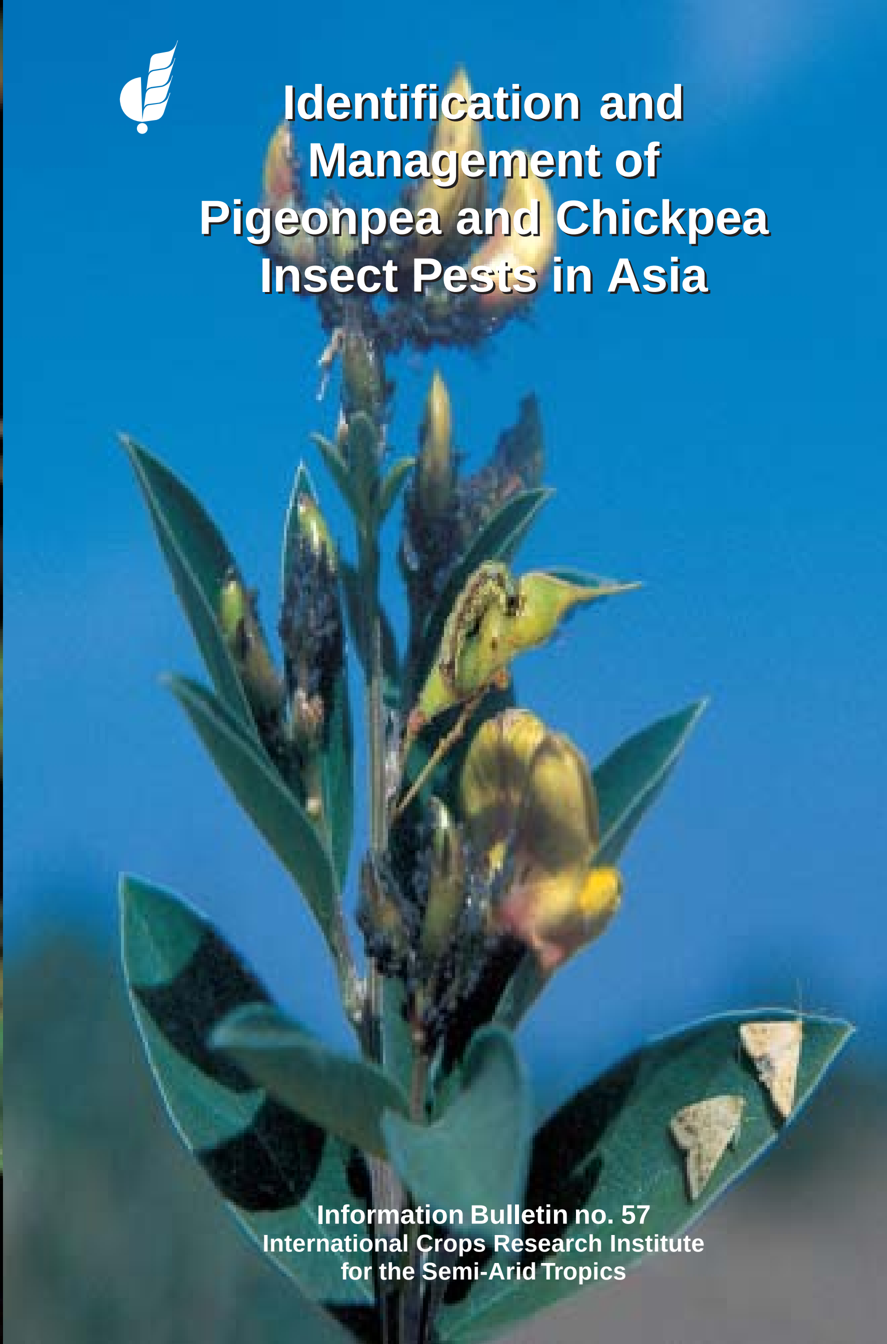
Identification and Management of Pigeonpea and Chickpea Insect Pests in Asia



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Abstract

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Pigeonpea (*Cajanus cajan* (L.) Millspaugh) and chickpea (*Cicer arietinum* L.) are important grain legumes in Asia. These crops are often heavily damaged by insect pests. Farmers in many areas apply insecticides in an attempt to manage these pests. This bulletin provides descriptions of the most common species, their biology, distribution, and damage symptoms. Color photographs are provided for easy identification. Possible modes of control are also included with an emphasis on integrated pest management and reduced reliance on insecticides.

Résumé

L'identification et la lutte contre les insectes ravageurs du pois d'Angole et du pois chiche en Asie. Le pois d'Angole (*Cajanus cajan* (L.) Millspaugh) et le pois chiche (*Cicer arietinum* L.) sont des légumineuses à grain importantes de l'Asie. Souvent, ces cultures subissent des dégâts importants causés par les insectes ravageurs. Dans beaucoup de régions, les paysans ont recours à l'application d'insecticides afin d'essayer de lutter contre ces ravageurs. Ce bulletin offre de courtes descriptions des espèces les plus importantes, leur biologie, distribution, et symptômes de dégâts. Des photographies en couleur permettent l'identification facile des insectes. L'ouvrage comprend également des stratégies de lutte qui mettent l'accent sur la lutte intégrée ainsi que sur la dépendance réduite des insecticides.

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Author’s note

Insects feed and live in every conceivable niche of pigeonpea and chickpea plants. Foliage, buds, flowers, pods, stems, roots, and even root nodules are eaten by one or more insect species. Fortunately not all insects are pests, even most pest species do not cause serious economic damage every year. In addition to feeding on different plant parts, the various pests of pigeonpea and chickpea use different feeding methods. Some pierce the plant and feed on the sap, while others chew on buds, flowers, and pods. Some of the pests that feed on plant juices carry pathogens such as viruses. These pests may cause greater damage by transmitting a disease than by feeding *per se* on the crop. This handbook is designed to assist agricultural scientists, extension workers, and students in the preliminary field diagnosis of common and important insect pests of pigeonpea and chickpea. One or more photos of each pest, including the stage responsible for damaging pigeonpea or chickpea, have been included to assist identification.

This handbook is divided into four sections:

- Insects attacking vegetative plant parts
- Insects attacking reproductive structures
- Insect pests of stored seed
- Integrated pest management (IPM)

The first three sections describe and illustrate the major insect pests attacking these two crops. The primary focus of this handbook, however, is the fourth section. It defines IPM and describes various strategies to manage these pests using effective, safe, and environmentally identifying effective alternatives to insecticides over the past 10 years. These alternatives are discussed in the final section.

Introduction

Pigeonpea

Background. Pigeonpea (*Cajanus cajan* (L) Millspaugh) is one of the most important grain legume crops of tropical and subtropical environments. Cultivated on almost 4 million hectares worldwide, it provides farmers with grain, fodder, and fuel wood. Though the bulk of the crop is produced in South Asia, it is also widely grown in Africa and parts of Latin America. Pigeonpea is an erect, woody, perennial shrub commonly grown as an annual. Its importance to semi-arid cropping systems is due to its efficient nitrogen-fixing ability, tolerance to drought, and contribution to soil organic matter. Seeds contain high quality dietary protein and are consumed in several ways. Pigeonpea seed is eaten fresh (green) primarily in Africa and the Caribbean, and dried, split, and dehulled (dhal) in South Asia.

Agronomy. Pigeonpea is usually grown as an intercrop, in combination with one or more shorter duration crops (Fig.1). Common intercrops include sorghum, millet, maize, cotton, soybean, groundnut, cowpea, urd bean, and mung bean. Pigeonpea grows slowly during the early vegetative stage and does not interfere with the companion crops. After harvest of the companion crop, pigeonpea plants continue to grow and may completely fill the canopy giving the appearance of a sole crop.

Traditional pigeonpea genotypes are tall growing up to 2 m high, and mature in 6 to 12 months. These crops are generally too tall and dense for the safe and effective application of insecticides. In the past ten years many short-stature (less than 1 m), short-duration (maturing in less than 100 days) genotypes have been developed and released (Fig. 2). These genotypes are generally more productive as high-density monocrops than as components of an intercropped system. Choice of genotype and cropping system has an influence on the composition and density of pests. For more details, see Section IV: on Integrated Pest Management.

