ISSN 1110-0419

Annals Of Agric. Sc., Moshtohor,
Vol. 44(2): 653-662, (2006).

INHERITANCE OF FUSARIUM WILT RESISTANCE AND SOME ECONOMIC TRAITS IN CUCUMBER

BY

Abdou, A.A.*; Dowedar, S.A.*; Gaafar, S.A. and Mohamed, A.M.****
* Hort. Dept., Fac. Agric. Al-Azhar Univ.
** Veget. Crops Dept. Hort. Res. Institute.

ABSTRACT:

This work was done to study the inheritance of resistance to fusarium wilt disease, yield and its components and fruit appearance in cucumber (*Cucumis sativus L.*) cross Beit alpha X Cus 125/1983. Genetic studies were made on six populations P_1, P_2, F_1, F_2, $B_{c1}$and B_{c2} derived from this cross. The results cleared that the resistance for *Fusarium oxysporum f. sp. Cucumerinum* is controlled by one pair of dominant genes either the percentage and severity of disease. The total yield /plant is controlled by one pair of over dominant genes with heterosis above the higher parent, fruit length is controlled by one pair of partial dominant genes with heterosis above the higher parent, fruit diameter is controlled by two pairs of partial dominant genes with tendency towards the lower parent. Fruit smoothness and spines color are controlled by one pair of dominant genes each.

INTRODUCTION

Cucumber (*Cucumis sativus, L.*) is one of the most favorable and common vegetable crops all over the world. Fusarium wilt caused by *Fusarium oxysporum F.sp. cucumerinum* is a harmful disease for cucumber in several parts of the world causing a great damage to the plant especially in greenhouses. In the field of resistance breeding, it is useful to know the nature of cucumber resistance to fusarium wilt as it is simply inherited character controlled by a single dominant gene (Netzer *et al.*, 1977). So, the use of resistant cultivars is the most acceptable and economic means of disease control, (Vakalounakis, 1988, 1993 and 1995). Evaluation of cucumber genotypes against Fusarium wilt was studied by many investigators to assess the resistance to fusarium. They found that the tested genotypes can be classified into susceptible, moderately and highly resistance indicating the possibility of using the resistant sources in cucumber breeding [Kiessling *et al.*, (1985) on cucurbits; Peterson *et al.*, (1985); Anikina (1991) and Zhang *et al.*,(1992) on cucumber]. Dong and Chen (1993) found, among 62 cucumber cultivars, none proved immune, one was highly resistant, 20 cultivars were resistant and the others were not. Zhao and Sun (1994) found the moderate resistance to Fusarium wilt in a new five cucumber cultivars. Vakalounakis (1995) found that among 34 cucumber cultivars tested at seedling stage for resistance, five were susceptible while the remainders were highly resistant.

Sugiyama *et al.*, (1998) mentioned that the two cucumber cultivars Hu 116 and Hu 119 were bred true and have high resistance to Fusarium wilt.

In the same time, it is very important to cucumber breeder to select the new cucumber genotypes which has high yielding ability through improving yield components characters adjacent to its ability to resist Fusarium wilt disease. Many workers studied the inheritance of cucumber total yield/plant and its components. Bite (1971) indicated that the hybrid plants were more productive than their parental vatieties. El-Shawaf and Baker (1981) found that additive genetic variance for yield was greater than none additive. El- Mahdy *et al.*, (1992) observed highly significant inbreeding depression for early and total yields as number and weight of fruits. Owens *et al.*, (1985) noticed significant genetic variability among selected inbred backcross lines within each population for fruit length. Awad (1996) showed in cucumber that the mean of fruit diameter for parents was higher than their hybrids. Ram *et al.*, (1996) found that the variability was high for fruit length and fruit breadth.

The objective of the present work was to study the inheritance of fusarium wilt resistance and some economic yield attributes in the six cucumber populations derived from a cross between the common and local cucumber cultivar "Beit alpha" which are susceptible to Fusarium wilt and another important cucumber genotype which is resistant to this disease.

