White Libi by about 0.4. Their means were 0.91 and 1.31, respectively. The F_1 mean (0.93) was very close to that of the low parent, indicating dominance for the low fruit shape index. The estimated ADH% (-29.24%) and potence ratio (-0.9) support the dominance hypothesis.

These results suggesting complete dominance for the low fruit shape index (Table 1).

Fig. 2. Distribution of fruit shape index in parental lines, F_1 and F_2 plants for the crosses (White Libi x Balady).



The distribution of the F_2 plants stretched over a wide range as fruit shape index scale. About 20.83% of the F_2 plants covered the range exhibited by the high parent (Balady). And the remaining F_2 plants were (79.17%) covered the range exhibited by the round parent (White Libi) and F_1 plants. This figure suggests that the character is controlled by 1-2 pair of genes.

The monosonic inheritance is verified by the high heritability (82.49%). These high values suggested that progress could be made in fruit shape index of pumpkin by selection within segregating progenies. The minimum number of genes was estimated as 1.57 and 2.20 according to Castl-Wright and Burton formulae, respectively. Abd El-Rahman *et al*., (2000) found that, adominance to round fruit was existed and one pair of genes control the character. Broad sense heritability was 67.2%.

It appears from the examination of data presented that this trait is simply inherited mostly complete dominance for the low fruit shape index (round fruit).

3- Flesh thickness:

Highly significant difference between the two parental lines was observed in flesh thickness. The White Libi line significantly exceeded Balady by about 2.51 mm.

The ADH% was estimated as 9.87% based on MP and as -13.62% based on high parents content suggesting partial dominance for the high flesh thickness. The estimated potence values (-0.36) for this cross is in accordance with this suggestion (Table 1).

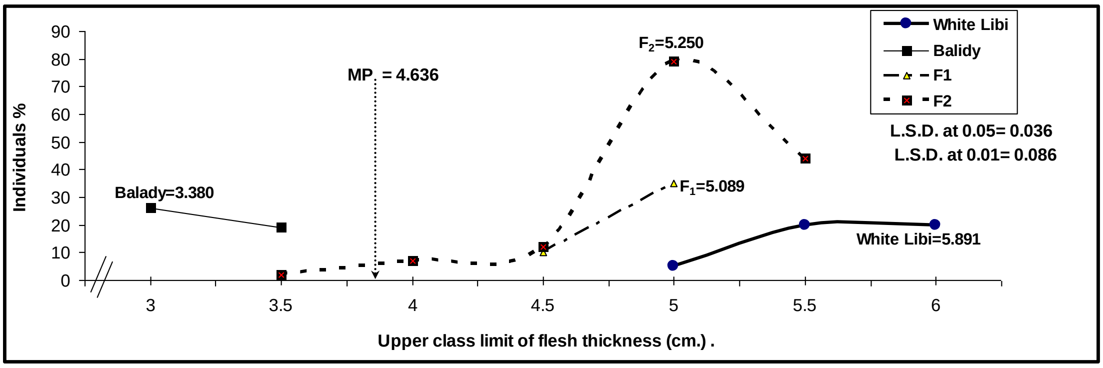
The F_1 distribution for the cross was skewed towards the high parental line, as expected according to the partial dominance of the high flesh thickness (Fig. 3).

Estimated BSH (69.36%) was approximately similar to Sudhakar, *et al*., (2008) who found the heritability for this trait was 68.30%. The minimum number of genes was estimated as 2.17and 5.07according to Castl-Wright and Burton formulae, respectively for this cross.

It appears from the examination of data presented that this trait is controlled by 2-5 pairs of genes with partial dominance for the high flesh thickness.

The distribution of the F_2 plants for this cross stretched over a wide range as flesh thickness of fruit scale. About 93.75% of the F_2 plants was covered the range exhibited by the high parent (White Libi) and F_1 populations. But the remaining F_2 plants about (6.25%) covered the range exhibited the recessive parent (Balady). This distribution (90:10) lied to suggest that this trait is controlled by 1-2 pair of genes. The estimate number of genes may be due to the environmental effects or to low size of the studied plants in F_2 population

Fig. 3. Distribution of flesh thickness (cm.) in parental lines, F_1 and F_2 plants for the crosses (White Libi x Balady).