Pests. More than 200 species of insects live and feed on pigeonpea, though relatively few cause heavy annual yield losses. The few serious pests however, can be devastating. For example, pigeonpea losses worldwide due to *Helicoverpa armigera* alone are estimated at more than US$ 310 million annually. Most of the pests have a sporadic or restricted distribution, or are seldom present at high densities. Pests that feed on reproductive structures, flowers, and pods, cause the greatest harm. Foliar damage rarely spurs seed yield reductions.

Figure 1. A pigeonpea/soybean intercrop

Figure 2. Short-duration pigeonpea

Chickpea

Background. Chickpea (*Cicer arietinum* L.) is grown on more than 9 million hectares worldwide and is the third most important pulse crop after dry beans, and peas. It is widely grown as an annual crop in South and West Asia, and in North Africa (Fig. 3). Smaller areas of chickpeas are also grown in Europe, Americas, and Australia. Although consumed predominantly as a whole, dry seed, chickpea flour is also used in preparing a variety of snacks, sweets, and condiments. Fresh, green chickpeas are commonly harvested shortly before maturity and consumed raw or roasted. Chickpea is relatively free from various anti-nutritional factors such as protease inhibitors and polyphenols, and has high protein and fiber content which improves digestibility. Compared to other pulses, chickpea has more phosphorus and calcium. Chickpea straw is also valued as a livestock feed.

Agronomy. Chickpea is often grown under harsh climatic conditions. It is well adapted to low moisture situations such as the postrainy season in South Asia. Grown at this time, the crop is also exposed to low temperatures in some locations. Chickpea is often grown as a sole crop but may be intercropped with other cool-season, drought-tolerant crops. Two types of chickpea are commonly recognized. The ‘kabuli’ type has large white seeds and is a popular food in many countries, especially in the Mediterranean area.‘Desi’-type chickpeas are generally smaller, have colored seeds (yellow, brown, green, or black), and are more common on the Indian subcontinent and in Mexico.

Pests. Relatively few insect pests attack chickpea compared to other legumes. This is probably because it is a cool-season crop and also because of the dense glandular trichomes found on all of its green tissues. The glandular trichomes (Fig.4) excrete an acidic substance comprised mainly of malic and oxalic acids, which deter many potential herbivores.

In West Asia, the leaf miner *Liriomyza cicerina* and pod-boring *Helicoverpa* spp are the principal pests of chickpea, while in

South Asia *H. armigera* is the dominant field pest. Worldwide losses due to the *Helicoverpa* spp in chickpea have been estimated at US$ 330 million annually. Among the two chickpea types, kabuli genotypes are generally more susceptible to insect pests than desi-types.

Figure 3. Chickpea plant, *Cicer arietinum* L.

Figure 4. Chickpea foliage with glandular trichomes

Insects attacking vegetative parts

Jassids or leaf hoppers in pigeonpea

Empoasca kerri Pruthi
(Homoptera: Cicadellidae)

Distribution. In most areas where pigeonpea is grown, jassids are found feeding on this crop. They are not easy to identify, frequently requiring the assistance of specialists. In India, *Empoasca kerri* is the species most commonly reported from pigeonpea and other legumes.

Symptoms. Leaflets damaged by jassids are cup-shaped and have yellow edges and tips (Fig. 5). Seedlings that have sustained considerable feeding by jassids may be stunted and have red-brown leaflets followed by defoliation.

History. These small green insects 2.5 mm long, suck sap from both the upper and lower surface of the leaflets. The adults (Fig. 6) fly when disturbed. The nymphs and adults have a similar shape and color, but the nymphs do not have wings and run sideways when disturbed. Eggs are laid along veins on the underside of leaflets. One generation requires 2 weeks under optimum conditions.

Control. Jassids are usually a minor pest of pigeonpea. They can become a serious threat if the seedling stage is heavily infested. Under these conditions, application of any contact or systemic insecticide is adequate restraint.

Figure 5. Jassid-damaged leaves

Figure 6. *Empoasca kerri* adult

Aphids

Aphis craccivora Koch in pigeonpea and chickpea
Aphis fabae Scopoli in pigeonpea
Myzus persicae (Sulzer) in pigeonpea
Macrosiphum spp in pigeonpea
Acrythosiphon pisum (Harris) in chickpea
(Homoptera: Aphididae)

Distribution. Several species of aphids have been reported in pigeonpea and chickpea, among which *A. craccivora* is the most prevalent. This species is widely distributed and has a broad host range.

Symptoms. Aphids colonize the young shoots, flowers, and pods of both crops (Figs. 7-8). Young leaves of seedlings become twisted under heavy infestation. Seedlings may wilt, particularly under moisture-stressed conditions. However, a more notable issue in chickpea is stunt disease, caused by the bean leaf-roll virus transmitted by these aphids. Stunt disease limits plant growth, rendering leaflets small, and reddish brown (yellow in kabuli-types) (Fig. 9). Scraping the lower part of the stem reveals brown phloem, a characteristic of the disease.

History. *A. craccivora* is common in a number of leguminous crops. The adults are black and shiny, up to 2 mm long and some are winged. The nymphs are similar to the adults but smaller. This species can reproduce without mating in Asia creating one generation in a week under optimum conditions. Individual adults can produce about 100 nymphs over a lifespan of up to 30 days.

Control. The winged adults that land on chickpea may be deterred and fly off, or be killed by the acid exudates on leaves and pods. Chickpea genotypes with little or no exudates maintain the largest colonies. Aphids are seldom key economic pests for either pigeonpea or chickpea crops. Natural enemies and abiotic factors generally keep aphid populations in check. Both general predators, such as coccinellids (Fig. 10), and specific parasitoids, such as the *Aphytis* spp inflict heavy mortality on aphid colonies. Among abiotic factors, rain and wind can dramatically reduce aphid infestations.

Figure 7. *A. craccivora* in pigeonpea

Figure 8. *A. craccivora* in chickpea

Figure 9. Chickpea stunt disease

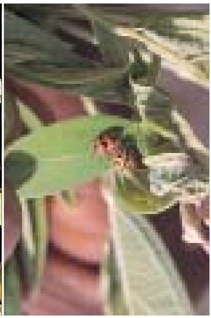

Figure 10. Ladybird beetles attacking aphids

Mites in pigeonpea

Aceria cajani Channabasavanna Eriophyid mite
(Acarina: Eriophyidae)
Schizotetranychus cajani Gupta Red spider mite
Tetranychus spp Red spider mite
(Acarina: Tetranychidae)

Distribution. These mites are widespread and common in pigeonpea throughout South Asia. Both eriophyid and spider mites are generally found on the lower leaf surface. The eriophyid mite, *A. cajani,* is the vector of the pigeonpea sterility mosaic disease, the most serious viral disease of this crop.

Symptoms. Plants infected with sterility mosaic disease develop light green, chlorotic foliage. Leaves have a mosaic pattern (Fig. 11), and early infection results in reproductively sterile plants. Spider mites cause yellow or white spots on the upper surface of the infested leaflets (Fig.12). Heavy infestation results in bronzing of the leaves, followed by defoliation.

History. The eriophyid mite (Fig. 13) is about 0.2 mm long and difficult to see without magnification (10 x or more). They are light-colored, long and spindle-shaped, and deposit their eggs on young foliage. In contrast, spider mites are larger at 0.5 mm, oval-shaped, and dark-colored (Fig. 14). Both groups of mites can complete a generation in less than two weeks under optimum conditions. Dispersal is either a direct plant-to-plant or wind-aided.

Control. In general, mite attack by itself does not pose an economic problem in Asia. However, the transmission of sterility mosaic disease by mites can cause significant yield reductions. The selective use of resistant cultivars is the most effective solution. Rain can also substantially reduce mite populations.

Attack by red spider mites may become severe in pigeonpea plants grown in greenhouses as the intensive chemical spraying eradicates diseases that red spider mites would otherwise succumb to. A number of generalist predators such as spiders and coccinellids that feed on mites keep their population under control. Several *Tetranychus* spp have developed high levels of resistance to one or more pesticides, hence caution is advised in their use as a preventive step against further mite outbreaks.

