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GRAM POD BORER (*HELIOTHIS ARMIGERA*) (HUB.) RESISTANCE IN CHICKPEAS¹

S.S. LATEEF

Pulse Entomology, International Crops Research Institute for the Semi-Arid Tropics, ICRISAT Patancheru P.O., A.P. 502 324 (India)

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ABSTRACT

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Heliothis armigera (Hub.) is the major pest of chickpeas (*Cicer arietinum* L.) throughout the Old World. Since 1976, using an open-field screening technique at ICRISAT Centre in India > 12 000 germplasm accessions were screened, some of which were found to suffer considerably less pest damage than others. Subsequent tests confirmed a difference in susceptibility and found it to be the result of differences in oviposition and larval preference and retention on the plant. Cooperative studies with the Max-Planck Institute for Biochemistry at Munich have shown that the amount of acid exudate on the leaves appears to be a useful criterion for distinguishing relatively resistant, from susceptible, genotypes. ICRISAT plant breeders are presently attempting to intensify this resistance and to combine it with other useful factors, including resistance to *fusarium* wilt.

INTRODUCTION

Pulse crops (grain legumes) are the major source of protein for very many people in the developing nations, particularly where animal proteins are not commonly included in their diet. Whereas most of these crops are vulnerable to attack by several pests in the field and storage, chickpea (*Cicer arietinum* L.) has comparatively few insect pest problems.

Heliothis armigera (Hub.), *H. virescens* (FAB) and *H. virescens* (Hufnagel) are the most serious pests of chickpeas in most areas of the world, with *H. armigera* (Hub.) predominating on this crop throughout the Old World (Bhatnagar et al., 1982). The larvae feed voraciously on the crop from the seedling stage to maturity (Fig. 1). Surveys conducted by ICRISAT entomologists in India during the past 5 years have shown pod damage

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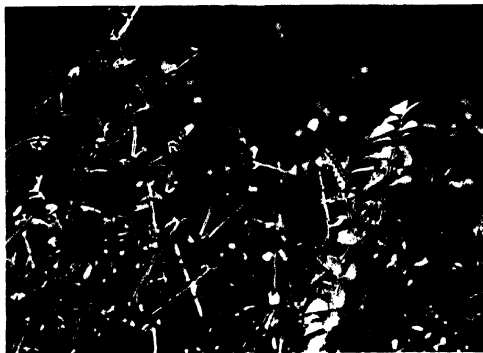


Fig. 1. *Heliothis armigera* damage to chickpea (*Cicer arietinum* L.) (top) plants; (bottom) pods.

ranging from 0 to 84.4% in different states, with an overall average of < 8% (Sithanatham et al., 1984). Undoubtedly, *H. armigera* is the most damaging pest of chickpeas in most areas and years. Although this pest can easily be controlled with suitable insecticides, < 20% of the farmers use these (Reed et al., 1980). In view of the known variation in susceptibility to *H. armigera* among chickpea cultivars (Singh and Sharma, 1970) an intensive pest resistance screening programme was initiated in 1976 at the ICRISAT Centre (Davies and Lateef, 1978; Rogers, 1982; Reed et al., 1983).

Absolute resistance to *Heliothis* has been difficult to obtain in other crops such as groundnut (Campbell et al., 1982), so emphasis has been placed on selecting for reduced susceptibility and greater yields at maturity, compared to the local standard checks, for advancing the material.

METHODS

An open-field screening technique, using natural populations of *H. armigera*, occasionally supplemented by laboratory-reared insects, was developed at ICRISAT Centre in India to identify sources of resistance to this polyphagous insect. The available germplasm of > 12 000 accessions was screened on unreplicated single row (1-m) plots. Many lines were rejected as being susceptible in these small-plot screening trials. The unreplicated tests were followed by a series of large plots (2–5 rows of 4 m), replicated trials, each containing the more promising lines within a particular, narrow maturity range, with standard checks of the appropriate maturity. At every step all those entries that yielded less and also suffered greater pest damage than the checks were rejected.

