Handbook on Chickpea and Pigeonpea Insect Pests Identification and Management

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Cover: Mud wasp's nest packed with *Helicoverpa* larvae.

Photos: *ICRISAT*

Handbook on Chickpea and Pigeonpea Insect Pests Identification and Management

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and MA Ghaffar

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ICRISAT Science with a human face

International Crops Research Institute for the Semi-Arid Tropics

Patancheru, Andhra Pradesh 502 324, India

2013

Author's note

Several insects live and feed on chickpea and pigeonpea 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, and even then, most pest species do not cause serious economic damage every year. Some insects pierce the plant parts and feed on the sap, while others chew on leaves, vegetative buds, flowers, pods and roots. Some of the pests that feed on plant juices transmit viruses. These pests may cause greater damage by transmitting the disease than by feeding *per se* on the crop. This handbook is designed to assist agricultural scientists, extension workers, and students in the field diagnosis of common and important insect pests of chickpea and pigeonpea in the field as well as storage. One or more images of each pest, including the stage responsible for damaging the crops, are included to assist in identification.

This Information bulletin is divided into four sections:

- Insects that attack roots and vegetative plant parts
- Insects that attack reproductive structures
- Storage pests
- Integrated pest management (IPM) strategies

The first three sections describe and illustrate the major insect pests that attack these two crops. The fourth section describes various IPM strategies to manage these pests using effective, safe, economically viable and environmentally feasible alternatives that have been developed and tested over the past three decades. We would like to thank Dr CLL Gowda, Director Research Program Grain Legumes, for his critical review and support for this publication.

We also wish to dedicate this bulletin to the Late Drs W Reed and SS Lateef who have devoted their career to insect pest management in pulses.

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Insects of post-harvest importance for chickpea and pigeonpea

Preface

The increasing human population and food demands are placing unprecedented pressure on agriculture and natural resources. Today, more than one billion people are hungry and undernourished, while natural resources are getting degraded. Safeguarding crop productivity by protecting crops from damage by insect pests, pathogens and weeds is a major pre-requisite to ensure food and nutritional security, and sustain natural resources.

Chickpea (*Cicer arietinum* L.) and pigeonpea (*Cajanus cajan* (L) Millspaugh) are important grain legume crops of tropical and subtropical countries in Asia, Africa and Latin America. Chickpea and pigeonpea are considered as the poor people's meat in the developing countries, and have a high potential in addressing human nutrition, soil health, and crop productivity because of their capacity to fix nitrogen from the atmosphere. Hence, the rotation of cereals crops with legumes or mixed or intercropped with legumes is essential to improve soil health and productivity. Average productivity of these legumes is still low (750 kg ha^{-1}) against the potential yields realized by researchers (4.0-6.0 t ha^{-1}). The gap between potential and actual yield is large particularly in subsistence farming. To improve the productivity at farm level, this gap needs to be bridged by incorporating high yielding varieties with market preferred traits and appropriate management strategies. Apart from the lack better yielding cultivars, good quality of inputs and the management of biotic and abiotic stresses remains a major constraint to legume production.

More than 200 species of insects live and feed on chickpea and pigeonpea crops. Chickpea and pigeonpea losses worldwide due to *Helicoverpa armigera* alone are estimated at more than US$600 million annually, in spite of several plant protection interventions. Most of the pests have a sporadic or restricted distribution, or are seldom present at high densities to cause economic losses. On the other hand some of them can be devastating to these crops.

In the present day plant protection scenario, there are several concepts in practice starting from total chemical dependence to completely organic cultivation. These are two extremes. Considering the food crisis in developing countries and the need to reduce the pre- and post-harvest losses due to insect pests, one has to draw a comprehensive strategy between these two concepts.

