Reprinted from

PLANT PROTECTION IN FIELD CROPS

(Lead papers of the National Seminar on Plant Protection in Field Crops, 29-31 January, 1986, CPPTI, Hyderabad)

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January 1987

INSECT PESTS OF PIGEONPEA AND CHICKPEA AND THEIR MANAGEMENT

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1. INTRODUCTION

Pigeonpea (*Cajanus cajan* (L.) Millsp.) and chickpea (*Cicer arietinum* L.) are the two major pusle crops in India, accounting for about 90 and 80 percent respectively of the world production. During 1983-84, the area grown to these two crops was about 3 and 7 million hectares, resulting in grain production of about 2 and 5 million tonnes.

Pigeonpea is sown in the rainy (*kharif*) season, mainly as an intercrop with sorghum, millet or cotton. The traditional cultivars mature in 5-9 months. Recently, sole cropping with short-duration varieties has increased especially in areas having supplemental irrigation, from which 2-3 harvests are possible in 8 months.

Chickpea is a crop of the postrainy (*rabi*) season, grown largely as a sole crop, but inter planting with crops such as safflower, mustard, linseed, barley, and wheat are also common. In peninsular India, *desi* (brown-seeded) short duration cultivars are grown that mature in 3-4 months. In central and northern India, longer duration cultivars, both desi and kabuli (white seeded), are grown and these crops mature in 5-7 months.

Nearly two hundred species of insects are known to infest pigeonpea, while the range of insect pests is very limited in chickpea. In the vegetative stage of these crops seedling mortality due to subterranean insects, defoliation by caterpillar pests and sap feeding especially by aphids may occur, but all these are of limited or occasional importance. In some areas of northern India, aphids (mainly *Aphis craccivora* Koch) become important in some seasons as vectors of the bean leaf roll virus causing stunt disease in chickpea. Much of the insect damage in these crops, however, occurs in the reproductive phase. Pod borers are important in both the crops, while podfly, plume moth and pod bug occur in damaging severities on pigeonpea in some regions and seasons. A list of the commonly occurring insect pests on these two crops is furnished in Table 1.

2. EXTENT OF LOSSES CAUSED AND ECONOMIC THRESHOLDS

In pulse crops, it is particularly difficult to estimate pest-caused losses because these crops have good ability to compensate for pest damage, even when it occurs in the podding stage (Reed, 1983). Pigeonpea and chickpea can withstand defoliation (up to 50 and 60 percent respectively) whithout appreciable effect on grain yield.

2.1 Surveys in farmers' fields

One of the major means of loss estimation has been to survey for pod damage in farmers' fields and to derive the extent of seed loss. Percent pod damage by pod borers may generally approximate the percent yield loss, while for pests like podfly which tend to attack only 1-2 seeds per pod, the extent of loss may be half or less the percent pod damage. A summary of the farmers' field surveys made in different regions of India for pod damage in these two crops is furnished in Table 2. In pigeonpea, lepidopteran borers are found to be the major sources of loss in the southern and central states, while podfly causes higher losses in some northern states. In chickpea, the pod borer is the major cause of loss and is important in all the three regions.

2.2. Avoidable loss

The extent of loss due to pests is also assessed by comparing the yields in plots protected from pests by insecticides with those without such protection. These estimates are availabe largely from research stations in well maintained plots. Further, the number of applications and coverage of insecticides as well as the cultivar used tend to confound these estimates, besides variations across seasons. In chickpea, the range in avoidable loss across locations is from 9 to 60 percent (Sithanantham *et al.*, 1983).

2.3 Economic thresholds

Very little information is available on economic thresholds, probably because not much insecticide has been used on these crops. Further, this is a complex aspect in pulses as the crop cultivars tend to differently compensate for insect damage. In chickpea, defoliation up to 50% in the vegetative stage has no affect on yield, while complete defoliation may result in only a small reduction in yield. Studies by pulse scientists at Jabalpur and Pantnagar have shown that 1 to 10 *Heliothis* larvae per meter row cause about 5 to 10 percent loss in yield (Sithanantham *et al.*, 1983). In pigeonpea, even such data are not available, except that Pawar (1986) has adopted an arbitrary threshold of 10 eggs or 3-5 small larvae/plant in farmers' field trials in Andhra Pradesh and found this to be satisfactory for spraying decisions.

