INHERITANCE OF RESISTANCE TO COTTON LEAFWORM (Spodoptera littoralis) IN SOYBEAN (Clycine max)

Habeeb, M.B.[1]; M.I.A. Sherif[2]; A.A. El-Hosary[3]; M.A. Naseeb[1] and A.M. Hablas[2]

1) Agriculture Research Centre, Cairo.

2) Department of Genetics, Faculty of Agriculture, Minuaiya Univ.

3) Department of Agronomy, Faculty of Agriculture, Moshtohor.

وراثة المقاومة لدودة ورق القطن Spodoptera littoralis فى فول الصويا (Glycine max)

محمود بسطويسى حبيب — مركز البحوث الزراعية ـ بالقاهرة

محمد ابراهيم عبد البارى شريف — قسم الوراثة ـ كلية الزراعة ـ جامعة المنوفية

على عبد المقصود الحصرى — قسم المحاصيل ـ كلية الزراعة ـ مشتهر

عبد المنعم محمد حبلص — قسم الوراثة ـ كلية الزراعة ـ جامعة المنوفية

محمد عبد الله نصيب — مركز البحوث الزراعية ـ القاهرة

ملخص البحث

أستخدم فى دراسة المقاومة لدودة ورق القطن الصنفين عاليا المقاومة Celest, D19-19455 والصنف التجارى الحساس Crawford من خلال ثلاثة معايير للصفة وهذه المعايير هى عدد الشعيرات والمساحة المستهلكة من الورقة ونسبة الفقد فى الأوراق . وقد أستخدم الهجينين D19-10455 x Crawford (II), Celext x Carwford,(I) والأجيال الانعزالية الناتجة عنها فى تقدير التقديرات الوراثية المختلفة . بينت النتائج المتحصل عليها أن قوة الهجين كانت سالبة وعالية المعنوية بالنسبة لكل من المساحة المستهلكة من الورقة ونسبة الفقد فى الأوراق ، بينما كانت موجبة وعالية المعنوية بالنسبة لعدد الشعيرات وذلك فى كلا الهجينين . وقد كان التدهور الناتج عن التربية الداخلية معنوى بالنسبة لعدد الشعيرات والمساحة المستهلكة فى كلا الهجينين ، وأيضا لنسبة الفقد فى الأوراق فى الهجين الثانى . بالنسبة لدليل السيادة فقد كانت السيادة جزئية تجاه المقاومة . وبالنسبة لطبيعة فعل الجين كان التأثير المضيف والسيادى ذو أهمية فى وراثة

الثلاثة معايير للصفة ، بينما ظهرت بالاضافة لذلك معنوية تأثير الجين التفوقى بالنسبة لعدد الشعيرات والمساحة المستهلكة فى الورقة . بين معامل الاختلاف الوراثى فيما متوسطه بالنسبة للمساحة المستهلكة من الورقة ونسبة الفقد فى الأوراق بينما أظهر قيما منخفضة بالنسبة لعدد الشعيرات . وكانت قيم المكافئ الوراثى بالمفهوم العام تتراوح بين قيما عالية وقيما متوسطة فى الثلاث صفات ، بينما كانت القيم بالمعنى الضيق عالية فى حالة عدد الشعيرات ونسبة الفقد فى الأوراق فى الهجين الثانى ولكنها كانت منخفضة فى الحالات الأخرى . وبالنسبة لنسبة الفقد فى الأوراق فى الهجين الثانى بينما كانت القيم متوسطة فى حالة المساحة المستهلكة من الورقة فى كلا الهجينين وفى نسبة الفقد فى الأوراق فى الهجين الأول ، أما فى حالة عدد الشعيرات فقد كانت القيم منخفضة فى كلا الهجينين .

ABSTRACT

Two highly resitant varieties D19-10455 and Celest; and the susceptible commercial variety Crawford were used to study resistance of soybean to leafworm through three criteria; i.e. hairiness; area consumed and defoliation. The two crosses D19-10455 x Crawford (I) and Celest x Crawford (II) and their segregating generations were used to estimate the different genetic parameters. Results obtained showed highly significant negative heterotic effects for leaf area consumed and defoliation in the two crosses, whereas highly significant positive heterotic effects were detected for hairiness and leaf area consumed in both crosses and in the second cross for defoliation. Values of potence ratio indicated partial deminance for resistance over susceptability and for high number of hairiness over low number. Both additive and dominance types of gene action were important in the inheritance of the three traits; although the epistatic gene effects had important attributes of inheritance with regard to hairiness and leaf area consumed in the two crosses. Genetic coefficient of variation expressed moderate values for leaf area consumed and defoliation, while low values were expressed for hairiness. High to moderate values for broad sense heritability were detected for the three traits. High values of narrow sense heritability were only obtained for hairiness and defoliation in the second cross. The expected genetic advance was higher for defoliation in the second cross, but it was moderate for leaf area consumed in both crosses and defoliation in the first cross. However, low estimates were obtained for hairiness in both crosses.