This information bulletin focuses on identification of insect pests, with information on their biology, host range, the extent of the damage and feasible pest management options including the IPM program. Since most of the legume pests are polyphagus, the recommendations provided here may be useful for other crops as well. Past experience suggests that most pest outbreaks are induced by the adoption of inappropriate pest management strategies such as ineffective crop rotations and excessive application of insecticides. Hence this information bulletin will be of value to scientists, students, extension workers and farmers in recognizing potential pest species and developing appropriate management strategies.

William D Dar
Director General
ICRISAT

Introduction

Chickpea (*Cicer arietinum* L.) is grown on more than 11.9 million hectares worldwide, with a 10.9 million ton production, and is the second most important legume crop after dry beans. It is widely grown as an annual crop in South and West Asia, and in East and North Africa (Fig. 1). India is the largest chickpea producer on 8.2 m ha with a production of 7.5 m tons. Smaller areas of chickpeas are also grown in Europe, the Americas, Australia and

Figure 1. Chickpea sole crop.

Canada. Although consumed predominantly as 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 is often grown under harsh climatic conditions, and is well adapted to low moisture situations such as the postrainy (winter) season in South Asia. 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' types are generally small seeded, have colored seeds (yellow, brown, green, or black), and are more common on the Indian subcontinent and in Mexico.

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.2) 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.

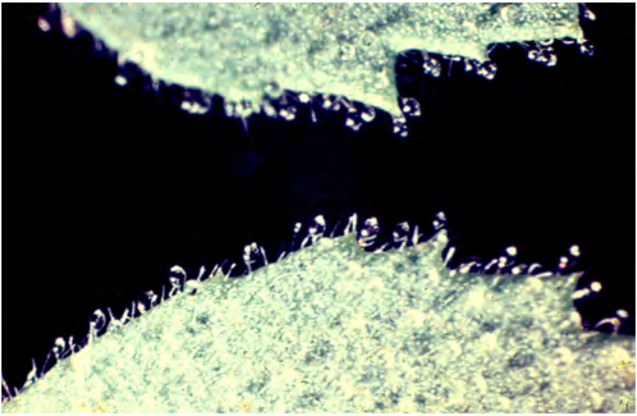

Figure 2. Chickpea foliage with glandular trichomes.

Pigeonpea [*Cajanus cajan* (L) Millspaugh] is one of the most important grain legume crops of tropical and subtropical environments, cultivated on almost 4.8 million hectares worldwide covering 22 countries in Asia, Africa and the Caribbean. India is the largest producer of pigeonpea accounting for 75% of area, and with 3.5 m ha, an average productivity of 750 kg ha^{-1}. 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 Asia, Africa and the Caribbean, and as dried, split and dehulled (dal) in South Asia. 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 usually grown as an intercrop, in combination with one or more shorter duration crops such as sorghum, millets maize, cotton, soybean, groundnut, cowpea, urd

Figure 3. Pigeonpea intercrop/relay-crop with groundnut.

bean, and mung bean (Fig.3). 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 land space giving the appearance of a sole crop.

Traditional pigeonpea genotypes are tall (upto 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 recent years, many short-statured (less than 1 m), short-duration (maturing in less than 100 days) genotypes have been developed and released (Fig. 4). These genotypes are generally more productive

Figure 4. Short-duration sole crop of pigeonpea.

as high-density mono-crops 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.

More than 200 species of insects live and feed on pigeonpea, though relatively few cause heavy 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 reduces seed yield. The post-harvest insect pests are also considered significant in inflicting losses during storage.

Soil dwellers and root feeding insects of chickpea and pigeonpea

Several soil inhabiting insects feed on roots of pigeonpea and chickpea. The root feeders are always dangerous to a crop because plants suddenly die at different stages of the crop. It is not easy to recognize dwelling insects until the damage is noticed, by which time it is too late. Hence it is difficult to make recommendations for the control of soil insects because they are sporadic and extremely difficult to detect before the damage is done.