3. BIOLOGY AND ECOLOGY OF MAJOR INSECT PESTS

The biology and ecology of major insect pests on the two crops are detailed in some of the recent reviews (Davies and Lateef, 1975, 1978; Saxena, 1978; Reed *et al.*, in press). The pod borer, *Holiothis armigera* constitutes the most important pest in both the crops. In pigeonpea, the podfly, *Melanagromyza obtusa*, is probably next in importance. The plume moth, *Exelastis atomosa* and the pod bugs, *Clavigralla* spp. can be considered important in some seasons and regions.

3.1 Pod Borer, *Heliothis armigera*

This insect is highly polyphagous and is known to infest 181 species of host plants belonging to 45 families in India (Manjunath *et al.*, in press). Several generations are completed in a year and the pattern of seasonal shift between different crop/weed hosts including these two pulse crops is described by Bhatnagar *et al.* (1982). On pigeonpea, early infestation commences soon after flowering while in chickpea, in southern

India, the insect attacks the crop from the vegetative stage. The eggs are pearly white and laid usually on flowers and pods but also on foliage in chickpea and these hatch in 3-5 days. The young larvae drill into the buds/flowers in pigeonpea while they feed on the foliage in chickpea. The larval stage passes through 4-6 instars and the larval duration extends from about 3 weeks to two months or more, depending on temperature and food quality. There is considerable color variation in the grown up larvae - dark green, light green, yellow, brown and even dark gray. The color of larvae may be governed by genetic and/or environmental factors. In these two crops the larvae with colors contrasting from the canopy are easily removed by bird predators, which results in more brown larvae on pigeonpea and green larvae on chickpea. Pupation takes place in the soil. The pupal period ranges from 8 to 20 days and pupal diapause is occasionally observed. The adults live for about a week, when they mate and females deposit from about 200 to 1500 eggs.

3.2 **Podfly,** *Melangromyza obtusa*

This insect is more important in central and northern India, on the commonly grown late maturity pigeonpea cultivars. The insect can breed throughout the year if pigeonpea pods are available. The generation time may range normally between 25 and 40 days depending on the climate and 2-3 generations may be completed on pigeonpea. Offseason survival is not clearly understood, but wild legumes seem to offer a possible source for breeding.

The adult female inserts the egg singly into the lumen of very young pods. The egg period lasts 2-4 days and the freshly hatched larva drills into the young developing seed. The larva grows by feeding on the developing seed. Larval growth is complete in 10-20 days and it pupates in the tunnels in the seed or inside the locule outside the seed. Before pupation, the larva cuts a circular window on the podwall, leaving a thin, papery outer layer intact for protection. The pupal stage lasts 8-20 days and the adult emerges from the pod through the window. The adult is small shining and metallic blue/black in colour. Mating takes place in the early hours and oviposition takes place largely in the morning. Adults visit the flowers often, probably for feeding on the nectar and live for 3-8 days; each female lays about 30 eggs. Bindra and Singh (1972) have summarised the available information on biology and ecology of this pest.

3.3 **Plume moth,** *Exelastis atomosa*

The plume moth is more common on medium to mid-long duration genotypes grown in southern and central India, the infestation being most common during November-January. The adult is a small, brown coloured moth with fringed, plume-like wings. The offseason survival has not been adequately studied. About 6 generations may be completed from November to April.

Eggs are small, round and laid singly on buds, flowers and pods. The eggs hatch in 2-6 days. The larvae are green to yellowish and finally turn brown in about 9-15 days. There is a short prepupal period (1-2 days) prior to the pupal period of about

3-7 days. The adults mate a day after emergence and the female lays about 50 eggs during the span of about 4-7 days. The biology, ecology and control of this pest were studied by Thakur (1964)

3.4 Pod bugs, *Clavigralla* spp.

Two species of this coreid bug, *C. horrens* Dohrn and *C. gibbosa* Spin. are commonly found on pigeonpea from November to the end of April. There is much overlapping of generations and probably six generations are completed by the end of April.

