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THE GENETIC BEHAVIOR FOR SOME ECONOMIC TRAITS IN WATERMELON UNDER WINTER PLANTING CONDITIONS AT THE OPEN FIELD

Abd El-Salam, M.M.
Veget. Res. Dept., Hort. Res. Inst., Agric. Res. Center, Egypt.

ABSTRACT

The crosses were made between watermelon cold sensitive cultivar (Giza21) and cold tolerant inbreed line (PIPP8-261). Individual plant data from six generations (P_1,P_2,F_1,F_2,BC_1,BC_2) were subjected to an analysis of generation means to study the genetic behavior for the vegetative, yield and fruit traits under winter conditions at open field. Heterosis of the F_1 over mid-parent was significant for all studied traits except mature leaf area. The value of potence ratio exceeds one for number of fruits / plant and total yield / plant, but it was less than one for fruit weight and total soluble solids content. Broad sense heritability was low for number of fruits / plant and total soluble solids; and high for fruit weight and total yield / plant. The low temperature – tolerance in winter was to controlled by a single dominant gene, which could be used for the development of new cold – tolerance varieties and F_1 hybrids, thus providing economic gain due to earlier planting in the open field.

INTRODUCTION

Watermelon (Citrullus lanatus (thunb.) Matsum and Nakai) is one of the most popular vegetable crops in Egypt. It like other cucurbits, requires high temperature for successful growth and yield.

To improve cold tolerance in watermelon in Egypt, the inheritance of low temperature for some important economic traits must be studying. Many studies were done for improving cold tolerance on cucurbits by Den Nijs (1985), Bulder *et al.* (1987) and Bulder (1992) on cucumber. Edelstein *et al.* (1991) and Mark and Brent. (1992) on seed germination of muskmelon at low temperature; and Provvidenti (1994) on the seedling stage of watermelon.

MATERIALS AND METHODS

Two parents of watermelon were used in this study, ie. the low temperature sensitive cultivar Giza 21 (p_1) and tolerance inbreed line PIPP8-261(P_2) were crossed to obtin F_1 seed in the summer season of 1999. The F_1 was back crossed to each parent and self–pollinated to obtain BC_1 BC_2 and F_2 seeds, in the summer season of 2000, seeds of P_1,P_2,F_1,BC_1,BC_2 and F_2 generations were sown on 1st October 2000, for the evaluation under the natural winter planting conditions at the open field of horticultur experiment station of El-Kassassen.

The six generations were arranged in randomized complete plots design with three replications, each replicate consisted of six rows 10m long and 2m width, the distances between plants were 1m apart. Data were recorded as follows.

1-Main stem length (cm)

2-Leaf area (cm^2), area of the 6^{th} mature leaf was measured with a CI-203 area meter. CID, Inc. U.S.A.

3-Main stem length development rate (cm/day). Measured by calculating the growth of the stem length during a period of time from 1^{st} of December until 15^{th} of January and dividing the extra length by the specified period (46 days)

4-Leaf area development rate (cm^2/day), leaf development rate in the field was calculated weekly on the terminal leaf by dividing leaf area over number of days.

5-Number of fruits/plant

6-Fruit weight (g)

7-Total yield /plant (kg)

8-Total soluble solids content.(T.S.S.) in fruits were calculated using hand Refractiomter according to method described by A.O.A.C (1960)

The X^2 test was used to test the goodness of fit of the BC_1 and F_2 the tolerante plants, which grow successfully from seedling to fruits maturity stage under winter conditions.

Heterosis over mid-parents (M.P.) and high-parents (H.P.) for the studied traits were calculated according to the following formula adopted by Bhatt (1971).