Figure 11. Symptoms of sterility mosaic disease in pigeonpea plant

Figure 12. Pigeonpea leaves damaged by red spider mites

Figure 13. Close up of eriophyid mite *Aceria cajani*

Figure 14. Close up of red spider mite *Schizotetranychus cajani*

Leaf-damaging weevils in pigeonpea

Myllocerus undecimpustulatus Faust
Phyllobius spp
(Coleoptera: Curculionidae)

Distribution. *Myllocerus* spp and *Phyllobius* spp are widespread in Asia in pigeonpea and several other host plants.

Symptoms. Adult weevils chew the leaflets, generally at the margins, giving them a ragged appearance (Fig.15). Grubs live in the soil, where they feed mainly on roots. Pupation also occurs in the soil.

History. The adult *M. undecimpustulatus* is 5 mm long with 11 black dots on its ash-grey body (Fig.16), and hence commonly called “ash weevil”. Grubs are white, legless, and stout-bodied. The biology of these species is not fully known.

Control. Though common, the damage caused by adults and grubs is not significant enough to merit separate control measures.

Figure 15. Pigeonpea leaf damaged by *Myllocerus* spp

Figure 16. *Myllocerus undecimpustulatus* adult

Lepidopteran defoliators of pigeonpea

Amsacta albistriga **Walker and** ***A. morri*** **Butler**
Spilosoma (Diacrisia) obliqua (Walker)
(Lepidoptera: Arctiidae)
Euproctis subnotata (scintillans) walker
(Lepidoptera: Lymantridae)

Distribution. Larvae of a number of widely distributed, polyphagous Lepidopterans feed on pigeonpea leaves. Three of the most dominant are listed above. The damage caused by them is similar and distinct.

Symptoms. *Amsacta albistriga* and *spilosoma obliqua* are the two most common of several species of “hairy caterpillars” that attack pigeonpea during the vegetative phase (Figs.17 and 18). *Euproctis. subnotata*, the so-called ‘tussock caterpillars’, also attack pigeonpea (Fig.19).

History. The *Amsacta* spp has one generation per year in India while *S. obliqua* and *E. subnotata* have multiple generations in a year each with a generation time of 30-40 days. Larvae of *Amsacta* spp. and *S. obliqua* are up to 50 mm long with reddish-brown hairs. In contrast, those of *E. subnotata* are smaller, up to 25 mm long, darker, and less hairy. They are easily identified by the prominent, dense tuft of hair on the back of the head. The larval period for these three species is about a month and they pupate in the soil.

Control. These species rarely cause serious economic damage, however there are occasional reports of severe defoliation, particularly by the *Amsacta* spp.

Figure 17. *Amsacta albistriga* adult and larva

Figure 18. *Spilosoma obliqua* adult and larva

Figure 19. *Euproctis subnotata* adult and larvae

Leaf webber in pigeonpea

Grapholita (Cydia) critica Meyr.
(Lepidoptera: Tortricidae)

Distribution. *Grapholita critica* (= *Eucosma = cydia critica*) is commonly found in pigeonpea throughout South Asia.

Symptoms. Larvae produce silk and use it to hold leaflets together. They feed from inside a web of leaflets, flowers, and pods (Fig. 20). When infestation includes the terminal bud, further growth of that shoot may be severely impaired. Infestations may begin as early as the seedling stage and continue through to the flowering and podding stages. Though primarily a foliage feeder, *G. critica* may also attack reproductive structures, especially when infestation occurs late in the development of the crop (Fig. 21). In such cases, the leaf webber also behaves as a pod borer.

History. *G. critica* is an inconspicuous, brown moth with a wingspan of 10-15 mm (Fig. 22). Eggs are normally laid in clusters of about ten, on buds and young leaves.The cream-yellow larva reaches a length of about 10 mm before pupating within the webbed plant material. It takes 3-4 weeks for a full life cycle under optimum conditions.

Control. The leaf webber damage is very conspicuous, causing farmers anxiety about possible yield losses. Although leaf-webber infestation being highly visible may induce the use of chemical pesticides, its impact on yield is usually negligible. In fact, plants may produce side branches to compensate for the loss of terminal buds. A large number of parasites and predators are also associated with this pest. Inappropriate use of chemical pesticides may have a negative impact on the natural enemies that attack major pigeonpea pest and little effect on well-protected, leaf webber larvae housed in the webbed leaves.

Figure 20. *Grapholita critica* larva in webbed leaves

Figure 21. Pigeonpea flower bud damaged by *G. critica larva*

Figure 22. *G. critica* moth

Soil beetles in pigeonpea and chickpea

Gonocephalum spp False wireworms
(Coleoptera: Tenebrionidae)

Distribution. Several species of false wireworms are widespread in Asia. These insects attack a number of cereal and legume crops in addition to pigeonpea and chickpea.

Symptoms. Adults feed on seedlings at ground level, killing the plants, and reducing crop stand. Plants that survive will often fill in the open spaces to compensate for low levels of damage.

History. The adult insect is a dull black in color, about 10 mm long and 5 mm wide (Fig. 23) beetle. In recent years, sporadic but severe seedling mortality in chickpea in southern India has been reported. Details of the biology of these species is not available.

Control. Because little is known of these insects, it is not possible to prescribe specific management strategies. Close monitoring of their populations is recommended, especially in areas that typically suffer above-average levels of seedling mortality. Increased seeding rates to compensate for seedling mortality may minimize crop losses.

Figure 23. *Gonocephalum* spp adult damaging a chickpea seedling

Jewel beetle in pigeonpea

Sphenoptera indica Laporte & Gory
(Coleoptera : Buprestidae)

Distribution. The destruction caused by this insect though sporadic, is widespread in Asia. It is associated with several legumes including pigeonpea.

Symptoms. Larvae tunnel in the stem above and below ground. A prominent gall may form around the stem at ground level (Fig. 24), and may be mistaken for similar galls associated with other insects, including weevil larvae. Wilting and death may occur when young plants are attacked, but older plants may survive with little reduction in yields.

History. Adults are dark, shiny beetles about 10mm long and 3 mm wide. Eggs are laid singly on stems, at the soil surface. On hatching, grubs bore into the stem. A fully grown larva is 25 mm long with a conspicuous, globular head (Fig. 25). Pupation occurs in the tunnel in the root or stem. A generation takes about 6-8 weeks.

Control. Because of the infrequent occurrence of this pest and its delayed infestation, it is difficult to recommend appropriate control strategies. Manual destruction of infested plant stems may help in reducing its population.

Figure 24. *Sphenoptera indica* damage to stem

Figure 25. Different life stages of *S. indica*

Cow bugs in pigeonpea

Otinotus oneratus W.
Oxyrachis tarandus F.
(Homoptera: Membracidae)

Distribution. These two species are widely distributed across South Asia, and feed on other legumes besides pigeonpea.

Symptoms. Nymphs and adults feed on tender shoots. These bugs are normally sporadic in occurrence and consequently of minor economic importance. However, their high visibility makes farmers over-react to infestations. Heavy infestations during early growth of the crop can result in stunting and reduced plant vigor. However, it is unlikely that cow bug damage adversely affects mature plants.

History. The dark brown-to-black adults measure approximately 7 mm in length, and have horn-like projections on the thorax. Eggs are laid in clusters of 15-20 on stems. Cow bugs excrete honeydew, a sugary substance that attracts ants (Fig. 26). The ants may protect the bugs from natural enemies, which would otherwise keep cow bug populations in check. To complete a cycle about a month is required under optimum conditions.

Control. Because cow bug attacks are sporadic and do not generally cause any economic damage, no specific management strategies are suggested.

Figure 26. Cow bug *Oxyrachis tarandus* adults and nymphs attended by ants

Scale insects in pigeonpea

Ceroplastodes cajani Maskell
Icerya purchasi Maskell
(Homoptera: Coccidae)

Distribution. Though a number of scale insects have been reported to feed on pigeonpea, the two listed above are the most common species in Asia.

Symptoms. Scale insects feed on the fluids in stems and occasionally, on leaves.

History. These insects are not major pests of the annual pigeonpea; perennial pigeonpea is more frequently attacked, as their populations need a number of seasons to build up. One generation can be completed in as little as 2-3 weeks. Young nymphs are mobile and can be dispersed by wind. Adult females do not disperse and are usually found in colonies (Fig. 27). Ants are attracted to the honeydew excretions of scale insects thus protecting the scale insect colony from natural enemies.

