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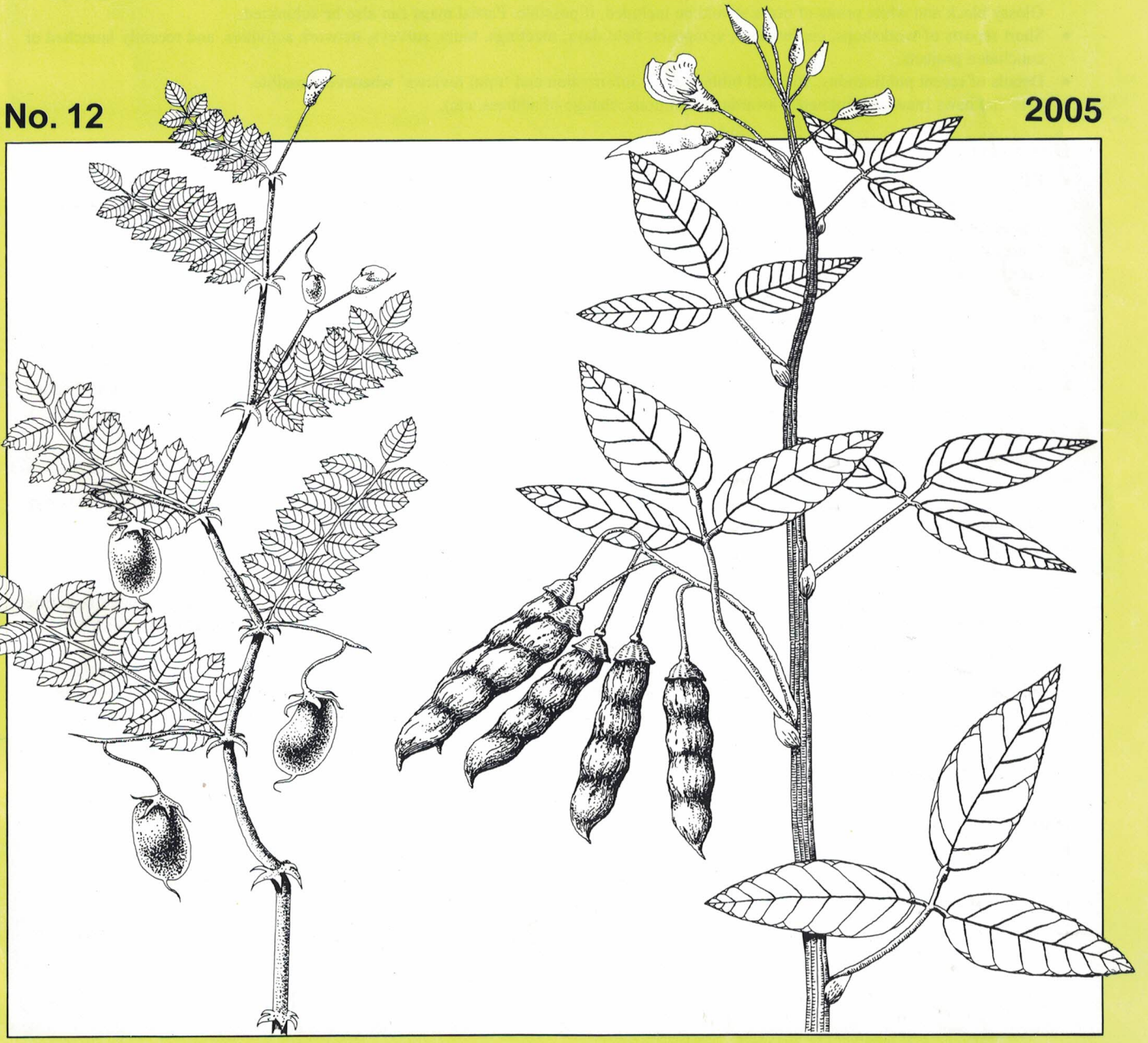

Table 1. Distribution of chickpea lines obtained from various sources in the disease reaction groups.