MATERIALS AND METHODS

This work was conducted to study the inheritance of resistance to fusarium wilt beside yield / plant and some of its components in cucumber. The experimental work was carried out during the period of 1998 to 2001 growing seasons. In 1998 season, fourteen cucumber genotypes introduced from the German gene bank were tested and evaluated as well as Beit alpha cultivar against *Fusarium oxysporum f. sp. Cucumerinum* and at the end of this season four genotypes were found to be resistant to fusarium wilt, i.e. Cus 125/1983, Cus 260/1980, Cus 451/1985 and Cus 463/1985. These four genotypes and Beit alpha were grown in 1999 to study their yielding ability and from their yield performance, the genotype Cus 125/1983 was crossed to Beit alpha cultivar to obtain F_1 seeds. In 2000 season, the two parents and their F_1 were grown and the selfing was done to obtain F_2 seeds as well as crossing of F_1 to their parents to obtain backcrosses seeds (BC_1 and BC_2). In 2001, the seeds of P_1 (Beit alpha), P_2 (Cus 125/1983), F_1, F_2, BC_1 and BC_2 were planted in randomized complete blocks design with four replicates. The experimental plots were in rows five meters long and one meter wide and planting was in hills 50 cm apart. In each replicate, one row was used for each of P_1, P_2 and F_1, three rows for both BC_1 and BC_2 and four rows for the F_2 population, while the planting was done on the two sides of the row. The evaluation and genetical studies of vegetative and yield characters were done in a greenhouses at Kaha Vegetable Research Farm, Kalubia governorate while the evaluation for fusarium wilt resistance was conducted at air conditioned greenhouse at Vegetable Research Department at Dokki, Giza, Egypt using the technique proposed by Riker and Riker (1936).

The studied characters in the present work were resistance to fusarium wilt disease and disease severity as outlined by Martyn *et al.*, (1991), total yield / plant, fruit length, fruit diameter, fruit spines color, and smoothness of fruits.

Genetical analysis included the following measurements for the four characters disease severity, total yield / plant, fruit length and fruit diameter:

a- Potence ratio: the relative potency of gene set (P) was used to determine the direction of dominance according to the formula:

$$P = \overline{F_1} - \overline{M.P.} \quad / \tfrac{1}{2} (\overline{P_2} - \overline{P_1}) \text{ (Smith, 1952)}$$

b- Heterosis: heterosis based on the mid and high parent was estimated according to the following equations.

$$\text{Mid-parent heterosis} = (\overline{F_1} - \overline{M.P.}) \times 100 / \overline{M.P.}$$

$$\text{High-parent heterosis} = (\overline{F_1} - \overline{H.P.}) \times 100 / \overline{H.P.}$$

c- Number of genes was calculated according to Castle and Wright (1921) formula:

$$N = D^2 / 8 (V_{F2} - V_{F1})$$

Where:
D = Mean of larger parent – mean of smaller parent.
V_{F1} = Variance of F_1 population.
V_{F2} = Variance of F_2 population.

d- Heritability: in both Broad and Narrow Senses (BSH & NSH) were estimated as follows:
BSH = V_G X 100 / V_P (Allard, 1960)
Where:

$$V_G = V_P - V_E$$

$$V_E = \sqrt[3]{V_{P1} \times V_{P2} \times V_{F1}}$$

NSH = $\{2V_{F2} - (V_{Bc1} + V_{Bc2})\} \times 100 / V_{F2}$ (Mather and Jinks, 1971).

e- For the two characters fruit spines color and fruit smoothness, the X^2 test was used to test the goodness of fit of F_2 plants to the ratio 3 black spines (coarse): 1 white spines (fine) and the segregated B_c plants to the ratio 1 black spines (coarse): 1 white spines (fine).

RESULTS AND DISCUSSION

The present work concerned mainly with the inheritance of cucumber resistance to fusarium wilt caused by *Fusarium oxysporum f. sp. Cucumerinum* as well as the determination of total yield and its two main components fruit length and fruit diameter beside the two qualitative characteristics fruit spines color and fruit smoothness. In this investigation, the six populations of the cross Beit alpha

X Cus 125/1983, number of plants, means and variances among the six populations were used and are shown in Table (1).

The results can be presented under these headings:

1 - Disease severity:

Quantitative genetic parameters obtained for fusarium wilt disease severity of P_1, P_2, F_1 and F_2 are presented in Table (2) .The negative potence ratio (P) with value -0.93 indicated partial dominance of the fusarium wilt disease severity towards the small parent. Mid and High parent heterosis values were -63.2 % and -78.1 % respectively. These results were in accordance with potence ratio value. The fusarium wilt disease severity was found to be controlled by one pair of genes. Broad and Narrow Sense Heritability (BSH and NSH) estimates with high values of 85.3 % and 84.3%, respectively. High BSH estimation indicated the minor role of environment on this character which coincided with Awad (1996).

2 - Total yield / plant (gm):

Quantitative genetic parameters obtained for the total yield per plant are illustrated in Table (2). The positive potence ratio (P) with value 1.97 indicated over dominance of the total yield per plant over high parent. Mid and better parent heterosis values were 28.3% and 12.19 %, respectively. Total yield was found to be controlled by one pair of genes. Estimates of Broad and Narrow Sense Heritability (BSH and NSH) had values of 62% each. These results were in accordance with potence value and in agreement with those obtained by Ghaderi and Lower (1979), Lower *et al.*, (1982), Solanki *et al.*, (1982), Ragab (1984), El-Mahdy *et al.*, (1992), Li Jian Wu *et al.*,(1995), Awad (1996) and Abd El-Hafez *et al.*, (1997).