In this way we have identified lines with considerable and consistently reduced susceptibility to *H. armigera*. The most promising of these have been identified to breeders, who have been attempting to intensify borer resistance and to incorporate *Fusarium* wilt resistance.

In order to study the mechanisms of *H. armigera* resistance, field and laboratory tests have been conducted to record oviposition on, and larval preference for, the different genotypes. In the field, resistant and susceptible cultivars representing different maturity groups were grown on two rows of 4 m in 3 replicates — RBD trials under unsprayed situations. Eggs and larvae of *H. armigera* were recorded on 5 tagged plants at weekly intervals. For the laboratory tests a portion (ca. 15 cm) of twigs bearing flowers and green pods were collected from these test entries and oviposition preference studies were carried out with the laboratory-bred moths. Collaborating with the Max-Planck Institute for Biochemistry, Munich, the chemical basis of pest resistance was initiated by analysing the plant exudates collected from the resistant and susceptible cultivars.

RESULTS AND DISCUSSION

In the small-plot (one row of 1 m) unreplicated tests, the major problem was that the uneven distribution of *Heliothis* infestation in space and time allowed some chance escapes from pest damage to be recorded as resistant. For example, in 1976-77, 8629 germplasm lines were tested in unreplicated plots, of which 955 had no *H. armigera* damage. However, a significantly higher proportion of borer damage-free samples were recorded from the plots of two check cultivars, which had been planted between every 20

TABLE I

Screening chickpea germplasm for susceptibility to *H. armigera*. Plots found to be free from damage in harvested samples, ICRIAT Centre during 1976-77

	No. of entries harvested	No. without <i>H. armigera</i> damage	% without <i>H. armigera</i> damage
Germplasm lines	8629	955	11.1***
Check BEG-482	221	43	19.5*
Check C-235	219	61	27.9*

Differences significant at * $P < 0.05$; *** $P < 0.001$.



Fig. 2. A comparison of *H. armigera* resistant (cv. ICC-506) and susceptible (cv. An-nigeri) plants.

plots of germplasm (Table I). The genotypes that had little or no damage in these unreplicated tests were obviously escapes, some showed consistently reduced susceptibility when compared in the subsequent replicated trials.

The ability of some chickpea genotypes to compensate for early losses has also been found to be very marked, so that selections were made not only for resistance but also for tolerance or compensation, both of which would be expressed in the yields under pesticide-free conditions.

Resistant or tolerant lines of chickpea which gave a consistently good performance under unsprayed situations have now been identified (Fig. 2). The results from some of the most promising selections are shown in Table II.

TABLE II

Chickpea cultivars showing differences in their susceptibility to *H. armigera* at ICRISAT Centre, Patancheru, AP, India, in different trials and years

Cultivars	1979/80		1980/81		1981/82		1982/83		1983/84	
	PD%	RR	PD%	RR	PD%	RR	PD%	RR	PD%	RR
Desi — early maturity group:										
ICC-506	5.7	3	4.5	3	5.2	3	7.1	3	12.3	3
ICC-10619	5.0	3	5.2	3	7.5	3	21.0	4	11.1	4
ICC-6663	4.3	3	9.9	4	4.1	3	12.0	3	4.2	3
ICC-10667	5.6	3	5.9	3	8.1	4	14.2	3	2.6	2
ICC-10817	5.6	3	8.3	3	7.3	3	16.4	4	18.9	4
Annigeri (check)	15.8	6	20.0	6	15.4	6	29.3	6	29.4	6
IC-73266-3-4-1P (susceptible)	23.4	9	22.6	6	14.9	6	33.0	8	29.5	6
Desi — mid- and mid-late-maturity group:										
IC-738-8-1-1P-BP	5.7	3	7.3	3	4.9	3	23.4	5	11.4	3
IC-7341-12-1-B	11.3	5	13.0	4	7.6	4	21.1	4	3.9	3
IC-7394-18-2-1P- BP	8.0	4	17.8	5	8.8	5	19.1	4	12.4	5
IC-3137 (suscep- tible)	13.5	9	40.7	8	33.6	9	48.6	9	25.3	9
IC-7320-11-1- 1H-B	2.8	2	4.8	4	3.8	3	9.4	4	4.4	6
Kabuli — mid-late-maturity group:										
IC-10870	7.4	3	17.0	6	11.0	3	13.8	5	4.4	4
ICC-5264	12.0	6	7.4	4	9.5	3	7.5	3	2.5	3
ICC-8835 (sus- ceptible)	14.9	6	21.2	7	NR		19.1	6	26.7	9
L-550 (check)	12.1	6	18.1	6	39.4	6	13.8	6	15.4	6

