Theor Appl Genet (1997) 95 : 506–508

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Inheritance of resistance to podfly and podborer in the interspecific cross of pigeonpea

Received: 11 March 1997 / Accepted: 4 April 1997

Abstract Pigeonpea, *Cajanus cajan*, is an important grain legume of Asia and Africa. The podfly, *Melanagromyza obtusa*, and the podborer, *Helicoverpa armigera*, are the major insect pests of this crop. An accession (JM 4147) of the wild species *Cajanus scarabaeoides* appears to possess resistance to these insect pests. For investigating the inheritance of resistance a cross was made between the susceptible cultivar Pant A-3 as female and the wild species. The parental lines and their F_1, F_2 and backcross generations were studied. For podfly, the per cent pod damage was recorded on individual plants. The results suggested that resistance to podfly is governed by the two recessive genes. In the podborer screening for antixenosis was carried out through the dual-choice arena test. The results indicated that a single dominant gene is involved in the antixenosis.

Key words *Cajanus cajan* · *C. scarabaeoides* · Podfly · Podborer · Interspecific cross

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millspaugh] is a major pulse crop of Asia and Africa. It constitutes an important source of dietary protein in vegetarian diet. The podfly, *Melanagromyza obtusa* Malloch, and the podborer, *Helicoverpa armigera* Hübner, are important insect pests of this crop. Ram Ujagir and Khare (1985) observed 86.2% yield losses when the pigeonpea crop was left unprotected against the podborer complex. The damage due to podfly was estimated to be as high as 60 and 63% in the Indian states of Bihar and Delhi (Ahmad 1938). However, limited success has so far been achieved in developing resistant cultivars against these insect pests. This is due to the difficulty in breeding and the lack of genetic variability within pigeonpea for this trait. *Cajanus scarabaeoides* is immune to podfly (Sithanantham et al. 1981; Saxena et al. 1990) and possesses both physical resistance and antibiosis to the podborer (Singh et al. 1990). However, the genetic basis of resistance against *M. obtusa* and *H. armigera* in the wild species has not been investigated. The present study was therefore undertaken out to clarify the inheritance of resistance to these insect pests.

Communicated by J. MacKey

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Materials and methods

This study was carried out in the rainy season (July to November) 1994 through to the spring of 1996. The experimental materials consisted of Pant A-3, the susceptible variety to *M. obtusa* and *H. armigera*, and *C. scarabaeoides* (JM 4147) which is a source of resistance to the podfly and the pod borer, together with their F_1, F_2 and backcross generations.

For screening against the pod fly, the experimental materials were sown on 11 March, 1996. The reproductive phase of the off-season crop coincided with the high pest population in April and more than 90% pod damage was observed in the Pant A-3 susceptible cultivar.

All the pods of individual plants were examined for the presence of the typical pin head exit hole, a marker of susceptibility, and the per cent pod damage by podfly at maturity was recorded. The test entries were then graded on a susceptibility rating scale of 1–9, where 1 = highly resistant ($<10\%$ pod damage) and 9 = highly susceptible ($>75\%$ pod damage). A rating scale from 1 to 5 was considered as resistant and from 7 to 9 as susceptible.

For screening against the podborer, the test entries were sown on December 19, 1995, in the glasshouse so that the reproductive phase (the susceptible stage) of the plant coincided with the maximum population of *H. armigera* during March, 1996.

The reaction of *Helicoverpa* on the parental lines in the field correlated with the leaf feed test in the laboratory. Therefore, a dual-choice arena test (Kogan and Goeden 1970) was conducted to assess the relative antixenosis mechanism of resistance in pigeonpea to *H. armigera*. Pant A-3 was used as the standard (susceptible check) for comparison in the feeding test. Leaves of similar age from the upper half of the stem portion (4th to 10th node from top) were used in all tests.

The feeding preference of larvae was conducted in 90×20 mm Petri-dish arenas. The bottom of each dish was covered with an 8-mm-thick of paraffin wax. A moist filter paper was kept over the wax layer. Three leaf squares (1.5×1.5 cm) were cut from the blades of freshly excised leaves of Pant A-3 and from the test plant and were held in position by placing a small piece of paper at the base of the leaf squares and piercing them with an insect collecting pin. These discs were positioned alternatively and equidistantly around the perimeter of the arena. The leaf squares were held 3 mm above the wax floor. Larvae (weight ranging between 210 and 290 mg and length between 2.0 and 2.4 cm) were collected form the chickpea field and starved for 24 h. Thereafter, in each dish three larvae were released for feeding in complete darkness. Feeding was terminated after 5 h and the outer edge of the leaf was then drawn on a graph paper to record the total leaf area eaten by the insect in the test entry and in the standard plant. Each treatment was replicated five times. The following formula was used in computing the preference index (C) for comparing the test plants with the standard plant (Kogan and Goeden 1970):

$$C = 2A/(M + A),$$

where A = feeding on the test plant and M = feeding on the standard plant.

Results and discussion

Podfly

The susceptible genotype, Pant A-3, exhibited pod damage ranging from 87.5 to 100% with an average of 94.7%. All the plants of Pant A-3 were in a rating score of 9, indicating a high pest population. *C. scarabaeoides*, as expected, showed negligible pod damage. Of the ten plants examined, nine were completely free and one plant showed 10% damage which revealed a very high level of resistance in this accession of the wild species against the podfly. The F_1 between Pant A-3 and *C. scarabaeoides* showed a relatively high level of pod damage ranging from 76.9 to 83.6% with a mean of 80.5%. All three F_1 plants were graded in class 9, which indicated the dominance of susceptibility over resistance. A total of 295 F_2 plants were studied and most of these plants were in the susceptible category. The per cent pod damage varied from 9.1 to 100% with an overall mean of 84.6%. None of the F_2 plants were as resistant as the resistant parent, while a large number of F_2 plants were as susceptible as the susceptible parent.