Heterosis over mid-parent (M.P.)= $\dfrac{\overline{F_1} - M.P.}{M.P.} \times 100$

Heterosis over high-parent (H.P.)= $\dfrac{\overline{F_1} - H.P.}{H.P.} \times 100$

The significant of heterosis over mid and high parents was determined using t-test as follow – (Wynne *et al.*, 1970).

$$t = F_1 - M.\bar{P}./\sqrt{3/8 ms_e}$$

$$t = F_1 - H.\bar{P}./\sqrt{2/b\sigma ms}$$

Potence ratio (P) was calculated from the formula given by Smith (1952) as follow:

$$P = \frac{\overline{F}_1 - M.P.}{1/2(\overline{P}_2 - \overline{P}_1)}$$

Whereas:

$\overline{F_1}$ = First generation mean.

$\overline{P_1}$ = The mean of the smaller parent.

$\overline{P_2}$ = The mean of the larger parent.

M.P.= Mid-parent value.

1- Complete dominance is considered when potence ratio is equal and/or did not differ significantly from ±1.0

2- Partial dominance is considered when potence ratio is between 1.0 and -1.0 but not equal zero.

3- Over dominanace is considered if potence ratio exceeds ±1.0

Broad-sense heritability estimates (H_B) based on variances of the parental and F_2 populations were calculated as $H_B = (S^2_{F_2} - \sqrt{S^2_{P_1} - S^2_{P_2}}) / s^2_{F_2}$. (Kelly and Bliss, 1975).

Electrophoretic studies:

Protein electrophoresis

This investigation was carried out at the Laboratory of Genetic Engineering Department of Genetics, Faculty of Agriculture, Ain Shams University.

Sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) was performed according the method of Leammli (1970). After being modified by Studier (1973) seeds samples were two watermelon cultivars (Geza 21& PIPP8-261), and their F_1 excluding reciprocal as well as backcrosses (BC_1,BC_2),.Geza 21 x F_1 and PIPP8-261 x F_1 respectively. Samples of 0.5gram of each genotype with 5 ml. of buffer was homogenized, then they centrifuged for 15 minutes at 15000 rpm. Supernatants containing water soluble protein to eppindorf tubes.

Incubaction and agitation were carried out at room temperature until bands appeared in clear background then the gel was washed with distilled water Yamamato *et al.* (1982) then gel was photographed

RESULTS AND DISCUSSION

Generation means and heterosis for vegetative growth are presented in Table 1, significant differencers were showed between F_1 population and Giza21for all vegetative growth traits except mature leaf area but the F_1 population did not differ significantly with PIPP8-261 for all studied vegetative growth traits. The significance differences between Giza 21 and PIPP8-261 were showed only in the main stem development rate and leaf development rate. The Giza 21 had the lowest values of all vegetative growth traits under winter conditions at open field. Provvidenti (1994) reported that the growth retardation due to low temperatures was clearly affecting the size of cold sensitive watermelon plants.

Table (1): Generation means and heterosis estimates for vegetative growth of watermelon under winter conditions at open field

Generations	Traits			
	Main stem length (cm)	Mature leaf area (cm^2)	Main stem development rate (cm/day	Leaf development rate (cm^2/day)
P_1 (Giza21)	118.0	90.04	1.5	1.14
P_2 (PIPP8-261)	138.9	140.20	1.7	2.2
F_1 (Giza21×PIPP8-261)	171.6	121.42	2.2	2.9
L.S.D (0.05)	45.5	78.69	0.56	1.03
Heterosis (M.P.)%	33.2**	5.5	-	-
Heterosis (H.P)%	23.5**	-13.4	-	-

****significant at 0.01 level of probability**

The F_1 values for all studied traits in Table1 are higher than the values of the tolerante parent (PIPP8-261)- except mature leaf area indicating that over dominance may be important for these traits in particular main stem length which exhibited significant hererosis over the mid and high parent. Giza 21 had the lowest values of all vegetative studied traits under winter conditions at open field,