Brown eggs are laid in clusters of 3 to 15, occasionally singly, mainly on pods. On an average, 60 eggs are laid per female, over a fortnight, but this period may extend to five months. The eggs hatch in 3-20 days. The nymphs take from one to three weeks to reach the adult stage. The duration of egg, nymph and adult stages is extended at lower temperatures. These bugs also attack lablab and cowpea. The mode of off-season survival is not known. Details of the bioecology of *C. gibbosa* were described by Bindra and Singh (1971).

4. COMPONENTS OF PEST MANAGEMENT

4.1 Pest Resistant Varieties

This is perhaps the most promising means of insect pest management in these pulse crops, since it does not require any cash investment or skill in use by the farmers. Considerable research progress has been made in this aspect during the last decade in India. Based on extensive screening of the germplasm accessions at ICRISAT and in the national program, several promising selections have been made for resistance to the pod borer (*H. armigera*) in both the crops and to the podfly (*M. obtusa*) in pigeonpea. Some of these selections are now being used by plant breeders for incorporating resistance into locally adapted varieties while others are being tested in research stations/farmers' fields (Table 3).

A common limitation is that most of the pest resistant selections are not high yielding. Further, the majority of the pod borer resistant lines are susceptible to *Fusarium* wilt, while podfly resistant selections tend to be small - seeded. So, these cannot be directly used for cultivation. Breeding efforts are under way to combine traits such as high yield, tolerance to wilt and larger seed size with the pest resistance. Several high yielding and/or wilt resistant lines with resistance to borer are in different stages of development in both these crops (Lateef *et al.*, 1986a, b).

4.2 Use of Varietal Phenology/Growth Habit

Selection of chickpea varieties that set most pods during Dec-Feb., when the cold winter suppresses pod borer activity, is likely to help avoid the pest attack severity in northern Indian conditions (Yadava *et al.*, 1983). In pigeonpea, determinate genotypes are known to suffer less damage by podfly, while indeterminate types are less prone to pod borer attack. The respective plant types, with moderate to high yield, may help in minimising the severity of attack by the concerned major pest (Lal *et al.*, 1986.).

4.3 Insecticide Use

Several insecticides have been found effective against the major pests and a list of these is furnished in Table 4. Insecticides effective against *H. armigera* are mostly useful in controlling other lepidopteran borers like *Exelastis, Maruca, Lampides* and *Autographa*. Where lepidopteran borers as well as podfly are to be controlled, monocrotophos may be preferable. Good control of pod sucking bugs (*Clavigralla*) is possible with dusts of contact insecticides or by spraying systemic ones. In areas prone to termite damage, as for chickpea in parts of Haryana, seed treatment with aldrin 30% EC at 10 ml or 5% dust at 5 g per kg of seed is advocated; where presowing soil application, is required, aldrin 5% dust at about 40 kg/ha may be adopted. Occasional problems of cutworms on chickpea can be countered by soil application of endosulfan, or aldrin dusts and with poisoned bran baits. Aphid incidence, if severe, can be checked with sprays of systemic insecticides.

The extent to which the recommended insecticides are adopted by farmers makes interesting study. The recommendations are mostly based on trials at research stations, where better management of the crops results in good yields and one or two applications of the insecticide can give ecomonic returns. However, the farmers' crops tend to yield much less and the economics of investment on the costly insecticides differs. Reed *et al.* (1981a) have analysed this problem indicating that only about 5% of the pigeonpea farmers in India applied pesticides and of these most used were DDT/BHC as wettalbe powder or dust formulations, although endosulfan had been recommended for more than a decade, mainly because the latter is costly.

Tests of neem products, such as kernel extract/leaf extract/oilcake suspension, have shown promise against *Heliothis* on both the crops. However, their adoption becomes a problem since motivation and coordination in ensuring local availability of the materials require considerable extension efforts.

The chitin inhibitor, diflubenzuron has been tested alone and in combination with *Heliothis* virus (NPV) against *H. armigera* on chickpea, but the results were not encouraging.