White grubs or chafer larvae

Lachnosterna (=Holotrichia) consanguinea (Blanch.)
Anomala transvaalensis Arrow
Schyzonycha spp.
(Coleoptera: Scarabaeidae)

Among various white grub genera, *Lachnosterna* is widespread in Asia, while *Anomala* and *Schyzonycha* are common in Africa. Though they are generalist feeders on a number of crops, they occasionally attack pigeonpea in several locations. All have a similar life cycle of one generation in a growing season.

The adult beetles (called cockchafers) are 18-20 mm long and 7-9 mm wide (Fig. 5). Mating takes place at the feeding sites. After feeding, the adults re-enter the soil to hide and lay eggs. A single female lays 20-80 white, roundish (2.0-2.5 mm diameter) eggs, often in clusters (Fig. 6). Eggs hatch in 9-11 days. The fully grown grubs are translucent and measure 6-7 cm long and are often C-shaped (Fig 7). Pupation takes place in the soil (40-70 cm deep), where the insects remain as pupae until the following year.

Figure 5. L. serrata adult.

Figure 6. L. serrata eggs.

Figure 7. L. serrata grub.

The adult beetles emerge with the first monsoon showers and feed at dusk on the foliage of trees such as neem (*Azadirachta indica*), acacia (*Acacia* spp.), ziziphus (*Ziziphus jujube)* and others. The larvae initially feed on soil organic matter for a few weeks and then eat roots. Severely infested fields have large patches of dead plants, the surviving plants are often stunted, and show signs of wilt.

Termites

Microtermes spp.
Odontotermes spp.
Macrotermes spp.
(Isoptera: Termitidae)

Termites are widely distributed in all chickpea and pigeonpea growing areas in Asia and Africa. They favor red and light soils, and are less of a problem in the postrainy season, when chickpea is grown in rice fallows and in Vertisols. Among the twenty species of termites that are known to infest legumes in Africa and Asia, *Microtermes* and *Odontotermes* are the most damaging, while *Macrotermes* spp., occasionally attack legumes. Members of genus *Macrotermes* in Africa and *Odontotermes* in Asia build conspicuous mounds and most others have scattered chambers in the soil.

Figure 8. Termites (Microtermes spp.*).*

Termites (Fig. 8), mainly *Microtermes* spp. and *Odontotermes* spp., can cause damage to pigeonpea and chickpea at different stages of development mainly by entering the root system and burrowing inside the root and stem (Fig. 9 and 10) resulting in plant mortality.

Figure 9. Termite damage in pigeonpea fields.

Figure 10. Termite damage in chickpea fields.

As chickpea and pigeonpea crops progress towards maturity, termite damage becomes more pronounced. Most often, termites invade the crops around 30-45 days to crop harvest. In case of chickpea, infested plants disappear rapidly due to removal of plant tissues by termites and the high rate of decay under tropical climatic conditions. Pigeonpea crops, often in light soils such as in Myanmar, are infested with termites at harvest, and the infestation is particularly severe in moisture stress situations.

Biology: Alates (winged forms) emerge from the soil at the onset of the monsoon. Mating occurs after a short dispersal flight and pairs then seek nest sites in the soil. In a few months the foraging caste starts moving out of newly founded colonies in search of food. Soldiers, which have large mandibles, defend their colony from intruders. The mound size varies with the species (Fig. 11). Colonies can extend several meters underground. They can be dug up after considerable effort, but cannot be considered destroyed until the large (50 mm long) queen is destroyed. Nests can often be detected by their familiar earth mounds and ventilation ducts.

Figure 11. Termite mound in nature.

Jewel beetle

Sphenoptera indica (Gory)
(Coleoptera: Buprestidae)

S. indica is widely distributed in Asia and Africa infesting several legumes including pigeonpea. The adult is a shiny beetle, 10 mm long and 3 mm wide. The eggs are laid singly on the main stem. On hatching the grubs bore into the stem and tunnel into the root (Fig. 12), causing the plant to wilt and die. The larvae are slow movers, and can

Figure 12. Roots damaged by S. indica.

easily be identified by their globular head and elongated, dorsoventrally flattened body. They grow to a length of 2.5 cm. However, they often go unrecognized in southern India during both the rainy and postrainy seasons. Pupation takes place in the larval tunnel. The life stages are shown in Figure 13. One generation takes about 6-8 weeks. Normally this species infest pigeonpea at a late stage of the crop (around 75 days after emergence) and the damage can be witnessed on 90-100 day old crops.