PD% = Percentage of pods damaged by *H. armigera*; RR = Relative resistance rating 1-9 : 1 = resistant, 9 = susceptible (Lateef and Reed, 1983); NR = not recorded.

TABLE III

Differences in oviposition by *H. armigera* moths and larval retention on some chickpea cultivars, shown as means of 3 replicates, in weekly counts during 1982-83

Cultivars	9 counts (weekly)	
	Eggs on 5 plants	Larvae on 5 plants
Early flowering		
ICC-506	38	58
Annigeri (check)	64	103
Mid-flowering		
ICC-10619	57	99
ICC-3137 (susceptible)	77	202
Late flowering		
ICC-7320-11-1	36	112
ICC-5264-E9	53	132
ICC-8836 (borer susceptible)	57	147
SE of mean	12.7	15.3

The susceptibility of the cultivar to attack by *H. armigera* was found to be the result of differences in oviposition (oviposition preference) and in larval preference and retention on plants. Some movement of III and IV instar larvae between plants and from plot to plot was observed, especially from the resistant to the susceptible plants, which was attributed to unfavourable or repellent characters of the resistant plants. The results of one such study on some of these selections are presented in Table III.

Some aspects of the various mechanisms of resistance in this crop were studied. The foliage, stems and pods of chickpea have a dense cover of glandular hairs which exude a very acidic liquid. This exudate, which has a pH of approximately 1.3 a high content of malic acid, was thought to be a major factor limiting the range of pests which attack this crop. With the help and cooperation of the Max-Planck Institute for Biochemistry at Munich, the composition of the exudate collected from chickpea cultivars having different susceptibilities was analysed. It was found that differences between cultivars in the level of malic acid, a major component of this exudate, could be used as an index of susceptibility of a cultivar to attack by *H. armigera*. A higher level of malic acid was detected from resistant cultivars compared to the susceptible ones (Rembold, 1981; Rembold and Winter, 1982).

Most of the lines having resistance to *Heliothis* are highly susceptible to wilt caused by *Fusarium oxysporum* f. sp. *ciceri*. This wilt is widespread in chickpea-growing areas but particularly common in central and peninsular India, where *Heliothis* causes most damage. A programme to breed for lines having a combined resistance to both *Heliothis* with *Fusarium* wilt has been initiated. This would provide an extremely useful cultivar for subsistence farmers in the semi-arid tropics, who are unable to afford chemical control measures.

CONCLUSION

In the semi-arid tropics the most appropriate means of reducing the losses caused by *Heliothis armigera* in chickpea was to breed for some form of resistance, tolerance or compensatory ability. Accordingly, material from extensive germplasm collections, breeders' crosses and disease resistant materials were screened in the open field trials for resistance or tolerance to this pest. The results have been encouraging and cultivars have been selected which either suffer much less damage, or whose ability to compensate for losses and recovery is rapid enough to produce worthwhile crops in the presence of this pest. A high malic acid content of leaf exudates was found to be associated with resistance to *H. armigera*.

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