Large quantities of water are required for insecticide spraying and are difficult to obtain in the dry areas. Although dust applications are easier, it may be difficult to ensure good coverage with these, especially in pigeonpea which often grows tall enough to render coverage difficult. Ultra low volume(ULV)spraying using devices like the Controlled Droplet Applicator (CDA) may be useful, not only in eliminating the need for large quantities of water but also in the ease of application and in quicker coverage, especially on pigeonpea (Pawar, 1986). Locally manufactured CDA sprayers are available and many types of assemblies to suit manual and bullock drawn application are being developed at ICRISAT. But, the two major limitations of ULV spraying are the risk for the operator because of the highly concentrated poison being sprayed, and the drift problems if wind speeds are high.

4.4 Biolgical Control

In India, much of the research on natural enemies of pests in these crops has been focussed on *H. armigera*. A comprehensive list of natural enemies recorded on this pest in India has been provided by Manjunath *et al.* (in press). A list of commonly occuring natural enemies of *H. armigera* along with those on other insect pests found on pigeonpea and chickpea is furnished in Table 5.

Among the natural enemies of *H. armigera*, the egg parasitoids *Trichogramma* spp. which can be cheaply produced, apparently avoid these crops and hence may not useful (Bhatnagar *et al.*, 1981). Among the larval parasitoids, *Campoletis chlorideae* (Ichneumonid) and *Carcelia illota* (Tachinid) are very common, but these cannot be economically mass bred for augmentation. Attempts to release an exotic Tachinid larval parasitoid, *Eucelatoria bryani* in pigeonpea and chickpea fields for five seasons at ICRISAT did not result in establishment. Several arthropod predators including spiders and *Chrysopa* spp. have been observed to feed on eggs and early stage larvae of *Heliothis.* Although mass production of *Chrysopa* is possible, it may not be economical. Further, the efficacy of field release of *Chrysopa* sp. has not been assessed on these crops. Birds are also a common group of predators, feeding mainly on large *Heliothis* larvae.

Field applications of the nuclear polyhedrosis virus (NPV) have been demonstrated to be effective against young larvae of *Heliothis* on chickpea (Narayanan, 1980) and on pigeonpea (Sithanantham, 1986). Recently, *Bacillus thuringiensis* has also been found effective against young *Heliothis* larvae (K. Narayanan, personal communication). These pathogens hold considerable scope for field application in India, but the Government clearance for their mass production and use in India is not yet available.

Although parasitoids have also been recorded from podfly and other pests on these crops, none of these seem to be useful for augmentative biocontrol.

4.5 Cultural Practices

In general, cultural practices do not offer much scope in pest control on these crops. The potential for intercrops to reduce pest damage has been studied to some extent. On chickpea, *Heliothis* damage tends to be reduced if there are non-legume intercrops such as mustard, linseed or wheat. In pigeonpea, however, the traditionally intercropped cereals sorghum/millet did not appear to affect the extent of damage by pod-infesting insects (Bhatnagar and Davies, 1979).

The scope for altering the seed rate (plant density) has been assessed extensively at ICRISAT. There appeared to be no advantage with enhanced seed rate as there was no benefical effect on yield and the number of *Heliothis* larvae per unit area tend to increase with plant density.

The adjustment of sowing date seems to offer very little scope in these crops since soil moisture status will largely determine the optimum timing for crop emergence and yield. Most often, the timing of sowing which can result in least pod damage in these crops, does not coincide with that required for optimum grain production or pod set.

5. INTEGRATION AND ADOPTION OF PEST MANAGEMENT PRACTICES BY FARMERS

The problems and prospects of pest management on these crops have been reviewed (Reed *et al.* 1980; 1981a b; Sithanantham, 1985).

5.1 Need based insecticide application

Promoting scouting for assesing the *Heliothis* infestation level and relating it to locally developed action thresholds before deciding to apply insecticides would be useful. This practice would be particularly important in southern India where the attack by this pest is often serious enough to warrant insecticide use.

5.2 Choice of selective insecticides

Among the range of contact insecticides that are available, it may be useful to choose insecticides such as endosulfan or phosalone, as they are less detrimental to some of the natural enemies of the pests.