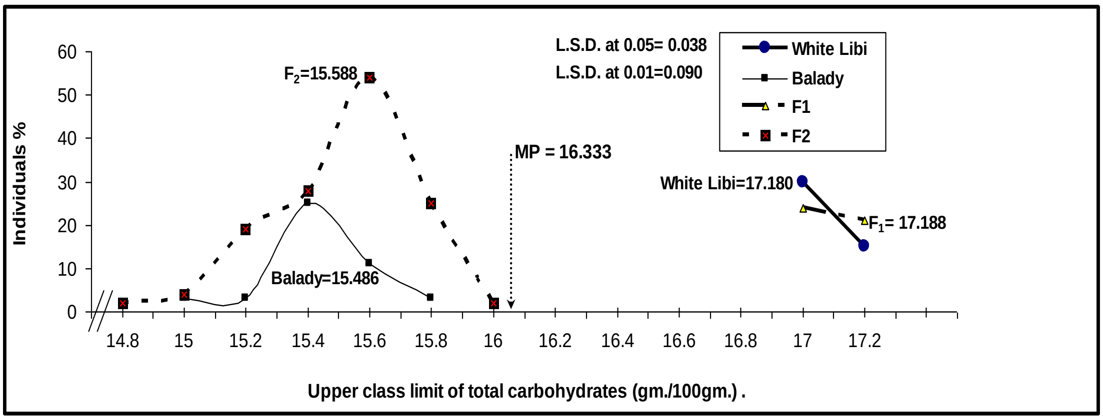
4- Total carbohydrates:

Data presented in Table (1) and Fig. (4) show highly significant difference between the two parental lines in total carbohydrates in fruit. The White Libi line significantly exceeded Balady by about 1.69 gm./100gm.

The ADH% was estimated as 5.23% and 0.04 based on MP and better parent, respectively, suggesting complete dominance for the high total carbohydrates. Complete dominance for the high total carbohydrates was verified by the estimated potence value (1.01%).

The distribution of the F_2 plants showed that most plants lied in the area of the low parent Balady. This figure disagrees with the expected distribution when the character is controlled by dominance genes of the high contents. This is may be due to the population size of F_2 is low, or to error in carbohydrate determination. The BSH (h_b^2%) was estimated as 76.28%. Data obtained suggest that this trait may be controlled by many pair of genes with complete dominance for the high carbohydrates content.

Fig. 4. Distribution of total carbohydrates (gm./100 gm.) in parental lines, F_1 and F_2 plants for the crosses (White Libi x Balady) .



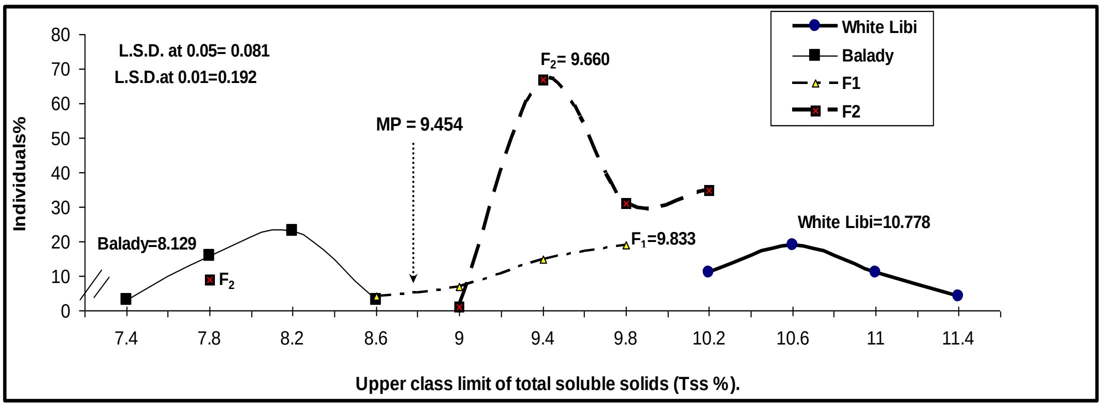
5- Total soluble solids (TSS):

Data presented in Table (1) and Fig. (5) show highly significant difference between the two parental lines in total soluble solids % (TSS). The White Libi significantly exceeded Balady by about 2.65%.