INTRODUCTION

Soybean is susceptible to several diseases and insects. One of the most harmful insects is cotton leafworm, Spodoptera littoralis (Boisd). This pest was found in all soybean growing areas in Egypt. Cotton leafworm becomes widespread and serious. So, it is imperative to breed varieties having a high degree of resistance to cotton leafworm. Currently, varieties such as Crawford group IV appear to be susceptible to leaf-feeding insects such as cotton leafworm. Therefore, insect control will be difficult and costly. However, several studies with cotton leafworm have demonstrated consistently higher level of resistance in Celest and D79-10455 under field and laboratory conditions. The objective of the present investigation is to study the inheritance of resistance to cotton leafworm insect in soybean.

MATERIALS AND METHODS

The present investigation was carried out at the Sakha Agriculture Research Station, during the three successive seasons, 1984, 1985 and 1986. Three varieties of soybean were used in this worm. Two of them were highly resistant to leafworm insect, i.e. D19-10455 and Celest and the other one was susceptible i.e. Crawford (Commercial variety).

In 1984 season, the three varieties were sown in four planting dates to avoid differences in flowering time and to secure enough hybrid seeds. During this season, two crosses were made as follows: D19-10455 x Crawford (I) and Celest x Crawford (II).

In the 1985 season, the hybrid seeds and the three parents were sown. F_1 plants were self-pollinated and backcrossed to both parents to obtain F_2's and the backcrosses seeds, also were crosses repeated between parents to obtain the F_1 seeds.

In the 1986 season an experiment for each of the two crosses was carried out. Each trial contained six populations, i.e., the two parents, their F_1, F_2 and the two backcrosses to each parent. The experimental design was randomized complete block design with three replications. Each plot consisted of one ridge 300 cm long and 60 cm. wide. Hills were spaced 20 cm. apart with one seed per hill. Each replicate consisted of 15 plots per hill. Each replicate consisted of 15 plots for F_2 plants, five plots for each of BC_1 and BC $_2$and two plots for any nonsegregating population.

Data were taken only on guarded plants. The study of the inheritance of resistance to cotton leafworm was evaluated using the following three criteria:

1. Hairiness: Number of hairs on the lower surface of the leaf were counted, and the leaflet from first trifoliolate of the upper third of plant was taken as a standard (Kamel, 1963). The binocular field (0.5 cm^2) was used to determine the average number of hairs for each plant.

2. The area of leaf tissue consumed: One fourth instar stage larvae were placed in a glass container, 1000 ml. capacity and were allowed to feed on fresh leaflets, excised randomly from the upper third of each plant, including their petioles. The area of leaf tissue consumed after 24 hours was measured (Thobbi, 1962 and Meisner <u>et al</u>., 1983).

3. Leaf feeding damage or foliage loss (defoliation): Visual ratings of percent defoliation were recorded, as the average of three times (every seven days) beginning two weeks after flowering, on each plant in the field experiment without insect control under the natural field infeciton. A standard area diagram for estimating the percentage of defoliation was reported by Smith and Brim, 1979 as shown in Figure (1).