Source	Total	Resistant	Moderately resistant	Susceptible
ICARDA, Aleppo, Syria	164	3*	11**	150
NARC, Islamabad, Pakistan	132	-	-	132
NIAB, Faisalabad, Pakistan	99	-	-	99
AZRI, Bhakkar, Pakistan	90	-	-	90
RARI, Bahawalpur, Pakistan	10	-	-	10
Total	495	3	11	481

* 2–3 score on 1–9 rating scale.
** 4–5 score on 1–9 rating scale.

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Entomology

First-instar *Helicoverpa punctigera* larvae: feeding responses and survival on desi chickpea and the wild relative *Cicer bijugum*

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Lepidopterous pod borers in the genus *Helicoverpa* are major constraints to chickpea (*Cicer arietinum*) production in the Indian subcontinent [especially *H. armigera* (Hubner)], Australia [especially *H. punctigera* (Wallengren)], and in many other parts of the world (Lateef 1985; Clement et al. 2000). Conventional insecticides are often used to control pod borers on chickpea and many other crops. However, intensive insecticide use on a wide variety of crops has led to widespread development of insecticide-resistant populations of *H. armigera* in India (Armes et al. 1996). Development of insect resistance to insecticides and the possible adverse effects of insecticides on humans and environment have stimulated interest in other methods such as resistant genotypes to manage pod borers (Lateef 1985). Screenings of *Cicer arietinum* germplasm stocks showed that *H. armigera* larvae reared on 'less susceptible' genotypes were lighter in weight and took longer to develop than those reared on 'more susceptible' genotypes (Srivastava and Srivastava 1989; Yoshida et al.

1995). Likewise, Sharma et al. (2002) recorded low weights for larvae of *H. armigera* and *H. punctigera* reared on some wild annual *Cicer* species, indicating that wild relatives of chickpea could be sources of resistance to *Helicoverpa*.

Although detailed observations of neonate lepidopteran larvae commencing their feeding on test plants have been used for evaluating resistance in crop plants (Zalucki et al. 2002). This approach has not been used to identify *Cicer* genotypes with varying levels of resistance and susceptibility to *H. punctigera*. Previously, ≥ 5 day trials, albeit without detailed observations of the host acceptance and feeding behavior of first-instar larvae, have been used to identify *Cicer* genotypes with varying levels of susceptibility to both *H. armigera* and *H. punctigera*. We employed 48 h trials to observe and quantify the onset of feeding and survival of neonate *H. punctigera* on *Cicer* genotypes to assess the usefulness of short-term trials so as to identify resistant germplasm and possible mechanisms of resistance (antibiosis and anti-feedant effects) in this pest.

The trials were carried out at the Entomology Laboratory, Commonwealth Scientific and Industrial Research Organization (CSIRO), Centre for Mediterranean Agricultural Research, Western Australia. A *H. punctigera* culture at the Entomology Laboratory provided larvae for experiments, and the experimental plant material was obtained from potted plants grown in a glasshouse (natural light, 15 to 26°C). Neonate larvae were exposed to test material from pre-flowering plants of two *C. arietinum* genotypes (Annigeri-susceptible; and ICC 506-resistant) and two accessions of annual wild species of *C. bijugum* (ILWC 260, ILWC 7, both resistant), which exhibited a range of susceptibility to *H. armigera* and *H. punctigera* in ≥ 5 day trials (Sharma et al. 2002, Ridsdill-Smith TJ unpublished data). Test material consisted of a main stem (with two branching stems and leaves) embedded into water-agar (10 g Bacto agar/l water) in a 35 ml plastic cup using forceps. There were three trials, each involving two *Cicer* genotype or species combinations (Table 1). The experimental design was a completely randomized design with three replicates per

Table 1. Comparison of feeding and mortality rates of first-instar larvae of *Helicoverpa punctigera* on selected *Cicer arietinum* (Annigeri and ICC 506) and *C. bijugum* (ILWC 7and ILWC 260) genotypes (Perth, Australia).