Control. Scale insects seldom reach population levels requiring control. There are several parasites and predators that keep scale insects in check. The abstinence of pesticides will allow these natural enemies to breed and multiply, keeping scale insect levels down.

Figure 27. Colony of scale insects *Ceroplastodes cajani* in pigeonpea

Cutworm in chickpea

Agrotis ipsilon (Hufnagel)
(Lepidoptera: Noctuidae)

Distribution. *Agrotis ipsilon* is widespread and feeds on many host plants throughout Asia.

Symptoms. Caterpillars cut seedling stems at ground level, killing the plant. Cutworm larvae are found in the soil or in leaf litter near damaged plants. Larvae feed on the foliage.

History. Adults are large moths 25 mm long with brown forewings and white hindwings (Fig. 28). A female can lay up to 1500 cream-colored eggs singly on plants or on the soil surface. The full-grown larva is up to 40 mm long and brown-black in color (Fig. 29). Larvae are nocturnal, residing in the soil during the day. Pupation takes place in the soil. Depending on favorable environmental conditions, a single generation can be completed in 4 to 5 weeks.

Control. Cutworms appear sporadically in chickpea crops, though they can reach damaging levels in some years or locations. Their populations may be overrun with parasites, prompting an awareness of natural enemies and their impact before implementation of other control strategies.

Figure 28. *Agrotis ipsilon* adult

Figure 29. Cutworm larva

Leafminers in chickpea

Liriomyza cicerina (Rondani)
Chromatomyia horticola *(*Goureau)
(Diptera: Agromyzidae)

Distribution. *Liriomyza cicerina* is an important insect pest of chickpea in West Asia. In India, *Chromatomyia horticola* reportedly attacks chickpea leaflets.

Symptoms. Larvae feed on the chlorophyllous tissue between the epidermal layers. The feeding damage produces plainly discernible pale, serpentine mines on the upper surface of the leaflet (Fig. 30). Heavy attacks can cause leaflets to drop.

History. Adult flies are dark and shiny, measuring about 1.5 mm in length. Females puncture the upper surface of the foliage to lay eggs and feed on plant juices exuding from the wound. Eggs hatch in approximately 4 days, and the yellow maggots begin feeding immediately. Larvae require about a week to develop, and measure about 3 mm in length when full-grown. Pupation occurs primarily in the soil but some pupae may be found in the leaflets. The egg-to-egg process requires 3 weeks.

Control. Heavy attacks by leafminers, which are more common in West Asia, can result in significant defoliation and yield loss. In South Asia leafminers generally do not cause any economic impact and hence need no control.

Figure 30. Damage caused by leafminers in chickpea

Armyworm in chickpea

Spodoptera exigua (Hubner)
(Lepidoptera: Noctuidae)

Distribution. *Spodoptera exigua* is a widely distributed, polyphagous pest throughout Asia.

Symptoms. The larvae feed mainly on leaflets and occasionally on pods. Heavy infestations at seedling stage can defoliate plants (Fig. 31).

History. The adults are medium-sized moths with a wingspan of about 25 mm. Forewings are brownish and hindwings, translucent (Fig. 32). Pale-white, oval eggs are laid on foliage of chickpea and nearby plants in batches of up to 150. Eggs hatch in 3 to 4 days, and the greenish larvae disperse to adjacent plants. The full-grown larva measures about 25 mm long (Fig. 33), and pupation occurs in the soil. This species can complete a generation in about 4 weeks depending on environmental conditions.

Control. Although this species may be common in chickpea crops in many parts of Asia, it seldom reaches population levels high enough to cause substantial yield reductions. This is because it has a large number of natural enemies, the species of which may vary from region to region.

Figure 31. *Spodoptera exigua* defoliation in chickpea seedling

Figure 32. *S. exigua* adult

Figure 33. *S. exigua* larva in chickpea

Insects attacking reproductive structures

Thrips in pigeonpea

Megalurothrips usitatus (Bagnall)
(Thysanoptera : Thripidae)

Distribution. Several genera and species of thrips attack pigeonpea flowers in Asia. The most common species is *Megalurothrips usitatus* (Fig. 34).

Symptoms. A large number of (up to 50) thrips may be present in each pigeonpea flower. This species also occurs in the flowers of a number of annual and perennial crops. Heavy thrip infestations may result in flower drop.

History. Adults are black and about 1 mm long. Both adults and nymphs feed on flowers. Minute eggs are laid in flowers and flower bud tissues. When flowers begin to senesce the thrips move to new flowers. A generation takes about 3 weeks.

Control. Populations of thrips can become quite large, though there is no evidence that thrips cause losses in yield. Pigeonpea plants produce more flowers than the plant can sustain, so many are lost naturally. No specific control measures are needed for the management of thrips.

Figure 34. *Megalurothrips usitatus* in flowers

Blister beetles in pigeonpea

Mylabris pustulata Thunberg
Mylabris thunbergii Billberg
Mylabris spp
(Coleoptera: Meloidae)

Distribution. Blister beetles are widespread in pigeonpea in Asia. In addition to pigeonpea, these insects feed on the floral parts of several other plants.

Symptoms. Adult beetles feed on flowers and tender pods, and may have a significant impact on yields, especially of short-duration genotypes.

History. *Mylabris pustulata* adults measure about 25 mm in length and have red and black alternating bands on the elytra (Fig. 35). Other species may vary in size but all are brightly colored. Eggs are usually laid in the soil and the diet of the larvae consists of other soil insects, including major pests. Thus, while the adults may cause considerable damage, the larvae are beneficial. The complete biology of these species is not documented.

Control. In locations where pigeonpea is a primary crop, the after effect of blister beetles is inconsequential because their numbers are diluted over a large area. Pigeonpea genotypes that flower early or crops cultivated on small holdings, may suffer substantial injury inflicted by these insects. Chemical control may fail because the beetles are large and robust, and highly mobile. Manual picking and destruction of adult blister beetles is often the only practical control measure (Fig. 36).

Figure 35. *Mylabris pustulata* adult

Figure 36. Hand picking of blister beetles

Pod-sucking bugs in pigeonpea

Clavigralla gibbosa Spinola
Clavigralla scutellaris (Westwood)
Anoplocnemis spp
Riptortus spp
(Hemiptera: Coreidae)
Nezara viridula (L.)
(Hemiptera: Pentatomidae)

Distribution. Several species and genera of pod-sucking bugs attack pigeonpea and other legumes in Asia. For pigeonpea, the most dangerous genera is the *Clavigralla*. *Nezara viridula*, the green stink bug, is found on many legumes and other hosts throughout the tropics and subtropics.

Symptoms. The adults and nymphs of all of these bugs use their piercing mouthparts to penetrate the pod wall and suck the liquid from developing seeds. Damaged seeds become shriveled, and develop dark patches (Fig. 37). The injury being similar to that of drought stress, and the impact of these pests has been underestimated in the past. Seeds spoiled by pod-sucking bugs neither germinate nor acceptable as human food.

Figure 37. Pigeonpea seed damaged by pod-sucking bugs

History. *Clavigralla* bugs are brown-gray with *C. scutellaris* being more robust than *C. gibbosa* (Fig. 38). In the field, *C. gibbosa* and *C. scuttelaris* are often mistaken for each other. The eggs of the two *Clavigralla* species however, are easily separated; those of *C. scutellaris* being smooth and shiny, and

Figure 38. *Clavigralla gibbosa* and *C. scutellaris* adults

not roughly sculptured like the *C. gibbosa's* (Fig.39). *C. gibbosa* generally lays clusters of 10-12 eggs compared to the 18-20 of *C. scutellaris's*.

Figure 39. Closeup of *C. scutellaris* and *C. gibbosa* eggs

Nezara viridula is 15 mm long, normally green (Fig. 40), but may also have some yellow coloration.

Figure 40. *Nezara viridula* adult and eggs

The adults of the *Anoplocnemis* spp vary in color from dark brown to black (Fig. 41) 30 mm, long and are the largest of these bugs.

Figure 41. *Anoplocnemis* sp adult

The *Riptortus* spp are 18 mm long, brown in color, and more slender than the other species (Fig. 42).