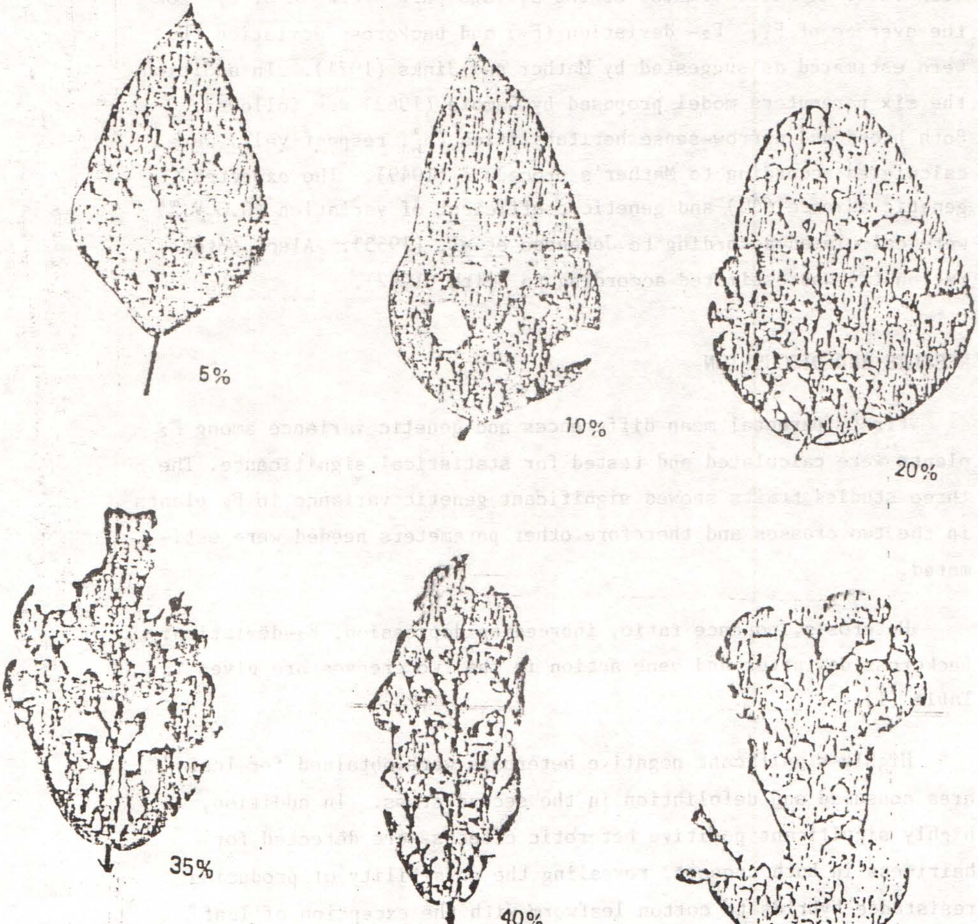

Fig. (1): Standard area diagram estimating the percentage of defoliation.

The genetic variance within F_2 population was firstly evaluated. If that variance is significant, various genetical parameters were them derived. Heterosis (H%) was expressed as percent increase of the F_1 performance above the mid-parent value. In breeding depression (I.d. %) was estimated as the average part decrease of F_2 from the average of F_1. F_2- deviation (E_1) and backcross deviation (E_2) were estimated as suggested by Mather and Jinks (1971). In addition, the six parameters model proposed by Gamble (1962) was followed. Both broad and narrow-sense heritabilities (h^2_b, respectively) were calculated according to Mather's procedure (1949). The expected genetic advance (ΔG) and genetic coefficient of variation (G.C.V.%) were calculated according to Johanson <u>et al</u>. (1955). Also, potenc ration (P) was estimated according to Smith (1952).

RESULTS AND DISCUSSION

First, parental mean differences and genetic variance among F_2 plants were calculated and tested for statistical significance. The three studied traits showed significant genetic variance in F_2 plants in the two crosses and therefore other parameters needed were estimated.

Heterosis, potence ratio, inbreeding depression, F_2-deviation, backcross deviation and gene action in the two crosses are given in Table (1).

Highly significant negative heterosis were obtained for leaf area consumed and defoliation in the second cross. In addition, highly significant positive heterotic effects were detected for hairiness in both crosses, revealing the possibility of producing resistance hybrids to cotton leafworm with the exception of leaf area consumed in the first cross, both heterosis and inbreeding depression are of a similar phenomenon. Therefore, it is logical

Table (1): Heterosis, inbreeding depression, potence ratio, F_2 deviation, backcross deviation and gene action for resistance to cotton leafworm in the two crosses D_{79}-10455 X Crawford (I) and Celest X Crawford (II).

Character	Cross	Heterosis %	Inbreeding depression %	Potence ratio	F_2 deviation E_1	BC deviation E_2	Gene action six parameters (Gamble procedure) m	a	d	aa	ad	dd
Hairiness	I	3.50**	4.54**	0.18**	- 0.32**	0.62**	10.72**	- 1.64**	2.90**	2.52**	0.44**	- 3.76**
	II	6.04**	5.73**	0.20**	- 0.39**	- 0.27	12.67**	- 2.89**	1.79**	1.02*	1.00**	- 0.49
Leaf area	I	- 1.31	- 4.65**	0.07	2.02**	- 6.58**	53.11**	5.40**	-21.92**	-21.24**	- 4.28**	34.39**
consumed	II	-32.64**	-47.03**	-0.68**	6.19**	- 0.99	39.92**	21.65**	-39.90**	-26.74**	2.28	28.71**
Defoliation	I	- 2.34	- 3.59	- 0.29	0.79	- 0.18	34.30**	2.50**	- 4.32*	- 3.52	- 0.34	3.87
	II	-21.00**	-19.97**	- 0.55**	1.41*	- 0.77	25.29**	10.71**	- 9.71**	- 4.10	- 0.54	2.57

* Significan at 5% level.