Figure 13. Various life stages of S. indica.

Infested crops show wilting of plants in patches. The grub burrows into the stem close to the soil surface and kills the plant. Infested fields show dead and dying plants, which when pulled up and examined, expose the grub/pupa in hollowed stem. Though it is of minor importance currently, a close watch on the distribution and abundance of this species is needed considering the root feeding habit, the resultant plant mortality and wider host range.

False wireworms

Gonocephalum spp.

(Coleoptera: Tenebrionidae)

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

The adult insect is a dull black color, about 10 mm long and 5 mm wide (Fig. 14), beetle. Adults feed on seedlings at ground level, killing the plants, and reducing the crop stand.

Figure 14. Adult Gonocephalum spp*. feeding on germinating plants.*

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. The biology of the false wireworms that attack these legumes is not fully known. *Gonocephalum* adults were frequently recorded in pigeonpea fields in West and southern Africa. They are more abundantly found in clay soils.

Management of soil dwelling insects

Soil insects are difficult and expensive to control with insecticides. Applying carbofuran (3 G) granules in the furrow @1 kg a.i. ha^{-1} can be an effective prophylactic measure. Seed treatment (with insecticide) that is sufficient to protect a crop from all soil insects for the complete cropping period, has not yet been identified; however, seed treatment with chlorpyriphos 20 EC @ 10-15 ml Kg^{-1} can provide effective control of soil insects in the first 30 days.

To control white grub adults, spray their feeding trees with carbaryl 50 WP (2 g L^{-1} of water) 3-4 times until mid-July, ideally with community approach. In endemic areas, deep plowing of soil after crop harvest can also reduce the population, mainly through bird predation and the destruction of pupae.

Because of the infrequent occurrence of jewel beetles and their delayed infestation, it is difficult to recommend appropriate control strategies. Manual destruction of infested plants may help in reducing its population. In endemic areas of jewel beetle incidence, since the seed treatment provides control only at the seedling stage of the crop, soil drenching with chlorpyriphos at the rate of 5 ml $liter^{-1}$ of water at the base of the plant (in spots where plant wilt is noticed) around 50 days of the crop, can take care of the crop until harvest. Since soil drenching requires a huge quantity of water and chemical, this is mostly recommended in hybridization plots, seed multiplication and high input situations.

The cultural operations such as removal of termite mounds near crop fields and applications of chlorpyriphos into the mounds (5 ml $liter^{-1}$ of water, and application of 2 to 3 liters of spray fluids $mound^{-1}$) can effectively minimize termite populations in cropping areas.

In case of false wireworms, not much is known about these insects, so it is not possible to prescribe specific management strategies. Close monitoring of their populations is recommended, especially in areas that typically suffer above 10% seedling mortality. Increased seeding rates to compensate for seedling mortality may minimize crop losses.

Insects that attack vegetative and reproductive parts of chickpea and pigeonpea

Many species of leaf and pod-eating insect pests are found on chickpea and pigeonpea crops, but only a few are of economic importance. Most of these insects are polyphagous and sporadic in occurrence, and crops can tolerate foliar damage during the vegetative phase, which is generally kept under manageable levels by natural enemies. Though damage caused by some of the pod feeders go unnoticed, mostly due to the subsistence nature of these crops, the indiscriminate use of insecticides can cause pest outbreaks that have the potential to inflict total crop loss.

Jassids or leaf hoppers in pigeonpea

Empoasca kerri Pruthi
Empoasca fabae Harris
Empoasca facialis Jacobi
(Homoptera: Cicadellidae)

The commonest jassid that attacks pigeonpea is *E. kerri* in Asia, *E. facialis* in Africa, and *E. fabae* is wide spread in the Americas.