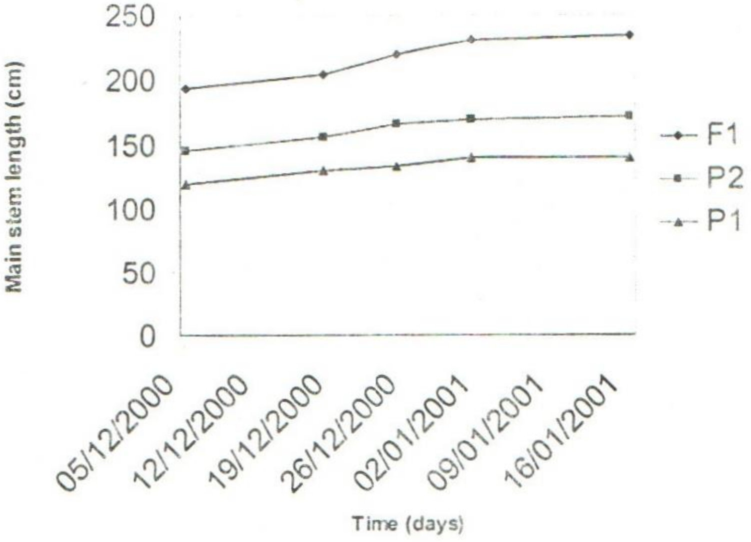


Figure 1: Main stem length development for Giza21 (P_1), PIPP8-261 (P_2) and their hybrid (F_1) under winter conditions.

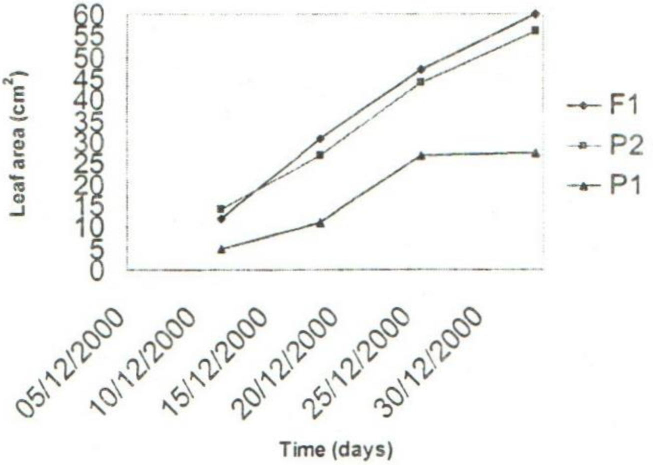


Figure 2: Leaf area development rate for Giza21 (P_1), PIPP8-261 (P_2) and their hybrid (F_1) under winter conditions.

These finding are consistent with the results of Den Nijs (1985) and Bulder (1992). An increase of the stem length under winter conditions was showed in Figure 1. In the first days of December the stem length of F_1 population was the tallest, at the same time the Giza 21 was close to that of the PIPP8-261. However, the low temperature in the first days of January stunted Giza21 stem length growth, but it did not affect the stem length growth of F_1 and PIPP8-261. In the half of second January, cold weather retarded the growth of all the three populations under the same conditions (Figure 1). In Figure 2, F_1 and PIPP8-261had the largest leaves area and quicker leaf development rate during the period from the first days of December to the beginning of January. Plants of PIPP8-261 and F_1 populations developed normally under low temperature conditions in winter, other wise the Giza21 cultivar suffered terribly under the same conditions (Table 3)

Means, heterosis, potance ratio and heritability for yield and its characters of the six populations are shown in Table 2. The three segregating populations (F_2, BC_1, BC_2) differed significantly than the low temperature sensitive parent (Giza 21) for number of fruits/plant, fruit weight and total soluble solids, BC_1 and Giza21 did not differ signifcantly with respect to total yield/plant. Means of the four traits in the BC_1 and F_1 were higher than the value of the sensitive parent (Giza21), the mean of the F_1 population was closer to value of tolerante parent (PIPP8-261), suggesting complete dominance for low temperature tolerance under winter conditions at open field, (Provvidenti 1994) determined that the dominant allele is responsible for cold resistance in watermelon. The P_2 (PIPP8-261), F_1,F_2 BC_1 and BC_2 populations were higher than P_1 (Giza21) for all studied traits. T.S.S was low in fruits of Giza 21 because of immaturity and small size of fruits under cold weather conditions.