Insignificant MP heterosis value (0.85) was estimated also low potence value (0.06) was found. From these estimation, it could be concluded that this character is controlled by no-dominance genes.

The F_1 frequency distribution was skewed towards the mid-parents, supporting the no-dominance hypothesis.

Fig. (5): Distribution of total soluble solids % (TSS) in parental lines, F_1 and F_2 plants for the crosses (White Libi x Balady).

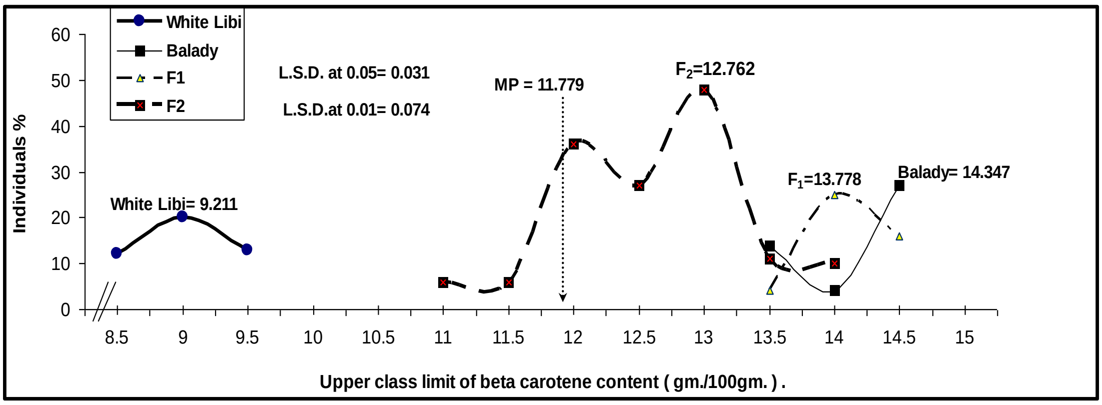


The distribution of the F_2 plants in this cross was stretched over a wide range of the total soluble solids scale without distinct classes, indicating that the character may be controlled by many genes. About 6. 75% of the plants covered the range exhibited by the low parent Balady populations, 68. 75% covered the range exhibited by the F_1 and about 24.31% of the F_2 plants covered the range exhibited by the high parent Libi populations. The minimum number of genes for this cross was estimated as 1.57 and 4.53 according to Castle-Wright and Burton formulae, respectively. The heritability (h_b^2) was estimated as 66.56%. Lastly, it could be suggested that this trait is mostly controlled by additive genes and controlled by 2-4 genes and affected by environmental factors.

6- β carotene content:

Data presented in Table (1) and Fig. (6) revealed significant difference between the two parental lines of this cross in this trait, with non-overlapping.

Fig. (6): Distribution of β carotene content (gm./100 gm.) in parental lines, F_1 and F_2 plants for the crosses (White Libi x Balady) .



Significant differences were observed between obtained (13.778 gm./100gm.) and expected (11.78 gm./100gm.) arithmetic means of the F_1 populations. Sudhakar *et al*., (2003) found that β carotene content ranged from 2.34 to14.85 gm./100gm.). It is noticed that, the obtained mean was lower than the theoretical one. It could be explained by the strong partial dominance of the high β carotene content. The ADH%, based on the MP value was estimated as 11.779) indicating dominance towards the high β carotene content. Partial dominance for the high fruit for β carotene content was detected, since it showed significant negative ADH values in relation to high parents. These values were (-3.97%) for this cross. The estimated potence values (0.78) was in accordance with the suggested partial dominance and additive effects hypothesis (Table 1). Jahan *et al*., (2012) reported that both positive and negative heterosis was observed for different qualitative and quantitative characters in F_1 hybrids of sweet gourd.

The F_1 distribution was skewed towards the high parent, due to the partial dominance of the high β carotene content in fruit. Significant difference between the actual means of the F_1 and F_2 supporting the partial dominance of the low fruit weight. (Table 1).