Jassids are small green insects, 2.5 mm long (Fig.15). The adults 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.

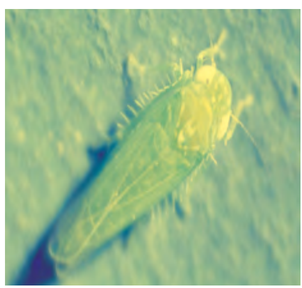

Figure 15. E. kerri adult.

Jassid eggs are inserted into the leaf tissue close to the midrib, or into the petiole. Under normal conditions the eggs hatch in about a week, and nymphs develop into adults in 10 days. About 40 nymphs can be expected from a single female. High and well distributed rainfall and low temperatures encourage jassid reproduction. One generation requires 2 weeks under optimum conditions.

Both adults and nymphs suck sap from young leaves, mostly from the lower surface. The first symptom of attack is a whitening of the veins. Chlorotic (yellow) patches then appear, especially at the tips of leaflets. Under severe infestation, leaflets are cup-shaped and have yellow edges and tips. Seedlings that have sustained considerable feeding by jassids may be stunted and have red-brown leaflets followed by leaf drop (Fig. 16).

Figure 16. Severe E. kerri damage on pigeonpea foliage.

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

Aphids

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

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

When the population density in the colony reaches a certain limit, winged individuals are found among the wingless forms. They fly away to form new colonies. Nymphs and adults suck sap from the tender growing shoots (Fig. 17-18). They secrete a sticky fluid (honeydew) on the plant, which turns black by fungal infection. Aphids are considered important in both rainy and postrainy seasons on these crops. Heavy rainstorms reduce aphid population densities and favor the development of the fungal diseases that suppress the population build up. Aphids are particularly susceptible to predators such as coccinellids, syrphids, lacewings, and a number of parasites. Although the feeding activity of aphid colonies can retard plant

Figure 17. Aphids feeding on tender shoot of pigeonpea

Figure 18. Aphids on chickpea shoots & pods.

growth particularly at seedling stage, infestation on young seedlings results in twisted shoots under heavy infestation. Seedlings may wilt, particularly under moisture-stressed conditions. However, a more notable issue in chickpea is the transmission of stunt disease, caused by the bean leaf-roll virus transmitted by these aphids. Stunt disease limits plant growth, rendering leaflets small, and reddish brown (Fig. 19).

Figure 19 . Symptoms of chickpea stunt disease.

Thrips in pigeonpea

Megalurothrips usitatus (Bagnall)
Scirtothrips dorsalis Hood
Thrips palmi Karny
Frankliniella schultzei (Trybom)
(Thysanoptera : Thripidae)

Several genera of thrips attack pigeonpea flowers in Asia, Africa and the western world including USA and the Caribbean, of which the most common species is *M. usitatus.*

Thrips (Fig. 20) are small insects that often live and feed on flowers of all legumes including pigeonpea. They are only about 2 mm long, black in color, and are usually hidden in floral buds and flowers. For these reasons they are not conspicuous. The eggs are inserted into young buds and foliage. Under optimal conditions, the immature stages last about 15 days. Adults live for 20 days and lay 40-50 eggs. A generation takes about 3 weeks. Nymphs and adults suck sap from the surface of the flowers. A large number (up to 50) of thrips may be present in each pigeonpea flower, but so far there is no evidence of losses in yield. Hence no specific control measures are needed for the management of thrips.

Figure 20. M. usitatus incidence in pigeonpea flower.

Mites in pigeonpea

Eriophyid mite

Aceria cajani Channabasavanna

(Acarina: Eriophyidae)

Red spider mite

Schizotetranychus cajani Gupta

Tetranychus spp.

(Acarina: Tetranychidae)

Mites are widespread and common in pigeonpea throughout Asia and Africa and are polyphagous. 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.