** Significant t 1% level.

to anticipate that heterosis in the F_1 will be followed by appreciable reduction in the F_2 performance. Leaf area consumed in the first cross, did not showed any heterosis, however, a highly significant value for inbreeding depression was detected. The difference most parameters may lead to the observed absence of heterotic effects (Marani, 1968).

It could be concluded that heterosis and inbreeding depression effects affecting the resistance of cotton leafworm, refer to the existense of some non-additive genetic types of gene action. Lambert and Kilen, 1984 showed that here is a strong trend for larvae of different insects reared on soybean F_1 plants of the crosses to be smaller than the mid-parent values. Also, they mentioned that mortality tended to be greater for larvae reared on resistant geneotypes, and larval weight for those reared on F_1 plants tended to be similar to those reared on the most resistant parents.

Nature of gene action was also studied according to the relationships illustrated by Gamble (1962). For estimating various parameters of gene effects, the variety with larger mean in each trait was usually considered as P_1. In all traits, the mean effect of parameters "m" was highly significant.

The additive genetic estimates were highly significantly negative for hairiness and positive for other traits (Table 1). These results indicate the potentiality of improving the performance of these traits by using pedigree seleciton program. Similar results were obtained by Abou-Tour (1986) for leaf area consumed, who detected additive effects through generation mean analyses. The estimates of dominance effects were significantly positive for hairiness and significantly negative for the other traits, it can be concluded that the dominance gene effects are effective in the inheritance of all traits. Similar conclusion was obtained by Abou-Tour (1986), and Kornegay and Temple (1986) for leaf-feeding ratings. On the other hand, Lambert and Kilen

(1984) found that there was a slight dominance effect for resistance.

Hairiness in the first cross exhibited significant estimates for the three types of digenic epistasis although the significant estimates were experessed for "aa" and "ad" only in the second cross. Also, the significant values of various types of epistatic effect were accompanied by highly significant estimates for E_1 and E_2 (Table 1). Therefore it can be said that the three types of gene action are important contributors to this trait.

For leaf area consumed, the significant estimates were obtained for the three types of epistatic effects in the first cross, but of different magnitudes and directions. It is interesting to note that if the estimated values for dominance and various epistatic parameters were of nearly equal magnitudes and opposite directions, no appreciable heterotic effect can be detected (Marani, 1968 and El-Hosary, 1983). In the II cross, significant values were detected for additive x additive and dominance x dominance types of epistasis. It is noteworthy that both types of epistasis were accompanied by significant estimates of E_1. Also, the heterotic effect previously obtained may be due to both dominance and epistatic gene action.

For defoliation, insignificant estimates were detected for three types of epistasis. It is noteworthy that the three epistatic types were accompanied by insignificant estimates for E_2 and E_1 heterotic effect in the first cross; and E in the second cross.

In both crosses, genetic coefficient of variation was of moderate values for leaf area consumed and defoliation (Table 2), while the hairiness had low values of G.C.V.%. Therefore, it is impossible to estimate the magnitude of heritable variation, when figured out with help of other heritability and the genetic advance (Swarup and Changale, 1962).

Table (2): Heritability percentage in broad and narrow sense, genetic advance as percent of the F_2 mean and genetic coefficient of variation for resistance to cotton leafworm in two crosses, $D_{79-10455}$ X Crawford (I) and Celest X Crawford (II).

Character	Cross	h' broad %	h' narrow %	GS	GS %	G.C.V. %
Hairiness	I	91.55	31.82	0.69	6.44	9.36
	II	90.62	79.78	2.19	17.28	10.03
Leaf area consumed	I	92.94	28.47	6.16	11.60	19.06
	II	70.98	18.43	4.59	11.50	25.50
Defoliation	I	58.54	32.89	4.13	12.83	14.50
	II	87.22	74.42	11.97	61.76	37.63

High heritability values in broad sense were detected in both crosses for all traits (Table 2). Poze (1974) found high heritability estimates in soybean for resistance to Epilachna varrestis. For hairiness and defoliation high values for narrow sense heritability were obtained in the second cross, which are nearly equal with their corresponding broad sense ones. For the other cases high heritability in the broad sense was accompanied by low value for narrow ones. This result revealed that the non-additive genetic variance has a great role in the existence of variability in these cases. This finding is in agreement with results previously obtained by means of gene action studies where estimates of dominance and various types of epistatic effect were mostly predominant. Abou-Tour (1986) found that heritability in narrow sense ranged from 34.47 to 63.58 in 1983 and from 40.36 to 56.35 in 1984 test for leaf feeding ratings.