Table (2): Generation means, heterosis estimates, potance ratio and broad sense heritability for yield and fruit traits of watermelon under winter conditions at open field.

Generations	Traits			
	No. of fruits/plant	Mean fruit weight (g)	Total yield/plant (kg)	Total soluble solids content %
P_1 (Giza21)	1.2	295.8	0.329	7.5
P_2 (PIPP8-261)	1.8	1943.0	3.46	10.5
F_1	2.2	1744.4	3.87	10.3
F_2	2.2	1290.5	2.81	9.7
BC_1(F_1×Giza21)	1.8	916.7	1.59	10.0
BC_2(F_1×PIPP8-261)	2.5	2222.2	5.63	10.5
L.S.D(0.05)	0.21	537.53	1.88	0.515
Heterosis M.P%	46.7^{**}	55.84^{**}	104.3^{**}	14.4^{**}
Heterosis H.P%	22.2^{**}	-10.2	11.8	-1.9
Potence ratio(P)	2.3	0.76	1.3	0.87
Broad sense				
Heritability(HB)	0.11	0.91	0.95	0.39

**significant at 0.01 level of probability, DinNijs (1985) obtained similar results on cucumber under low temperature conditions. Heterotic expression over mid-parent was positive and significant for all studied traits in Table 2, indicating that these traits are influencing by dominance genes. Over dominance may be Important for number of fruits/plant it exhibited positive significant heterosis over high parent. The value of potence ratio (Table2) explain that the degree of dominance of the individual genes for these traits may be only in the range of partial and over dominanace.

Heritabilities of number of fruits / plant and T.S.S traits were low 0.11 and 0.39, indicating that these traits were much influenced by low temperature in winter and other environmental effects. The respective high broad-sense heritability values of 0.91 and 0.95 may be in part due to a substantial dominance variance component.

Resulting F_2 population segregated in a ratio of 3 tolerance : 1 sensitive. Plants of BC_1 (F_1 x Giza21) segregated 1tolerance : 1sensitive (Table 3). Hence it was evident that the cold tolerance is a dominant trait and is controlled by a single dominant gene, Provvidenti (1994) arrived similar result under the same conditions.

Table (3): Inheritance of tolerance to low temperature in winter season on parents, F1, F2 and back crosses generation of watermelon.

Generations	No. plants		Expected ration Tole : Sen	X^2 value	P
	Tolerance	Sensitive			
P_1 (Giza21)	0	28			
P_2 (PIPP8-261)	25	0			
F_1 (Giza21×PIPP8-261)	36	0			
F_2	91	29	3 : 1	0.044	0.80-0.95
Bc_1 (F_1×Giza21)	27	29	1 : 1	0.071	0.50-0.80
Bc_2 (F_1×PIPP8-261)	63	0			

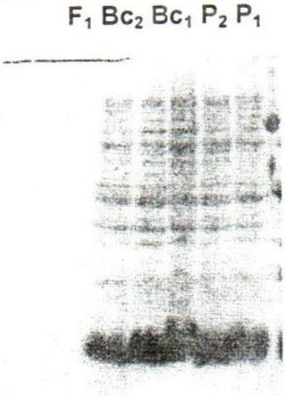
Protein electrophoresis:

Electrophoretic protein banding pattern, (SDS-PAGE) of the two watermelon cultivars and their F_1 hybrid excluding reciprocal as well as their backcrosses (BC_1, BC_2) are presented in (Figure3). The two parents showed different appearance in band intensity. However the major bands were equal in number for all genotypes. Giza21 cultivar had faint bands, moreover the PIPP8-261 inbreed line in spite of having the same major groups of bands but with more intensity. From the previous results, it could be deduced that the variation in banding patterns between the two parents; showed different behavior for winter planting under open field conditions, where as one out of the two, Giza21 was sensitive and the other was tolerant such result confirms that these two parents are genotipically and evolutionary different. This was substained by the facts that some of the substractions of a particular protein either slightly disappeared or were reduced in size and mobility.