Plants infected with sterility mosaic disease develop light green, chlorotic foliage. Leaves have a mosaic pattern (Fig. 21), and early infection results in reproductively sterile

Figure 21. Symptom of sterility mosaic disease on pigeonpea.

plants. Spider mites cause yellow or white spots on the upper surface of the infested leaflets. Heavy infestation results in bronzing of the leaves, followed by defoliation and flower drop.

Adult eriophyid mite 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.22). 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 aided by wind.

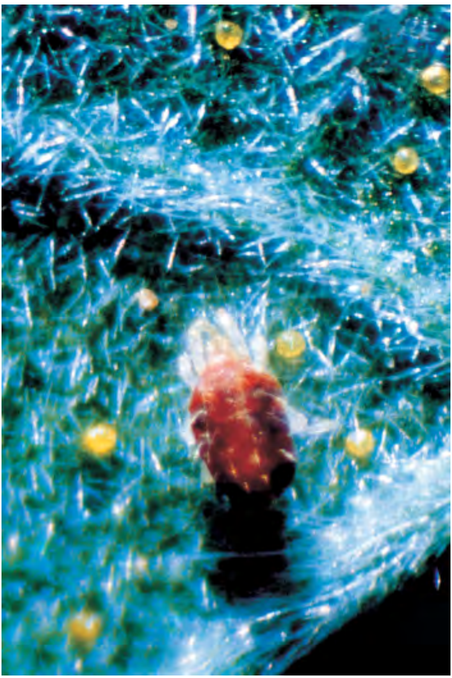

Figure 22. Adult spider mites on pigeonpea.

Problems with spider mites usually worsen when certain fungicides and insecticides are used. Attack by red spider mites may become severe in pigeonpea plants grown in greenhouses. 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. Rainfall and humid conditions are likely to lower mite numbers.

Cow bugs in pigeonpea

Otinotus oneratus W.

Oxyrhachis tarandus F.

(Homoptera: Membracidae)

Cow bugs are widely distributed across Asia, Africa and the Caribbean, infesting several legumes besides pigeonpea.

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. 23). The ants may protect the bugs from natural enemies, which would otherwise keep cow bug populations in check. Life cycle takes about a month under optimum conditions.

Figure 23. Cow bug infestation on pigeonpea with ant association.

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.

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

Scale insects in pigeonpea

Ceroplastodes cajani Maskell

Icerya purchasi Maskell

(Homoptera: Coccidae)

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

Among scale insects, *I. purchasi,* popularly known as cottony cushion scale of citrus, feeds on several species of woody plants, and is now found worldwide where citrus crops are grown. One species, *Laccifer lacca,* whose secretion produces the commercial lac, is sometimes cultivated on pigeonpea in Asia.

Both adult and nymph scale insects feed on the stems and occasionally, on the reproductive parts of pigeonpea. In addition to the direct damage from sap sucking, the insects also secrete honeydew, on which sooty mold often grows, which causes further damage to the host plant.

The adult female scale insect is capable of self-fertilization and lays about 500 to 800 eggs. Eggs are laid within an egg sac and are red and oblong. The scale population increases most rapidly during the drier months and requires about 2-3 weeks for a generation. Fortunately, there is a heavy natural mortality among the eggs and the first instar nymphs. The early instars of the scale insects are bright red in color with reddish-brown antennae and thin black legs. By the third instar, the scale is broadly oval and reddish-brown, but is largely obscured by a cottony, waxy secretion. The adult female scale is oval and convex, but its characteristic feature is a long white egg sac which has a cottony appearance.

These insects are not major pests of the annual pigeonpea but perennial pigeonpea is more frequently attacked, as their populations need a number of seasons to build up. One generation can be completed in as short 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. 24). Ants are attracted to the honeydew excretions of scale insects and protect the scale insect colony from natural enemies.