The F_2 plants segregated into 23 resistant and 272 susceptible which gave a good fit for a 1 (resistant): 15 (susceptible) ratio ($\chi^2 = 0.895$, $P = 0.50$–0.25). This indicated that resistance to podfly showed a digenic duplicate factor interaction in which resistance is governed by two recessive genes and susceptibility results when one or two dominant gene(s) in a homozygous or heterozygous condition are present. All the four BC_1F_1 ($F_1 \times$ Pant A-3) plants were classified as susceptible to podfly. This was expected with a digenic duplicate factor interaction governing resistance. The five BC_2F_1 ($F_1 \times$ *C. scarabaeoides*) plants gave a segregation pattern of 2 (resistant): 3 (susceptible) showing a good fit to a 1:3 ratio ($\chi^2 = 0.59$, $P = 0.90$–0.75) which also supports the hypothesis of a digenic duplicate factor interaction involved in the inheritance of resistance to podfly.

Podborer

The data obtained by the feeding test provided a comparison between the amount of feeding by larvae on a leaf square of *C. Cajan* cv Pant A-3 (standard plant) and a test plant. A preference index (C-value) was determined for a comparison of feeding on all test plants. The C-value obtained for *C. scarabaeoides* as a test entry was 0.260, indicating antixenosis (Kogan and Ortman 1978) of this wild species over the cultivated species (Pant A-3) which showed a mean C-value of 1.103 indicating a preference to the borer. The mean C-value of F_1 plants was 0.332 suggesting that the antixenosis mechanism of resistance was dominant. For classifying the segregating populations into resistant and susceptible categories it was necessary to identify a point of discrimination. The distribution of F_2 plants according to C-value was plotted (Fig. 1) and a C-value of 0.8 with the lowest peak of the curve in between the two parents was taken as a point of discrimination between the resistant and susceptible nature of the plant. Values lower than 0.8 considered as resistant while those above were classified as susceptible.

Out of the total 256 F_2 plants screened, 185 were rated as resistant and 71 as susceptible (Table 1). The data showed a good fit to a 3 (resistant): 1 (susceptible) ratio, $\chi^2 = 1.02$, $P = 0.50$–0.25), indicating that a single dominant gene is involved in antixenosis to *H. armigera*. The BC_1F_1 ($F_1 \times$ Pant A-3) generation segregated into 2 (resistant) and 2 (susceptible) plants with a good fit to a 1:1 ratio and, as expected, all the BC_2F_1 ($F_1 \times$ *C. scarabaeoides*) plants were resistant with a single dominant gene governing this character. The segregation pattern of the BC_1F_1 and BC_2F_1 generations confirmed the findings of the F_2.

This is the first study on the inheritance of antixenosis to *H. armigera* in a wide cross of pigeonpea. The pattern of segregation suggested that the antixenosis is controlled by single dominant gene which can be incorporated in the adapted cultivar by the simple backcross method of breeding.

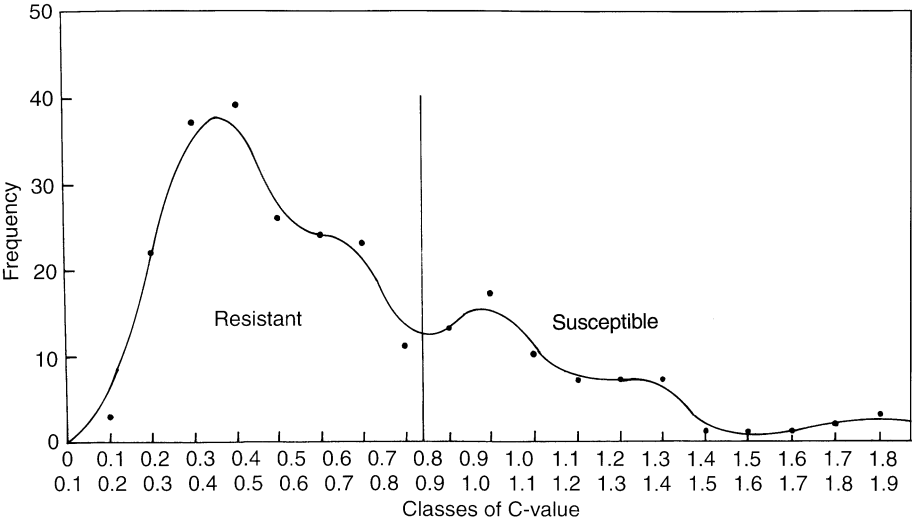

Fig. 1 Distribution of the F_2 population for the reaction to *H. armigera* based on the preference index

Table 1 Segregation for resistance to *H. armigera* in pigeonpea

Cross/generation	Observed segregation		Expected ratio	Chi-square	*P*-value
	Resistant	Susceptible			
Pant A-3	–	10	All susceptible	–	
C. scarabaeoides	10	–	All resistant	–	
Pant A-3 × *C. scarabaeoides* (F_1)	3	–	All resistant	–	
Pant A-3 × *C. scarabaeoides* (F_2)	185	71	3:1	1.02	0.50–0.25
F_1 × Pant A-3 (BC_1F_1)	2	2	1:1	–	
F_1 × *C. scarabaeoides* (BC_2F_1)	5	–	All resistant		

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