The predicted genetic advance was rather higher for defoliation in the second cross; and moderate values for leaf area consumed in both crosses and for defoliation in the first cross. However, hairiness in both crosses gave low estimates of the predicted genetic advance (Table 2).

Johanson et al. (1955) working with soybean reported that heritability estimates along with genetic gain are usually more usefull in predicting the resultant effect of selection that heritability values alone. On the other hand Dixit et al. (1970) pointed out that high heritability is not always associated with high genetic advance, but to make selection effective, high heritability should be associated with high genetic gain.

High to moderate genetic advance were found to associate with high to moderate heritability estimates in narrow sense in all traits. Therefore, selection for these traits should be effective and satisfactory for successful breeding purposes. It is noteworthy that defoliation in the second cross showed the highest predicted genetic advance, Abou-Tour (1986) working on cotton, reported that genetic advance in two crosses was 13.33% to 22.30% in 1983 and 14.90%-22.51 in 1984.

Relatively low genetic advance was associated with moderate heritability value in hairiness in first cross. It could be concluded that selection for this trait would be less effective than former five cases.

REFERENCES

Abou-Tour, H.B.I. (1986). Genetical studies on resistance to insect in Egyptian cotton. Ph.D. Thesis. Genetics Department, Faculty of Agric., Tanta Univ.

Dixit, P.K.; P.D. Saxena and L.K. Bhati (1970). Estimation of genotypic variability of some quantitative characters in groundnut. Ind. J. Agric. Sci. 40: 197.

El-Hosary, A.A. (1983). Genetical studies on field beans (Vicia faba, L.). I. Yield and yield components. Egypt. Soc. of Crop Sci., 1: 95-108.

Gamble, E.E. (1962). Gene effects in corn (Zea mays, L.). I. Separation and relative importance of gene effects for yield. Cand. J. Plant. Sci., 42: 330-348.

Johanson, H.W.; H.F. Robinson and R.E. Comstock (1955). Estimation of genetic and environmental variability in soybean. Agron. J., 47: 314-318.

Kamel, S.A. (1963). Breeding cotton resistant to some of the major cotton pests. Agric. Res. Centre, Bahtim.

Kornegay, J.L. and S.R. Temple (1986). Inheritance and combining ability of leaf hopper defense mechanisms in common bean. Crop. Sci., 26: 1153-1158.

Lembert, L., and T.C. Kilen (1984). Influence of three soybean plant genotypes and their F_1 intercrosses on the development of five insect species. J. Econ. Entomal. 77(3): 622-625.

Marani; A. (1968). Heterosis and inheritance of quantitative characters in interspecific crosses of cotton. Crop.Sci., 8:299.

Mather, K. (1949). Biometrical Genetics. 1st Edition Metheum and Co., London, 162 pp.

Mather, K. and J.L. Jinks (1971). Biometrical Genetics 2nd ed. Chapman and Hill Ltd., London 382 PP.
Meisner, J.M.Z. and E.B. Moshe (1983). Laboratory evaluation of the response of Spodoptera littoralis (Boisd) to selected cotton genotypes. Zeitschrift Für Angewandte Entomologic (1983) 95 (5): 467-470. (C.F. Rev. APP. Ent. 71(11): 7571, 1983).
Paze, P.E. (1974). Heritability of Mexican bean beetle resistance in soybean and interrelationships with ageonomic characters. Diss. Abst. Inten., B., 35 (6): 2546 B.
Smith, H.H. (1952). Fixing transgressive vigor in Nicotiana rustice. In Heterosis. Iowa State College Press. Ames. Iowa U.S.A.
Smith, C.M. and C.A. Brim (1979). Resistance to mexican bean bettle and corn earworm in Soybean genotypes derived from PL 227687. Crop Sci., 19(3): 313-314.
Swarup, V. and D.D. Changale (1962). Studies on genetic variability in sorghum. I. Phenotypic variation and its heritable component in some important quantitative characters contributing towards yields. Ind. J. Genet. 22:31.
Thobbi, V.V. (1962). Growth response of Prodenia litura F. in relation to three species of cotton. Empire Cott. Gr. Rev. 39:300.