The distribution of the F_2 plants for this cross stretched over a wide range as weight scale of fruit. About 14.58% of the F_2 plants for this cross was covered the range exhibited by the high parent and F_1 populations. While, about 85.417% of the F_2 plants was covered range are located between the two parents in the direction of the high parent Fig. (6).

The minimum number of genes was estimated as 3.75and 3.58 according to Castle & Wright and Burton formulae, respectively. The BSH (h_b^2) was estimated as 63.39% in this cross. The relatively low BSH obtained indicates that β carotene content in fruit is controlled by many genes and accordingly affected by environmental factors.

It could be concluded that the β carotene content in fruit is controlled by more than two pair of genes with partial dominance for the high β carotene content in fruit.

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دراسات على وراثة بعض الصفات فى القرع العسلى.

مَحمُود قَطب حَاتِم

قسم بحوث تربية الخضر . معهد بحوث البساتين . مركز البحوث الزراعية .

أُجريت هَذهِ الدراسَة بمَزرَعة مَحطة بحُوث البَساتين بالقَناطِر الخَيرية خِلال المَواسِم الصَيفية لأعْوام 2012 ، 2013 ، 2014 بهدف الحُصول على المزيد من المَعلومات الخاصَّة بوراثة بعض الصفات الهامة في القرع العسلى حيث تفيد هذه المَعلومات المُربى في وَضع وتَنفيذ بَرامج التربية لِتَحسين هذا المَحصُول . واستُخدِمت في هذه الدِراسَة سلالتان أبويتان مِن القرع العسلى وهى ليبى أبيض(White Libi) ، بلدى (Balady). وقد أُجريت لِهذه السُلالات التربية الداخلية لعِدة أجيال لِتَنقيتُها وُراثِياً . وقد أُجرى التَهجين في مُوسم 2012 لإنتاج الجيل الأول . وفى مُوسم 2013 زُرعت بُذور الأبوين والهَجين الناتج، وتم التهجين بينها لزيادة بذور الجيل الأول وكذلك إنتاج بذورالجيل الثانى من التلقيح الذاتى لنباتات الجيل الأول .

وفى مُوسِم 2014 زُرعت الأباء والهُجُن والجيل الثانى في تجرُبَة مُصممَة بِطَريقة القِطاعَات الكامِلةُ العَشوائِية في ثلاث مُكررات بالحَقل المَكشوف، والصِفات التي تناوَلتها هذه الدراسة هى:- متوسط وزن الثمرة – معدل شكل الثمرة – سُمك لحم الثمرة – الكربوهيدرات الكلية (جم/100جم) – نسبة المواد الصلبة الذائبة الكلية – كمية صبغة بيتا كاروتين (جم/100جم).

وكانت أهم النتائِج المُتَحصِّل عَليّها هى :

[1] كانت وراثة كل الصفات التى تمت دراستها صِفات كمية التَوريث مع وُجُود سِيادة تامة للأب العالى فى محتوى الكربوهيدرات الكلية، وسيادة تامة للأب المنخفض فى صفة معامل شكل الثمرة، وسيادة جزئية للأب العالى فى كل من : متوسط وزن الثمرة وسُمك لحم الثمرة وكمية صبغة بيتا كاروتين. وإنعدام السيادة فى صفة المواد الصلبة الذائبة الكلية.

[2] أظهرت النتائج أن تلك الصفات الستة يتَحَكَّم فيها من زوجين إلى خمسة أزواجٍ من الجيناتِ.

[3]كانت الكفاءة الوراثية بالمفهوم الواسع مرتفعة لكل الصفات وتتراوح بين 63.39% بالنسبة لصفة كمية صبغة بيتا كاروتين إلى 82.49% بالنسبة لصفة معامل شكل الثمرة.

وبصفة عامة تحمل هذه النتائج إمكانية تحسين مواصفات الصنف البلدى للقرع العسلى عن طريق التهجين مع الصنف الليبى الأبيض مما يؤدى إلى تحسين المواصفات الثمرية لهذا الصنف.