5.3 Use of bioagent along with insecticide

If *Heliothis* virus (NPV) is permitted for large scale use, combining it with low doses of insecticides would not only reduce costs, but also reduce the insecticide load on these crops and the disturbances to natural enemies could thereby be reduced.

5.4 Problems of adoption by farmers

The adoption of sound pest management practices on these crops calls for considerable extension effort, not only to demonstrate the economic worth, but also to ensure that the required inputs as well as the back up advice are available. Conducting demonstration trials on need based use of insecticides, as well as training programs on scouting for judging the pest severity become important. Researchers have to consider the socioeconomic constraints to adoption of the promising tactics. It is gratifying that we have started looking into this aspect of adoption in India recently.

6. GENERAL GUIDELINES/PRACTICES SUGGESTED FOR PEST MANAGEMENT

Since the extent of loss caused by pests on these crops is often highly variable across regions and seasons, it is only possible to list out guidelines, based on which the practices can be chosen or modified to suit local needs. These are summarised below:

6.1 Selection of cultivars

It is better to select pest resistant cultivars. These are not currently ready for farmers' use, but many are likely to become available in the near future. Wherever possible, farmers in the locality should be encouraged to use cultivars of same maturity, so to restrict the breeding and shifting of pests.

6.2 Agricultural practices

In chickpea, it would be useful to adopt mixed cropping with wheat, lentil or mustard, wherever possible, so to reduce pest damage. In both the crops, synchronous sowing in the locality can cause benefit by diluting the pest attack.

6.3 Insecticide use

In both the crops, vegetative stage does not require insecticide use except against occasional problems of termites, cutworms and aphids mainly on chickpea. From flowering onwards, it would be useful to regularly inspect the crop, so to ensure timely applit cation of insectiticides. Choice of insecticide should be such as to be effective agains, the pests concerned. In pigeonpea, endosulfan is preferable if pod borers are dominant-while dimethoate is better when podfly is dominant; monocrotophos seems useful if both these pests are important. Endosulfan and phosalone are likely to be less detrimental to beneficial insects and may be selected wherever suitable. Use of labour and time saving appliances like CDA would enable easy coverage; however, the operator has to be very careful so to avoid hazards in handling such concentrated poisons. Dilution, dose rate and coverage should be controlled so to obtain a proper control of the pests.

6.4 Biological control

No bioagent is available for such use at present but *Heliothis* virus (NPV) is likely to be useful, in combination with insecticides. The commercial use of virus is not yet approved by the Government of India.

6.5 Pheromone traps

Heliothis pheromone traps are commercially available and may be used, as a means of indicating impending oviposition peaks, so to be prepared for insecticide use in time.

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Table 1. Common insect pests of pigeonpea and chickpea in India.

Common Name	Secientific name	Plant part damaged*	Season of common occurence	Pest status	Importance in different states/Other remarks
1. Pests of Pigeonpea					
Pod borer	*Heliothis armigera*	F,P,S	Sep-Mar	Major	All (more in South India)
Podfly	*Melanagromyza obtusa*	S	Sep-Mar	Major	All (more in North India)
Pod bug	*Clavigralla* spp.	S	Oct-Mar	Major	All (more in Central India)
Plume moth	*Exelastis atomosa*	P,S	Nov-Mar	Major	—Do—
Legume pod borer	*Maruca testulalis*	F.P.S	Aug-Nov	Minor (sometimes major)	In short duration cultivars
Blister beetles	*Mylabris* spp.	F,P	—Do—	—Do—	—Do—
Blue butterfly	*Lampides boeticus*	F,P	Sep-Feb	—Do—	In medium/ late maturity cultivars
Bud weevil	*Ceuthorrhynchus asperulus*	B,F	—Do—	—Do—	—Do—
Seed weevil	*Apion benignum*	P,S	Nov-Apr	—Do—	In Eastern India
Pod wasp	*Tanaostigmodes cajani*	P,S	—Do—	Minor	AP, Karnataka, Maharashtra
Leaf tier	*Cydia critica*	L,F,P	—Do—	—Do—	All states
Leaf hoppers	*Empoasca* spp.	F	Sep-Jan	Minor	North western region
Bruchids	*Callosobruchus* spp.	P,S	Nov-Apr	Minor	Mainly in South India
2. Pests of Chickpea					
Pod borer	*Heliothis armigera*	L,F,P,S	Nov-Apr	Major	All (more in South India)
Semilooper	*Autographa nigrisigna*	—Do—	—Do—	Minor	Mostly in north India
Cutworms	*Agrotis* spp.	L,St	Nov-Jan	Minor	In limited pockets
Termites	*Odontotermes* spp.	R	—Do—	—Do—	Limited in north western region
Aphid	*Aphis carccivora*	St, F, P	Nov-Apr	—Do—	Vector in north India