All of the pod-sucking bugs lay their eggs in clusters on leaves and pods. Most of these species require 4 to 5 weeks to complete one generation. Since adults live for more than 3 months, all the stages of its life cycle can be simultaneously observed in the field.

Control. Because pod-sucking bugs are highly mobile, insecticides may be inadequate in repressing the extent of their spread, especially in small fields. Natural enemies, in particular various species of egg parasitoids can cause high levels of bug mortality by the end of the season.

Figure 42. *Riptortus* adult

Pod borers in pigeonpea and chickpea

Helicoverpa (Heliothis) armigera (Hübner)
Helicoverpa assulta (Guenee)
Heliothis viriplaca (Hufnagel)
Heliothis peltigera (Denis & Schiffermuller)
(Lepidoptera: Noctuidae)

Distribution. *Helicoverpa armigera* is commonly found throughout the tropics and subtropics in Asia, and has an assortment of host plants. It is the single most important constraint to pigeonpea and chickpea production throughout much of South Asia. In addition to its wide distribution and host range, high levels of insecticide resistance make this species one of the most difficult pests to manage. In West Asia, *H. viriplaca* and *H. peltigera* are also found in chickpea, while *H. assulta* is occa- sionally reported in chickpea in India.

Symptoms. The *Helicoverpa* spp destroys buds, flowers, and pods on both crops. If flowers and pods are not available, larvae will feed upon foliage. Foliar damage is more common in chickpea than in pigeonpea. Larvae prefer to feed on the protein-rich seeds within the pods.

History. Adult *H. armigera* have a wingspan of about 40 mm with dull brown forewings (Fig. 43). A single female can lay up to

Figure 43. Male (left) and Female (right) moths of *Helicoverpa armigera*

2000 small white eggs, usually singly (Fig. 44). In pigeonpea, eggs are laid on flower buds and young pods while in chickpea, eggs are usually deposited on foliage (Fig. 45).

Figure 44. *H. armigera* eggs on pigeonpea flower buds

Figure 45. *H. armigera* eggs on chickpea leaves

Full-grown larvae are 30 to 40 mm long and may have various body color and banding patterns (Figs. 46-47). Pupation occurs in the soil or in plant debris. One generation takes 4 weeks under favorable conditions.

Control. *H. armigera* is one of the key pests of pigeonpea and chickpea and must be the focus of any pest management program. A full discussion of integrated pest management is provided in the last Section. Individual pest management measures for their eradication are listed below and further information is provided under the "Additional Reading" section at the end of this booklet.

Figure 46. *H. armigera* damaging pigeonpea leaves and pods

Figure 47. *H. armigera* feeding on chickpea leaves and pods

- **Cultivar adoption**

A number of pigeonpea and chickpea genotypes with resistance and/or tolerance to *H. armigera* have been developed. These genotypes, though effective, have not been adopted at large. The reasons include lack of seed, susceptibility to diseases, low yield quantity and/or quality, and less-preferred agronomic traits.

- **Natural enemies**

There reportedly exist a large number of natural enemies of *H. armigera*, though many are less effective in pigeonpea and chickpea than in other crops. Some success in restriction has been demonstrated by manipulating natural enemy populations, including vertebrate predators such as birds.

- **Crop management**

Cultural practices, including intercropping, time of sowing, spacing, water/nutrition management, and crop rotation may be effective in certain locations. It is difficult, to suggest general strategies irrespective of region.

Insecticides are the most commonly used restraint for this pest in pigeonpea and chickpea. Several insecticides, individually or in combination, have been successful in checking the pod borer.

- **Organic pesticides**

A fatal viral disease of *H. armigera* attributed to the nuclear polyhedrosis virus (HNPV), is currently being produced as a means of control. High quality HNPV properly produced and applied has yielded good results. Another alternative to synthetic pesticides is the use of naturally occurring plant-derivatives. These include extracts of neem seed kernel, tephrosia, tobacco, pongamia, chili/garlic, and others. Plant protection operations should be initiated in pigeonpea when one notices

- 1 small larva or 3 eggs per plant in short-duration

- 3 small larvae or 5 eggs per plant in medium-duration
- 5 small larvae or 10 eggs per plant in long-duration

For chickpea, plant protection operations should not begin until the flowering stage as plants generally compensate for any damage that occurs earlier. The recommended action threshold for *Helicoverpa* in chickpea is 2 small larvae per plant.

- Female moths can be deterred from ovipositing by the spraying of 5% neem kernel suspension.
- Applying HNPV at a rate of 500 larval equivalents (LE) per ha in pigeonpea, and 250 LE in chickpea at egg hatch is potent. This application can be repeated at 15-20 days intervals. To minimize UV effects on the virus, spray in the evening and mix 1 ml of a mild detergent for every liter of spray fluid.
- In cases of heavy infestation, physical shaking of pigeonpea plants to dislodge larvae is favored.
- Bird perches placed just above the crop canopy will also help to reduce the numbers of this pest.

Considering the frequent misuse of pesticides, and their secondary effects such as resistance, resurgence, and creation of secondary pests, synthetic insecticides should be used only as a last resort.

Semilooper in chickpea

Autographa nigrisigna (Walker)
(Lepidoptera: Noctuidae)

Distribution. Several semiloopers have been reported to feed on chickpea in Asia, but the most important, appears to be *Autographa nigrisigna.*

Symptoms. Larvae feed on leaflets and pods. Semiloopers produce ragged, irregular damage to the chickpea pod walls in contrast to the neat, round hole that *H. armigera* chews out (Fig. 48).

History. Adults have typically patterned forewings with a wingspan of 25 mm. Eggs are laid in clusters of up to 40 on foliage. The larvae are green and reach a length of 25 mm. (Fig. 49) Pupation occurs in the soil. A single generation lasts about 4-5 weeks.

Control. This species is only occasionally a pest in chickpea. The general management principles and tactics described for *H. armigera* may be effectively applied for *A. nigrisigna.*

Figure 48. Chickpea pods damaged by semilooper

Figure 49. *Autographa nigrisigna* larva

Blue butterflies in pigeonpea

Lampides boeticus **(**L.)
Catochrysops strabo (Fabricius)
(Lepidoptera: Lycaenidae)

Distribution. Both of these species are widely distributed in Asia. Larvae feed on pigeonpea, and on several other cultivated and wild legumes.

Symptoms. The larvae chew leaves, buds, flowers, and pods.

History. *Lampides boeticus* adults are slender, bluish-gray with a wingspan of 30 mm (Fig. 50). Pale blue eggs are laid singly on buds (Fig. 51). Larvae are about 12 mm long, green, oval, flat and slug-like (Fig. 52). In contrast to other lepidopterans on pigeonpea these caterpillars are relatively sedentary. Pupation occurs in the soil or in plant debris. Five weeks are required to complete one generation in field conditions.

Control. Although these butterflies are common and lay many eggs on pigeonpea plants, relatively few larvae are found on the crop, probably because natural enemies reduce their numbers. Specific control for these insects is rarely required but the general management recommendations for *H. armigera* may be used here.

Figure 50. *Lampides boeticus* adult


Figure 51. *L. boeticus* egg


Figure 52. *L. boeticus* larva

Legume (or cowpea) pod borer in pigeonpea

Maruca vitrata (= testulalis) (Geyer)
(Lepidoptera: Pyralidae)

Distribution. *Maruca vitrata* attacks several leguminous crops throughout Asia.

Symptoms. Larvae feed from inside a webbed mass of leaves, buds, and pods. This behaviour makes *Maruca* a foliage feeder and pod borer.

History. Adults have distinctive white bands on brown fore-wings with a wingspan of 20 mm (Fig. 53). Eggs are laid in small clusters of 10 to 15 on leaves, buds, and flowers. A full-grown larva measures 15 mm in length, with a pale body lined by rows of conspicuous black spots on its dorsal surface (Fig. 54). The spots may be absent or obscure at the prepupal stage. Pupation takes place in the web or on the soil surface in a silk cocoon. Under optimum conditions, a complete life cycle takes 3 weeks. *M.vitrata* becomes a menace in early-season pigeonpea especially in areas with high relative humidity.