Such quantitative and qualitative variations in protein banding patterns of the parental sources could be found if one assumed that the genes responsible for these metabolic phenomena are different in their action. Similar results were obtained by Volodin *et al.* (1984); Cook (1990); Matsumoto *et al.* (1997); Amer *et al.* (1999); and Ismail and El-Ghareeb (2000).

The F_1 hybrid was characterized by increasing slightly in banding pattern intensity compared with their parental cultivars. The de novo appearance of these slightly dark stained band (heavier in molecular weight) reflected dominance action.

BC_1 (F_1×Giza21) and BC_2 (F_1×PIPP8-261) showed more darkly appearance in banding pattern intensity. The appearance of very distinctive darkly stained bands were observed in BC_1 (F_1×Giza21) and the F_1 (Giza 21 × PIPP8-261) the same results were obtained by Amet (1992). From the previous results, the qualitative differences and expressed variability in banding patterns reflected the amount of heterotic effects. These results were very near with Charkabatri et al (1992). Thus such investigation suggested some sorts of association between protein electrophoretic banding patterns and both sensitivity and tolerance for low temperature during planting under winter conditions at open field.Whereas, low temperature – tolerance is a dominant simple trait in watermelon, and furthermore all studied traits behaved dominantly under winter conditions at open field. We can easily exploit the former conditions for the production of new varieties or F_1 hybrids by backcross and hybridization methods. Furthermore, they are cultivated without low tunnel in winter.



P1=Giza21
P2=PIPP8-261
F1=Giza21×PIPP8-261
Bc1=F1×Giza21
Bc2=F1×PIPP8-261

Figure3: Sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) for seed protein of two parents and their hybrid as well as their backcrosses.

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السلوك الوارثي لبعض الصفات الاقتصادية في البطيخ تحت ظروف الزراعة الشتوية في الحقل المفتوح

محمد محمد عبد السلام
قسم بحوث الخضر - معهد بحوث البساتين - مركزالبحوث الزراعية - القاهرة - مصر.

أجريت التلقيحات بين صنف البطيخ المحلى جيزا ٢١ الحساس للبرودة وسلالة البطيخ المتحملة للبرودة PIPP8-261. وقد أخذت البيانات علي النباتات الفردية لستة من الأجيال هم الأب الأول (جيزة ٢١) والأب الثاني (PIPP8-261) والجيل الأول الهجين والجيل الثاني والتلقيحان الرجعيان الأول والثاني وذلك لإجراء التحليل علي متوسطات الأجيال لدراسة السلوك الوراثي للصفات الخضرية والمحصول وصفات الثمار تحت ظروف الشتاء في الحقل المفتوح. قوة الهجين للجيل الأول علي أساس متوسط الأباء كان معنويا لكل الصفات ما عدا مساحة الورقة الناضجة. كما أن قيمة الـ Potence ratio تجاوزت الواحد الصحيح لصفاتى عدد الثمار علي النبات والمحصول الكلي للنبات، في حين كانت أقل من الواحد لصفتى وزن الثمرة و محتوى المواد الصلبة الذائبة الكلية. معامل التوريث بمعناه الواسع كان منخفضا لصفتى عدد الثمار علي النبات و محتوى المواد الصلبة الذائبة الكلية وكان عاليا لصفتى وزن الثمرة والمحصول الكلي للنبات. كما أظهرت النتائج أن التحمل لدرجة الحرارة المنخفضة في الشتاء كان محكوم بجين واحد سائد هذا الجين يمكن استغلاله في أنتاج أصناف بطيخ جديدة أو هجن محلية يمكنها تحمل درجة الحرارة المنخفضة في الشتاء وبالتالي تحقق عائد اقتصادي جيد نتيجة زراعتها مبكرا.