* R = Root; St. = Stem; L = Leaf; B = Bud; F = Flower; P = Pod; S = Seed.

Table 2: Extent of pod damage due to pests on pigeonpea and chickpea.

Crop	Pest (s)	% pod damage *		
		Southern states	Central states	Northern states
Pigeonpea (a)	Lepidopteran borers **	34.1	30.0	12.6
	Podfly	9.0	24.8	19.1
	Tanaostigmodes	2.1	3.0	0.1
	Bruchid	7.2	3.6	0.3
Chickpea (b)	Pod borer	5.6	10.9	6.7
	Birds ***	0.03	0.47	0.56

* For estimating grain loss percent, the % pod damage (×) in pigeonpea may be convierted as × × 0.7 for lepidopteran borers, X × 0.3 for podfly and bruchid and X × 0.5 for *Tanaostigmodes*, assuming the ratio for pod: grain damage by the concerned pests. In chickpea, Pod damage % may be taken as grain loss percent.

** Mostly *H. armigera* plus *E. atomosa*, *L. boeticus*, *C. critica* and *M. testulalis*.

*** Mainly parakeets and mynahs.

(a) Reed *et al.* (1980); (b) Sithanantham *et al.* (1983)

Table 3. Promising pest resistant selections of pigeonpea and chickpea.

Selection	Maturity group*	Level of resist-ance**	Other major chara-cters ***	Status of uti-lisat-ion ****	Ref.
1. Pigeonpea					
Podfly (*M. obtusa*)					
ICP 909-EB	EM	MR	BR, PFR HY	A, B	ICRISAT (1985)
ICP 10531-E1	M	R	PFR	A	Lateef et. al. (1986a)
CIP 6977-E1	M	R	PFR	A	,,
ICP 7941-E1	M	R	PFR	A,C	,,
ICP 7946-E1	ML	R	PFR	A,C	,,
ICP 7194-1-S4*	ML	R	PFR	A,C	ICRISAT (1985)
ICP 8102-5-S1*	L	MR	BR, PFR SMR	A,B,C,	,,
ICP 7176-5	L	R	PFR	A,C	,,
Pod borer (*H. armigera*)					
ICPL 2*	E	R	BR	A,C	ICRISAT (1986)
ICPL 269	E	R	BR	A.C	,,
ICPL 288	E	MR	BR	A,C	,,
PPE 45-2	EM	R	BR, HY	A,B,C,	Lateef et al. (1986a)
ICPL 84060	EM	R	BR, HY	A,B,C,	Lateef et al. (1986b)
ICPL 332 (ICP 1903)	M	R	BR, HY	A,B C	Lateef et al. (1986a)
ICP 3328-E3	M	MR	BR, HY	A,B	ICRISAT (1985)
ICP× 77303	M	R	BR, HY	A,C	,,
ICP 10466	M	R	BR	A,B,C	Lateef et al. (1986a)
2. Chickpea					
Pod borer (*H. armigera*)					
ICC 506	E	R	BR, HY	A,C	Lateef (1985)
ICCP 10619	E	R	BR, HY	A,C	,,
ICC 6663	E	R	BR	A,C	,,
ICC 10667	E	R	BR	A,C	,,
ICC 10817	E	R	BR, MWR	A,B.C	,,
ICCV 7 (ICCX 730008-8-1-1P-BP)	M	R	BR	A,B,C	,,
ICCX 730041-8-1-B	M	R	BR	A,C	,,
ICCX 730094-18-2-1P-BP	M	R	BR	A,C	,,
ICCX 730020-11-1-1H-B	L	R	BR, WR	A,B,C	,,
ICC 10870	ML	R	BR	A,C	,,
ICC 5264-E10	ML	R	BR	A,C	ICRISAT (1985)
ICC 10234	L	R	BR	A,C	,,

* E = Early; M = Mid; L = Late.