Control. This is a leading pest of pigeonpea and other grain legumes in many areas of Asia. Indeterminate pigeonpea genotypes suffer less damage than the determinate-type. This difference in susceptibility among genotypes may be used to develop cultivars resistant to this insect. Relatively few natural enemies, and no egg parasitoids, have been reported to attack *M. vitrata*. Chemical control is complicated by the fact that larvae live in well-protected webs. Systemic pesticides may accomplish more restraint than contact insecticides.

Figure 53. *Maruca vitrata* adult

Figure 54. *M. vitrata* larva, webbed leaves, and flower buds

Plume moth in pigeonpea

Exelastis atomosa (Walsingham)
(Lepidoptera: Pterophoridae)

Distribution. This species is widely distributed on several legumes in Asia. It is common in pigeonpea and is a major pest in several areas of India.

Symptoms. Larvae feed on buds, flowers, and pods, resulting in reduced yields.

History. Adult plume moths measure 10 mm in length, and have fringed wings that are held perpendicular to the body at rest (Fig. 55). Eggs are laid singly on buds and pods. The full-grown larva is about 15 mm long, green, and has a spindle-shaped body covered with short spines. Pupation occurs in the foliage and the pupa is similar in looks to the larva, except that it is brown (Fig. 56). An egg-to-egg cycle can be accomplished in about 4 weeks. Plume moth caterpillars are more rampant during the postrainy season than during the rainy season.

Control. *Exelastis atomosa* can be quelled by the same insecticides, excluding HNPV, employed to suppress outbreaks of *H. armigera*.

Figure 55. *Exelastis atomosa* adult

Figure 56. *E. atomosa* larva (green) and pupa (brown)

Lima bean pod borer in pigeonpea

Etiella zinckenella Treitschke
(Lepidoptera: Pyralidae)

Distribution. This species is widely distributed on several legumes in Asia.

Symptoms. Larvae are generally found infesting maturing and dried pods. Lima bean pod borer populations build up by the end of the pigeonpea season, when the temperature is high. The presence of dry, light-colored frass granules, and webbing in the pod is an indication of *Etiella* infestation.

History. Adults are small, brown moths with a wingspan of about 20 mm (Fig. 57). Eggs are laid in clusters of 2-12 on fully mature pods. The young larvae are green, but become pinkish-red as they get older (Fig. 58). Larvae feed inside the pod, reaching a maximum length of 15 mm. Pupation takes place in the soil. One generation requires 4 weeks under favorable conditions.

Control. In India, *E. zinckenella* is not ranked a noteworthy offender of pigeonpea, deserving any explicit course of action.

Figure 57. *Etiella zinckenella* adult

Figure 58. *E. zinckenella* larvae in damaged pods

Podfly in pigeonpea

Melanagromyza obtusa Malloch
(Diptera: Agromyzidae)

Distribution. *Melanagromyza obtusa* is a widespread and major pest of pigeonpea in Asia. It has a narrow host range and only feeds on pigeonpea and closely related species.

Symptoms. Podfly infested pods do not show external evidence of damage until the fully grown larvae chew holes in the pod walls. This hole provides an emergence "window" through which the adults exit the pod. Podfly-damaged seeds will not germinate and are unfit for human consumption.

History. The small, black fly (Fig. 59) is about 5 mm in length. Eggs are laid in the wall of an immature pod. The white maggots feed on the developing seed and reach a length of 3 mm before pupating (Fig. 60). The brown puparium is formed between the remnant of the seed and the pod wall. One generation requires 3 to 4 weeks under field conditions.

Control. No specific control strategy has been universally implemented for podfly management. However, use of systemic insecticides can lessen the extent of podfly damage. Work on developing podfly-resistant pigeonpea genotypes is in progress and may provide the ultimate solution to this problem.

Figure 59. *Melanagromyza obtusa* adult

Figure 60. *M. obtusa* larva, and puparia, in a damaged pod

Pod wasp in pigeonpea

Tanaostigmodes cajaninae La Salle
(Hymenoptera: Tanaostigmatidae)

Distribution. Pod wasp is a minor but widely encountered pest of pigeonpea in India. Its incidence outside of India is not known.

Symptoms. Eggs are laid very early in pod development, perhaps even in the newly fertilized ovary of the flower. Feeding by the grubs produces malformed, atrophied pods that do not grow at all. Locules or individual seed compartments that escape invasion may develop into normal seeds, while locules containing pod wasp remain undeveloped giving an abnormal appearance to the pod (Fig. 61). Pod wasp exit holes are smaller than those of podfly.

History. Adults are small, only 2 mm long, and shiny-black in color (Fig. 62). Females lay small, oval eggs on or in flowers, and tender pods. The grubs feed on developing seeds reaching a length of 2 mm (Fig. 63). The wasp pupates in the same locule where it fed. In 3 weeks one generation of pod wasp can be completed.

Control. This species is probably a secondary pest resulting from the increasing use of pesticides on pigeonpea which have destroyed its natural enemies. In India, pod wasp populations do not cause appreciable harm to warrant any control.

Figure 61. Symptoms of damage caused by *Tanaostigmodes cajaninae*

Figure 62. *T. cajaninae* adult

Figure 63. *T. cajaninae* larva feeding on maturing pigeonpea seeds

Insects attacking stored seeds

Bruchids feeding on stored pigeonpea and chickpea seeds

Callosobruchus analis (Fabricius)
Callosobruchus chinensis (L.)
Callosobruchus maculatus (Fabricius)
(Coleoptera: Bruchidae)

Distribution. These pests are widespread in Asia and attack stored seeds of numerous legumes, including those of pigeonpea and chickpea.

Symptoms. For pigeonpea, infestations begin in the field, while chickpea pods are seldom infested in the field. Pigeonpea seeds are prone to invasion by *Callosobruchus maculatus* whereas chickpea seeds are apt to be raided by *C. analis*. Infested seeds lose their viability and are unfit for human consumption (Fig. 64).

History. Adults are small, 3 mm long brown beetles with black spots on the elytra. Eggs are laid on the seed surface. In field-infested pigeonpea seed, the adult bruchid bores a small, shallow hole in the pod and lays an egg on the seed surface (Fig. 65). Larvae feed and pupate entirely within the seed. One generation is completed in 4-5 weeks.

Control. Several factors are involved in the protection of pigeonpea and chickpea seeds against bruchid attack. Cleaning seed and storing in sealed containers guards against initial attack in the stored state. Moisture content of the seed should be less than 5%. Sun-drying before storing the grain in a clean case helps minimize moisture. Stored seeds can also be protected from bruchids by fumigating them with aluminum phosphide without adversely affecting seed viability. Pigeonpea and chickpea seed split for dhal, renders itself unattractive to ovipositing female bruchids and is safe from

Figure 64. *Callosobruchus* sp damage in stored pigeonpea and chickpea seeds

Figure 65. *Callosobruchus* sp damage initiation in pigeonpea under field condition

Integrated Pest Management

Definition

There are many definitions of integrated pest management (IPM) but the basic concept is the containment of a pest below economically damaging levels, using a combination of control measures. Two fundamental premises are that individual pest control methods are often not successful alone and that pests only need to be managed when present at populations high enough to cause economic damage. IPM relies on the use of natural enemies and a **selective** use of insecticides in a supervised program. “Supervised” refers to an active program of monitoring pest and natural enemy population levels. Four primary components of IPM are usually recognized. They are as follows:

1. Host plant resistance
2. Manipulation of the farming system to minimize pest infestation or damage
3. Enhanced natural control processes
4. Selective use of biorational and/or synthetic pesticides

Background

A thorough and fundamental knowledge of the ecology of the farming system is a prerequisite to the development of successful IPM programs. Its importance cannot be overemphasized. This knowledge base includes the results of strategic research e.g. pest-forecasting systems based on pheromone trapping, mechanisms of host-plant resistance, crop and insect phenology, and the relationships between insect populations and crop yield losses.

Action threshold

As mentioned above, pests only need to be regulated when their population reaches levels that endanger the economy. This is generally referred to as the economic injury level, and is defined as the population level at which damage caused by the pest exceeds the cost of control. Immediately below this level, is the action threshold at which control tactics need to be implemented to prevent economic damage. The only pigeonpea and chickpea pest for which action thresholds have been established is *Helicoverpa armigera*, and these levels are at best arbitrary. The diversity of pests attacking these crops, the variety of cropping systems in which the crops are grown, the incomplete knowledge of input costs, and the long crop cycle make it difficult to define useful and realistic action thresholds for most pests.