3 - Fruit length:

The obtained quantitative genetic parameters regarding the fruit length are tabulated in Table (2). The positive potence ratio (P) with value 0.12 indicated partial dominance of the fruit length character towards the high parent. The dominance of this character may differ according to the genotypes involved in the crossing. Mid-parent heterosis had a positive value (4.54%) but high parent heterosis had a negative one (-24.9%). This result confirmed the partial dominance of this character in cucumber. Fruit length estimation was found to be controlled by one pair of genes. Broad and Narrow Sense Heritability were 36.6% and 17.6 %, respectively. This indicates either the presence of dominance or dominance epistatic effect because the narrow sense was low and the number of genes that controlled this character was one. Our results are in agreement with the results of Ragab (1984) and Awad (1996). The dominance of this character does not agree with the foundation of Imam *et al.*, (1977) who found that it is towards the short fruit and this was explained by that the results differ according to the genotypes involved in the crossing.

Table (1): Means of fusarium disease severity, total yield, fruit length, fruit diameter and their variances in the six populations of the cross Beit alpha X Cus 125/1983.

Characters / Populations	Disease severity			No. plants	Total yield g/ plant		Fruit length(cm)		Fruit diameter(cm)	
	Mean ±SE	No. plants	Variance		Mean ±SE	Variance	Mean ±SE	Variance	Mean ±SE	Variance
Beit alpha (P_1)	5.93 ±0.07	60	0.2916	54	1436.1 ±22.5	27324.09	15.4 ±1.6	139.24	3.22 ±0.034	0.0625
Cus 125/1983 (P_2)	1.13 ±0.12	60	0.8649	55	1918.8 ±34.6	65843.56	35.3 ±3.9	835.21	4.22 ±0.028	0.4410
F_1	1.30 ±0.15	60	2.5600	57	2152.7 ±32.7	60959.61	26.5 ±3.0	510.76	3.51 ±0.026	0.0400
F_2	2.24 ±0.17	150	4.3264	215	1680.0 ±34.3	252908.4	26.5 ±1.7	3014.01	3.85 ±0.010	0.0100
BC_1	2.29 ±0.2	120	0.0400	180	1512.4 ±20.0	71984.89	18.8 ±1.3	302.76	3.31 ±0.020	0.0729
BC_2	1.43 ±0.12	120	1.7161	179	1885.6 ±21.2	80428.96	31.2 ±2.1	789.61	4.02 ±0.250	11.1556

4 - Fruit diameter:

Quantitative genetic parameters obtained for the fruit diameter are presented in Table (2). The negative potence ratio (P) with value -0.105 indicated partial dominance of the low fruit diameter character. Both Mid and High parent Heterosis had negative values being -5.9% and – 17.7%, respectively. Fruit diameter was found to be controlled by two pairs of genes. Estimates of BSH and NSH were 32.9% each, indicating the role of inheritance effect in this character. This result coincides with Kubickib and Korzeniewska (1983) and it is a simple referring to the suggestion of Awad (1996).

5 - Fruit spines color:

Data of P_1, P_2, F_1, F_2, BC_1 and BC_2 population about the fruit spines color are documented in Table (3). The fruits of P_1 (Beit alpha) are characterized with black spines while P_2 (Cus 125/1983) fruits had white spines.

The results showed that all the plants of F_1 progeny bear fruits with black spines. This result indicated that the black color of spines is dominant character over white one. Accordingly, one can expected that the F_2 population will segregate to a ratio of 3 black : 1 white. Using X^2 value, it was found that the figures divided into two groups with a ratio between black and white fitted to 3: 1, respectively. This indicated that the black and white color in the phenotype is depending, in its expression, upon a single pair of genes. The backcross to the parent (Beit alpha) carrying the dominant character produced progeny with black spines on fruit. On backcrossing F_1 plants to the recessive parent (Cus 125/1983), progeny segregated to fit 1:1 between black & white. These results confirmed the evidence of monogenic inheritance of this character. However, the obtained trend agrees with the results of Kubickib and Korzeniewska (1983), Ragab (1984), Peterson *et al.*, (1985) and Pyzhenkov (1986) where they found that the fruit spines color was controlled by a dominant single gene (B) toward the black spines.

6 - Fruit smoothness:

Data of P_1, P_2, F_1, F_2, BC_1 and BC_2 about the smoothness of fruits are presented in Table (3) .The results cleared that fruits of P_1 (Beit alpha) had fine spines and those of P_2 (Cus 125/1983) had coarse ones. Plants of F_1 generation bore fruits with coarse spines. Therefore, it can be concluded that the coarse spines is dominant over the fine ones. However F_2 population segregated close to a ratio of 3 coarse: 1 fine spine according to X^2 value (1.44) with probability value of 3: 1 indicating that the coarse spines: fine in phenotype is depending in its expression upon a single pair of genes.