** R = Resistant; MR = Moderately resistant.

*** HY = High yield; WR = Wilt resistant; BR = Borer resistant; PFR = Podfly resistant; BS = Borer susceptible; SMR = Sterility mosaic resistant.

**** A = Used as resistance source in breeding;
B = Under testing in farmers' field;
C = Under multilocation testing by entomologists in India and elsewhere.

Table 4. List of commonly recommended insecticides for controlling the major pests on pigeonpea and chickpea.

	Insecticide	Formulation (a.i.%)	Concentration (a.i.%)	Dosage (a.i./ha)
1.	**Pigeonepa and chickpea pod**			
	BHC	Dust (10%)	—	2.0 kg
	Carbaryl	Dust (5%)	—	1.0 kg
	Cypermethrin	EC (25%)	0.006%	—
	Dimethoate	EC (30%)	0.04%	—
	Endosulfan	Dust (4%)		0.8 kg
		EC (35%)	0.07%	0.7 kg
	Fenvalerate	EC (20%)	0.02%	—
	Malathion	Dust (5%)	—	1.0 kg
	Monocrotophos	EC (40%)	0.04%	0.4 kg
	Parathion	Dust (2%)	—	0.4 kg
	Quinalphos	Dust (1.5%)	—	0.3 kg
		EC (25%)	0.05%	
2.	**Pigeonpea podfly**			
	Dimethoate	EC (30%)	0.04%	0.4 kg
	Monocrotophos	EC (40%)	0.04%	0.4 kg

Table 5. List of commonly occurring natural enemies on pests of pigeonpea and chickpea in India.

Natural enemy	Family	Average (%) mortality caused	Period of activity
	1. Heliothis armigera		
Egg predator :			
Chrysopa sp.	Chrysopidae	10	Nov-Feb
Larval parasitoids :			
Campoletis chlorideae Uchida	Ichneumonidae	10	Sep-Feb
Enicospilus sp. nr. *zyzzus* Chiu	,,	2	Jan-Mar
Eriborus argenteopilosus Cam.	,,	3	Oct-Jan
Carcelia illota Curran	Tachinidae	15	Nov-Mar
Goniophthalmus halli Mesnil	,,	10	Oct-Jan
Larval predators			
Delta spp	Eumenidae	5	Oct-Jan
Polistes olivaceus De Geer	Vespidae	2	Oct-Jan

Clubiona sp.	Clubionidae	—	Oct-Feb
Thomisus sp.	Thomisidae	—	Oct-Feb
Neoscona theis	Araenidae	—	Oct-Feb
Larval pathogen :			
Nuclear polyhedrosis virus	—	5	Oct-Jan
2. Melanagromyza obtusa			
Larval parasitoids :			
Euderus sp.	Eulophidae	10	Nov-Apr
Ormyrus sp.	Ormyridae	15	Nov-Apr
3. Exelastis atomosa			
Larval parasitoids:			
Apanteles paludicolae Cam.	Braconidae	10	Oct-Jan
Tropimeris monodon Boucek	Chalcididae	5	Jan-Mar
4. Clavigralla spp.			
Egg parasitoid :			
Gryon antestiae (Dodd)	Scelionidae	30	Aug-Mar
5. Maruca testulais			
Larval parasitoid:			
Phanerotoma hendecasisella Cam.	Braconidae	10	Aug-Jan
6. Lampides boeticus			
Larval parasitoid:			
Hesperencyrtus lycaeniphila (Risbec)	Encyrtidae	20	Jan-Mar
7. Cydia critica			
Larval parasitoids:			
P.hendecasisella	Braconidae	15	Jun-Dec
Apanteles spp.	Braconidae	15	Aug-Nov
Goniozus indicus Ashm.	Bethylidae	5	Nov-Jan
8. Tanaostigmodes cajaninae			
Larval parasitoid:			
Paraholaspis sp.	Torymidae	10	Nov-Feb