Evolutionary process

IPM is not a research tool or an extension activity, but rather a **process** that takes place in farmers' fields as a result of decisions made by the farmer. IPM is interactive and evolves as knowledge and experiences are accumulated. Techniques may encapsulate the results of many years of component research, followed by a concerted technology-transfer program including modification and adaptation to local conditions.

Components

Host-plant resistance

More than 14,000 germplasm accessions of both pigeonpea and chickpea have been evaluated at research stations and in farmers' fields over many years under high pest pressure. A number of genotypes associated with resistance to one or more pest species have been determined. The greatest progress has been made in identifying genotypes resistant to specific diseases such as wilt and sterility mosaic in pigeonpea, and stunt and botrytis *gray* mold in chickpea. A few genotypes that are tolerant to insect pests have also been reported. However, these genotypes often posses other characteristics that are undesirable such as small seeds. Thus, the search for pest-resistance should also consider other factors such as agronomic performance, consumer preferences, and disease resistance. The pursuit of pigeonpea and chickpea that can endure insect pests, will continue. Current pest management programs should include the selective use of recently developed, high-yielding, and disease-resistant pigeonpea and chickpea cultivars that form the foundation of an IPM program.

Cultural control

The second major component of an IPM program is cultural control. Farming systems can be manipulated in a variety of ways. These options include early or delayed sowing, selection of the intercrops, altering plant density or arrangement, and sowing genetic mixtures to reduce the impact or severity of insect pests. These maneuvers are location-specific and must be designed to suit local practices and customs. Chickpea is usually grown as a monoculture but it may be intercropped with safflower, linseed, or coriander. In contrast, pigeonpea is often intercropped with cereals, legumes, or fiber crops. Altering its sowing time, or the arrangement and plant density by the careful selection of companion crops may reduce the impact of *H. armigera* or increase the effectiveness of its natural enemies. There is some evidence that intercropping pigeonpea with short-season legumes such as soybean or mung bean reduces the influence of *H. armigera* on pigeonpea. Similarly, intercropping linseed or coriander with chickpea may provide nectar sources for adult parasitoids improving natural control of *H. armigera* in chickpea (Fig. 66). In heavy infestation, manually shaking pigeonpea plants to dislodge larvae is often resorted to, in India (Fig. 67).

Figure 66. Chickpea intercropped with linseed

Figure 67. Manual shaking of pigeonpea to dislodge *Helicoverpa* larvae

Natural Enemies

Pigeonpea and chickpea insect pests have many natural enemies. These can be organized into three main groups: predators, parasitoids, and pathogens. Predators hunt and consume all or part of their prey. They need to eat more than one victim. In contrast, parasitoids live on or in the body of their host, and need only a single host for sustenance. Another difference between predators and parasitoids is size; predators being larger than their prey while parasitoids are of the same size as, or smaller than their host. The third group of natural enemies is pathogens or diseases, a number of which infect pests in pigeonpea and chickpea fields.

It is not possible to illustrate all of the natural enemies of the pigeonpea and chickpea pests in this book. Photographs of a few representative examples have been included. It is essential that students, researchers, extension personnel, and farmers be able to distinguish between pests and the beneficial insects found on these crops. A comprehensive record of the parasites and predators of some of these pests is available (see Additional Reading section).

Predators. Many predators (Figs. 68-78) feed on insect pests that attack pigeonpea and chickpea. For example, more than 60 species of arthropods have been reported to prey on *H. armigera* in India. In addition to predatory insects, several species of spiders, lizards, and birds feed on *H. armigera*. The mobility of these predators makes it difficult to manipulate their populations in the field. One increasingly popular strategy is to install bird perches in the field to attract predatory birds. The perches provide a resting-place encouraging birds to prey on pests.

Figure 68. Praying mantis, a generalist predator

Figure 69. Robber fly, a *Helicoverpa* predator

Figure 70. Dragon fly, a *Helicoverpa* and Jassid predator

Figure 71. Spider, a general predator

Figure 72. The king crow or drongo, a *Helicoverpa* predator sitting on a perch

Figure 73. *Chrysopa* sp, a generalist predator


Figure 74. A reduvid feeding on *Helicoverpa* larva

Figure 75. *Cheilomenes sexmaculatus*, an aphid predator

Figure 76. A mud wasp carrying a *Helicoverpa* larva

Figure 77. A mud wasp’s nest packed with *Helicoverpa larvae*

Figure 78. Cattle egrets feeding on caterpillars

Parasitoids. Many parasitoids have been reported to feed on pigeonpea and chickpea pests. For example, more than 75 insect parasitoids attack various life stages of *H. armigera* in India. All these parasitoids are members of two orders: Hymenoptera and Diptera. A few examples are illustrated here (Figs. 79-80). Some parasitoids can be mass-reared, and released into an infested field. In addition, a number of commercial companies are marketing parasitoids, the most common being the egg parasitoids *Trichogramma* spp which attack eggs of *H. armigera* and other lepidopterans.

Figure 79. Pupae of *Apanteles* (wasp) parasite on pigeonpea

Figure 80. Pupa of *Campoletis chlorideae*, a parasitoid of *Helicoverpa armigera on chickpea*

Diseases. There are several disease-causing organisms, including nematodes, fungi, bacteria, and viruses that infect and kill insects. Diseases that afflict insect pests are beneficial, and considerable research has been conducted on some of these.

Nematodes are a very large group of organisms that attack a wide variety of plants and animals. Some attack insects but there is very little information on nematodes that plague pigeonpea and chickpea pests. *Helicoverpa armigera* larvae are sometimes infected with nematodes, especially in the rainy season. These nematodes, *Ovomermis albicans* (Fig. 81) grow to a length of 10 cm or more. As they grow, they coil up inside *H. armigera* larvae, killing them before they can pupate by consuming and disrupting their internal organs.

Of **viruses** that attack pests, the nuclear polyhedrosis virus that infects *H. armigera* (HNPV) is widespread, having been reported in Africa, Asia, and Australia. Ailing larvae become sluggish, feed less, and eventually die. The infected larvae are often found hanging head-down from twigs (Fig. 82). The cadavers are full of brown liquid containing virus particles. If these dead larvae are crushed, mixed with water, and then applied to the crop, the disease could be converted to an epidemic. Larvae that feed on foliage or pods contaminated with the virus fall prey to the disease. Small, infected larvae may be killed before doing any significant damage to the crop. Larvae infected later (>3rd instar) may take a week or more to die continuing to feed on the crop meanwhile, and causing substantial damage. Hence application of HNPV at egg eclosion will rein in *H. armigera* levels, minimizing damage. A point of caution is that the virus is inactivated by sunlight, making it essential that virus sprays be preserved with stabilizers and ultra-violet protectors to maintain their persistence.

Figure 81. *Ovomermis albicans*, a nematode parasite in *Helicoverpa* larvae

Figure 82. *H. armigera* larva infected by nuclear polyhedrosis virus

Biorational and synthetic pesticides

There are many biorational and synthetic pesticides that are commercially available to farmers. Biorational pesticides contain biologically active products such as plant-derived products, hormones, microbial agents like *Bacillus thuringiensis*, nuclear polyhedrosis viruses, pathogenic fungi, etc. These products are usually 'safe' for human beings, beneficial organisms, and for the environment. Among various biorational products, neem and NPV are popularly used in plant protection. Awareness of the need for safer agents has grown with an increasing concern for the toxicity of synthetic pesticides. Hence, biorational pesticides have immense potential. A number of neem-based formulations are being produced by small-scale formulators and marketed as insecticides. Most of them are made from neem oil and contain varying amounts of azadirachtin. There have however, been problems with inconsistent quality. To overcome this, we encourage pulse farmers to procure their own neem seed and prepare their own spray of 5% neem-seed-kernel extract using the following procedure.

1. Collect fresh, good quality neem fruit and place them in water. Then squeeze them to separate seeds.
2. Dry the seed and extract kernel.
3. Powder the dried kernels.
4. Soak the powder in water overnight before use (1 kg powder in 5 l water).
5. Filter the neem kernel solution through fine cloth.
6. Add 2 - 3 grams of detergent as sticker per 1 l spray fluid.
7. To obtain 5% neem seed extract, take extract from 5 kg kernel powder and mix in 100 l of water (12.5 kg seed powder is needed to cover 1 ha of chickpea with 250 l of water using high volume sprays).