		% larvae feeding at[1]				
Trial	Genotypes	1 h	4 h	24 h	48 h	% mortality at 48 h[2]
1.	Annigeri	61.1	94.3	94.3	94.3	5.6a
	ICC 506	39.0	78.0	83.3	83.3	16.7a
	ANOVA		F	*P*		
	Genotype (G)		2.78	0.17		
	Time (T)		19.48	<0.01		
	G x T		0.40	0.76		
2.	ILWC 7	27.7	66.7	100.0	94.3	5.6a
	ICC 506	44.3	66.7	78.0	66.7	33.3b
	ANOVA		F	*P*		
	Genotype (G)		1.15	0.34		
	Time (T)		42.11	<0.01		
	G x T		8.11	<0.01		
3.	ILWC 260	66.7	94.3	88.7	77.7	22.2a
	ICC 506	44.3	72.3	78.0	78.0	22.2a
	ANOVA		F	*P*		
	Genotype (G)		2.86	0.17		
	Time (T)		15.96	<0.01		
	G x T		2.72	0.09		

1. Means are based on three replications of 6 larvae per replication.
2. Means followed by the same letters do not differ significantly ($P = 0.05$). Data transformed ($\log_{10}(x + 1)$) to meet assumptions of ANOVA. Untransformed means reported here.

Cicer genotype. One potted plant provided all of the test material for a replication, which consisted of six larvae (one per plastic cup). After a 2 h starvation period, a neonate larva was transferred with a camel-hair brush to the basal part of test plant material and its movements were observed with the aid of a stereoscopic microscope for 2 minutes at 1, 4, 24 and 48 h intervals. At each reading, we recorded if a larva had established a feeding site and was feeding or if it had not commenced feeding. The number of dead larvae was also recorded. Cups were randomly distributed on a laboratory (≈ 22°C) bench near a window for natural light and redistributed after each reading. From these observations, the percentage of larvae feeding on the plant per replication was calculated.

The analysis of variance [completely randomized design with one-way treatment structure (genotypes) with repeated measures] showed that larval feeding rates were not affected by genotype, but time significantly affected feeding with the lowest rates at 1 h and higher rates (irrespective of plant genotype) recorded from 4 h onwards in all trials. There was a significant genotype x time interaction in trial 2, indicating that the effect of time on feeding rates on ILWC 7 and ICC 506 was different. In all trials, the onset of feeding by neonate *H. punctigera* larvae was consistently delayed on ICC 506 and larval mortality was relatively high (16.7–33.3%) on this *desi* chickpea (Table 1). The leaf chemistry of this genotype may influence the feeding and survival of neonate and first-instar *H. punctigera*, as was suggested for *H. armigera* (Lateef 1985; Yoshida et al. 1995). Also, the results of trial 1 confirmed the susceptibility of Annigeri to *H. punctigera.* Contrary to Sharma et al. (2002), who detected *H. punctigera* resistance in ILWC 7 and ILWC 260 after 5 day feeding assays, our 48 h trials did not reveal the existence of strong resistance (compared to ICC 506) in the *C. bijugum* genotypes (Table 1).

This study detected *H. punctigera* resistance and susceptibility in ICC 506 and Annigeri, respectively, but failed to confirm resistance in *C. bijugum* as previously found after 5-day feeding trials (Sharma et al. 2002). More investigations are required, because this study shows that interactions between first-instar larvae of *H. punctigera* and species and genotypes of *Cicer* are variable, with the possibility that different plant resistance factors are involved.

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Screening of Chickpea for Resistance to Pod Borer *Helicoverpa armigera* (Hubner) at Rahuri, Maharashtra, India

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Gram pod borer, *Helicoverpa armigera* (Hubner) is a key pest and with its regular occurrence in the state of Maharashtra from early vegetative to podding stage causing 60–80% losses (Puri et al. 1998) in chickpea. It is economically significant. In North India, Sehgal and