Regarding the backcrossing F_1 plants to the recessive parent (Beit alpha), progeny segregated to fit 1 coarse: 1 fine spines on the fruits. The backcross to the parent (Cus 125/1983) carrying a dominant character produced progeny with coarse spines on the fruits. These results confirmed the evidence of monogenic inheritance of this character and it is in harmony with the results of Robinson (1978), Ragab (1984) and EL-Shawaf *et al.*, (1984) on cucumber.

Table (2): Quantitative genetic parameters of disease severity to fusarium wilt, total yield, fruit length and fruit diameter in the cross Beit alpha XCus125/1983.

Parameters \ Characters	Disease severity	Total yield	Fruit length	Fruit diameter
Potence ratio (P)	-0.93	1.97	0.12	-0.105
Mid- parent heterosis %	-63.20	28.30	4.54	-5.900
High parent heterosis %	-78.10	12.19	-24.90	-17.700
Minimum number of genes	0.84	0.44	0.40	1.140
Broad sense heritability %	85.30	62.00	36.60	32.900
Narrow sense heritability %	84.30	62.00	17.60	32.900

Table (3): Distribution of fruit spines color and fruit smoothness for P_1, P_2, F_1, F_2, BC_1 and BC_2 populations in the cross Beit alpha X Cus125/1983.

Population \ Character	Fruit spines color				
	Observed		Total	X^2	Ratio
	Black	White			
Beit alpha (P_1)	54	0	54	-	-
Cus 125/1983 (P_2)	0	55	55	-	-
F_1	57	0	57	-	-
F_2	172	43	215	2.66	3:1
B_{c1}	167	13	180	-	-
B_{c2}	92	87	179	0.40	1:1
	Fruit smoothness				
	Observed		Total	X^2	Ratio
	Coarse	Fine			
Beit alpha (P_1)	0	54	54	-	-
Cus 125/1983 (P_2)	55	0	55	-	-
F_1	57	0	57		-
F_2	169	46	215	1.44	3:1
B_{c1}	97	82	179	1.10	1:1
B_{c2}	171	9	180	-	-

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وراثة المقاومة لمرض الذبول وبعض الصفات الاقتصادية فى الخيار

عرفه عبدالقوى عبده*، سعد عبدالجيد دويدار*، سامى عبدالجواد جعفر،**
أيمن محمد عبدربه محمد**
* قسم البساتين- كلية الزراعة - جامعة الأزهر.
** معهد بحوث البساتين- وزارة الزراعة.

أجريت هذه الدراسة خلال الفترة من ١٩٩٨-٢٠٠١ وذلك بهدف دراسة توريث صفة المقاومة لمرض الذبول الفيوزارمى وكمية المحصول ومواصفات الثمار التى شملت طول وقطر الثمرة ولون الأشواك على الثمار وملمس الثمرة فى الهجين الناتج من التلقيح بين الصنف التجارى بيتا ألفا والـتركيب الوراثى البرى Cus 125 / 1983، (Beit Alpha X Cus 125/1983) وقد اشتملت الدراسة الوراثية على تقدير درجة السيادة وقوة الهجين ودرجة التوريث وعدد الجينات المتحكمة فى كل صفة من الصفات المدروسة وذلك فى جميع العشائر الناتجة من التهجين والتى شملت الأبوين والجيل الاول والجيل الثانى والتهجين الرجعى لكل من الابوين (P_1, P_2, F_1, BC_1, BC_2) و قد أوضحت النتائج أن الصنف التجارى بيتا ألفا شديد الحساسية للمرض وأن الاب البرى مقاوم له و أن شدة الاصابة يتحكم فيها زوج واحد من العوامل الوراثية السائدة وان محصول النبات الكلى يتحكم فيه ايضا زوج واحد من الجينات مع سيادة فائقة تجاه الاب الاعلى وكانت درجة التوريث بمعنييها الواسع والضيق ٦٢٪ لكل منهما. وأن طول الثمرة محكوم بزوج واحد من الجينات وسائد سيادة جزئية تجاه الاب الاطول أما درجة التوريث فكانت ٣٦,٦٪ و ٧,٦٪ بمعنييها الواسع والضيق على الترتيب أما قطر الثمرة فيتحكم فيه زوجان من الجينات السائدة سيادة جزئية فى إتجاه الأب الأصغر ودرجة توريثها ٣٢,٩٪ بمعنييها. كما ظهر أن صفة لون الأشواك الاسود سائدة على اللون الأبيض وأن صفة ملمس الثمار الصلب ووجود النتوءات عليها سائدة على الملمس الناعم و يتحكم فى كل منهما زوج واحد من الجينات السائدة.