Farmers can also produce suspensions of the Helicoverpa nuclear polyhedrosis virus (HNPV) using simple techniques appropriate for village level production. The following 7-step procedure has been developed.

1. Collect larvae	5. Extract virus
2. Infect larvae with virus	6. Store virus
3. Rear larvae	7. Apply virus appropriately
4. Harvest virus	

The following method has been used to produce high quality HNPV in our laboratory

1. Collect healthy fourth-instar larvae, 1 - 1.5 cm long, from the field
2. Prepare the inoculum using 5 ml HNPV stock solution on 500 chickpea seeds that have been presoaked for 12 hours. Each ml of HNPV stock solution should contain 6 x 10^9 polyhedral ocular bodies (POB).
3. Place 2-3 inoculated chickpea seeds in each container with a larva
4. Change the food on day 3
5. Collect the dead larvae starting at day 5 after inoculation and keep refrigerated.
6. Homogenize dead larvae in a blender with distilled water, if necessary.
7. Filter the mixture through muslin cloth.
8. Centrifuge for about 15 minutes at 5000 rpm.
9. Discard the supernatant liquid, and preserve the virus-containing sediment.
10. Check the quality using a haemocytometer to take a POB count.
11. Preserve the viral solution in a refrigerator.
12. Mix the UV shield, Robin blue^R @ one ml per one liter of spray solution, at the time of application
13. Spray @ 250 Larval Equivalents (LE) per ha on chickpea and 500 LE on pigeonpea during late afternoons only (100 LE= 6x 10^{11} POB, and one 5-6 instar infected larva contains 3x 10^9 POB).

In addition to the biorational pesticides there are numerous synthetic pesticides on the market. These are employed, both individually and in different combinations. In response to the slow and certain acquisition of insecticide resistance, particularly in *H. armigera*, farmers have resorted to the use of innovative insecticide cocktails, applying these indiscriminately on different crops. Specific pesticide recommendations vary among countries and even among states or provinces of a country. As new products are introduced, recommendations also change. Farmers should contact local extension personnel for approved compounds, rates, timings, and precautionary information.

Sampling and monitoring pests and natural enemies

Effective monitoring of pests as well as natural enemies is a prerequisite for any successful plant protection program. The decision on whether and when to follow control measures is based on the information available at a particular time. Sampling should begin before the pest invades the crop. Several methods of detection can be used: direct observation of insects on the plant, shaking down insects from the plant onto a ground cloth or tray for observation, the setting up of light traps, pheromone traps, sticky traps, and the use of vacuum-powered collecting devices, etc. Before beginning a sampling program one must have background knowledge of the pest, and its biology including the time and the portion of plant-attack, as well as the activity of any known natural enemies.

Pests can be directly sampled by observing the number of insects in a known sample unit, for example, insects per twig, terminal, pod, whole plant, or in a certain volume of soil or air. Some insects can be dislodged from the plant, to a ground cloth by shaking the foliage. This method is good for tall crops like pigeonpea. However, care must be taken for highly mobile insects that escape before observations can be recorded.

Light traps. There are many different types of light traps. The intensity of a particular wavelength of light determines its trapping power. Light in the near ultra-violet (320-420 nm) wavelength attracts a wide range of insects. The basic design of a light trap consists of a light source surrounded by baffles, and suspended over a funnel (Fig. 83). Insects that are attracted to the light are captured in the collection chamber, below the light source. This device indicates the presence of pest species and their fluctuating population-dynamics. The information gathered can be used to trigger crop scouts to initiate or intensify their monitoring activities. In some cases, like that of red hairy caterpillars, mass trapping of their adults at the time of emergence using light traps can significantly reduce its population.

Figure 83**.** Light trap

Sticky traps. Coating a surface with any sticky substance will ensnare insects. The surfaces may be flat, triangular, or cylindrical and colored, or treated with a chemical attractant to increase the catch (Fig. 84). Color can affect the types of insects captured: yellow is attractive to aphids, blue to leafhoppers, and red to fruit-feeding insects. Insects trapped on the surface can be removed with a solvent and sent for identification.As with all traps, the number of insects caught will depend on weather conditions, position and height of the trap in the field.

Figure 84. Sticky trap

Pitfall traps. This type of trap is useful for monitoring population levels of insects that live on the soil surface. Predators such as beetles, ants, and spiders can be easily collected in this type of trap. Pitfall traps are simple, deep, smooth-sided containers such as jars that are buried in the soil with their opening in line with the soil surface (Fig. 85). Regular inspection is needed to empty the trap and to prevent any damage to the insects. If a trap cannot be visited regularly then a preservative, such as formaldehyde, or a detergent can be placed in the container to preserve the catch.

Figure 85. Pitfall trap

Pheromone traps. Sex pheromones are used to monitor populations of a number of pest species including *Helicoverpa* spp and *Spodoptera* spp. Pheromone traps consist of a synthetic pheromone impregnated to a septum usually of rubber or polyethylene, and placed in a trap (Fig. 86). Traps can be of different shapes or colors, and placed at heights based on insect activity and crop architecture. Pheromones are specific to individual species, saving time in the sorting and identification of the seizure. Data obtained from these traps helps predict infestations and assists in the timely use of control measures. By themselves, they cannot check pigeonpea or chickpea pests.

Figure 86. Pheromone trap

De Vac. To monitor insects in motion, motorized vacuuming devices such as the De Vac are the best option. This machine sucks insects from the plant surface (Fig. 87). Though the De Vac is basically used for monitoring insect fauna, in some situations it can considerably reduce pest populations like that of jassids, and white flies. Since the De Vac is usually used in the day, beneficial insects could be disturbed while sampling pest population.

Figure 87. De Vac

IPM program

The following IPM strategy has been developed for arthropod pests on chickpea and pigeonpea crops in Asia. This strategy combines a number of individual tactics into a generalized management program. The focus is on managing *Helicoverpa armigera*, a key pest. Though focused on the pod borer, the program is flexible enough to accommodate location-specific practices such as planting times, row widths, and intercrop components. The strategy incorporates the experiences of many plant protection workers and farmers. We believe that by following these procedures chickpea and pigeonpea farmers can successfully overcome the major insect pests in their crops and produce high and stable yields.

Suggested IPM components

- Seed treatment with fungicide before sowing
- The use of tolerant/resistant varieties for wilt disease in endemic areas
- Following optimum spacing based on the duration and growth habit of the variety
- The installation of *H. armigera* pheromone traps at the time of sowing for intensive monitoring and tuning of control strategies
- The application of correct fertilizer dosages at appropriate stages of crop growth
- Intensive weed management in the early stage of the crop
- Increased monitoring for pod borers at flower initiation stage
- Fixing of bird perches after crop establishment
- Application of 5% neem kernel extract at flower initiation
- Application of HNPV @ 500 LE per ha for pigeonpea and 250 LE per ha for chickpea at peak oviposition phase and

repetition of the same after 15-20 days in case of fresh oviposition

- Manual shaking of pigeonpea plants to dislodge larvae, and the handpicking and destruction of larvae in chickpea, in "outbreak" situations
- Cautious application of appropriate chemical pesticides, if the controls recommended above do not contain pest population below levels of economic damage

Conclusion

Insect pests are the most serious constraint to pigeonpea and chickpea production in Asia. Farmers use, and often misuse synthetic pesticides on these crops. Misuse has led to heightened levels of resistance, creation of secondary pests, loss of bio-diversity, and the rise of numerous human health hazards. Integrated pest management (IPM) can help to minimize the use of these chemicals by providing farmers with effective alternatives. IPM programs must be developed locally to fit into local farming practices and customs. These local programs however, will have many common features such as

- use of high yielding, disease resistant cultivars
- frequent monitoring of pests and natural enemies by farmers
- agronomic practices that minimize pest infestations or increase natural enemy activity
- use of biorational insecticides when appropriate
- minimal, "emergency-only" use of synthetic pesticides

Additional reading

These references are either reviews or book chapters. They will provide more detailed information about specific pigeonpea and chickpea insect pests, and pest management strategies.

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