Scale insects seldom reach population levels requiring control. There are several parasites and predators that keep scale insects in check. The non-use of pesticides will allow the natural enemies to breed and multiply, keeping scale insect levels down. Manual clipping of infested twigs and destroying them outside the field would be of immense value in reducing the infestation.

Figure 24. C. cajani infestation on pigeonpea.

Leaf-damaging weevils in pigeonpea

Myllocerus undecimpustulatus Faust

Nematocerus spp.

Phyllobius spp.

(Coleoptera: Curculionidae)

Myllocerus spp. and *Phyllobius* spp. are widespread in Asia, and *Nematocerus* spp. in Africa in pigeonpea and several other host plants. Besides these, other genera and species are also known to feed on pigeonpeas, but are of minor importance.

The adult measures 5 – 6.5 mm in length with a broad snout. The larvae resemble small white grub and mature grubs measure 9.5 mm in length. The eggs are laid on the foliage close to the soil in masses of 12-130, and are white in color. After hatching, the young grubs enter the ground and start feeding on the roots. The development from egg to adult ranges from 60 - 120 days. There are 6 larval instars. Larvae live and pupate underground. A female lays about one thousand eggs during her 160 day life span.

Gray (or ash) weevils feed on foliage of pigeonpea and a wide variety of hosts. Notching or scalloping the edges of leaves (Fig. 25) is the typical character of these species. They are generally of minor importance, but may pose problems in hybridization blocks because they also feed on flowers. These insects are not known to have attained demonstrable pest status in farmers' fields. The range of larval hosts and the developmental biology is not clearly known, but looking at its distribution and host range it can be noted as a potential pest.

Figure 25. (Right) Pigeonpea foliage damaged by M. undecimpustulatus. (Left) Myllocerus adult feeding on pigeonpea flower.

Lepidopteran defoliators of pigeonpea

Amsacta albistriga Walker

A. morri Butler

Spilosoma (Diacrisia) obliqua (Walker)

(Lepidoptera: Arctiidae)

Euproctis subnotata (scintillans) Walker

(Lepidoptera: Lymantridae)

Several species of hairy caterpillars attack pigeonpea, of which the most commonly seen are red hairy caterpillars, *A. albistriga*, *S. (Diacrisia) obliqua* and *E. subnotata*. These are polyphagus and are widely distributed in Asia and Africa. Red hairy caterpillars can be devastating, but are highly sporadic on pigeonpea. About a decade ago they were considered to be the key pests of several crops during the rainy season. However their status has now changed as they are important in isolated pockets and are unpredictable.

A. albistriga and *S. obliqua* are the two most common species of 'hairy caterpillars' that attack pigeonpea during the vegetative phase (Figs. 26 and 27).

Figure 26. A. albistriga adult.

Figure 27. S. obliqua adult.

Figure 28. E. subnotata adult.

E. subnotata, the common 'tussock caterpillars', also attack pigeonpea (Fig. 28).

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, larvae of *E. subnotata* are smaller, up to 25 mm long, darker, and less hairy (Fig.29, 30 and 31). 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. These species rarely cause serious economic damage, however there are occasional reports of severe defoliation, particularly by the *Amsacta* spp.

Figure 29. A. albistriga larva.

Figure 30. Euproctis larvae.

Figure 31. S. obliqua larva.

Leaf webber in pigeonpea

Grapholita (Cydia) critica Meyr.

(Lepidoptera: Tortricidae)

G. critica (= *Eucosma* = *Cydia critica*) is commonly found on several legumes including pigeonpea in Asia and Africa.

The adult is an inconspicuous, brown moth with a wingspan of 10-15 mm (Fig. 32). 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.

Figure 32. G. critica adult.

Larvae produce silk and use it to hold leaflets together. They feed from inside a web of leaflets, flowers, and pods (Fig. 33). When infestation includes the terminal bud, further growth of that shoot

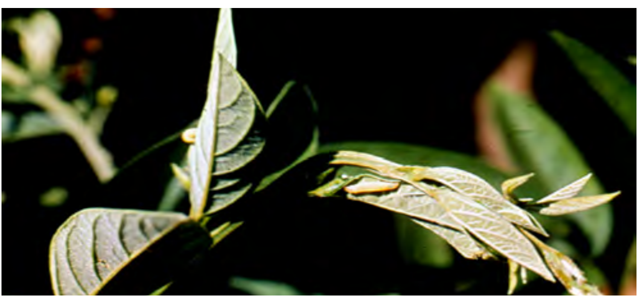

Figure 33. G. critica damage on pigeonpea foliage and larva.

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. 34). In such cases, the leaf webber also behaves as a pod borer.

Figure 34. G. critica damage on floral parts of pigeonpea.

The leaf webber damage is very conspicuous, causing anxiety among farmers about possible yield losses. Being highly visible, leaf-webber infestation may induce the use of chemical pesticides, but its impact on yield is usually negligible. In fact, plants may produce side branches to compensate for the loss of terminal buds. As this webber is an early visitor to the pigeonpea crop, 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 unless selective pesticides are prescribed.

Pod-sucking bugs in pigeonpea

Clavigralla gibbosa Spinola

Clavigralla scutellaris (Westwood)

Clavigralla tomentosicollis Stal

Anoplocnemis spp.

Riptortus spp.

(Hemiptera: Coreidae)

Nezara viridula (L.)

(Hemiptera: Pentatomidae)

Several species and genera of pod-sucking bugs attack pigeonpea and other legumes in the world. For pigeonpea, the most dangerous are *C. gibbosa, C. scutellaris* and *N. viridula* (the green stink bug) found on many legumes and other hosts throughout the tropics and subtropics. *C. tomentosicollis* is widespread in Africa. Besides these, several other species of family coreidae and pentatomidae are also occasionally found on the pigeonpea crop.

Clavigralla bugs are brown-gray and measure about 12 mm in length with *C. scutellaris* being more robust than *C. gibbosa* (Fig. 35). In the field, *C. gibbosa* and *C. scuttellaris* 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 not roughly sculptured like the *C. gibbosa's* (Fig. 36). *C. gibbosa* generally lays clusters of 10-12 eggs compared to the 18-20 of *C. scutellaris*.

N. viridula is 15 mm long, normally green (Fig. 37), but may also have some yellow coloration, and the eggs are laid in clusters of about 100 each.

Figure 35. C. gibbosa adults.

Figure 36. C. gibbosa and C. scutellaris eggs.

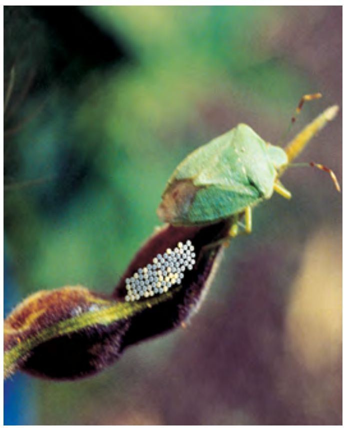

Figure 37. N. viridula adult and eggs.

The adults of the *Anoplocnemis* spp. vary in color from dark brown to black (Fig. 38) 30 mm long, and are the largest of the bugs. The *Riptortus* spp. are 18 mm long, brown in color, and more slender than the other species (Fig. 39).

Figure 38. Anoplocnemis adult.

Figure 39. Riptortus adult.

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.

The adults and nymphs of all of these bugs use their piercing mouthparts to penetrate the pod wall and suck the sap, from developing seeds. Damaged seeds become shrivelled, and develop dark patches (Fig. 40). 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 40. Pigeonpea seeds damaged by pod sucking bugs on right.

Because pod-sucking bugs are highly mobile, insecticides may be inadequate to suppress the extent of their spread, especially in small fields. Natural enemies, in particular various species of egg parasitoids, can cause high levels of mortality by the end of the season. In recent years the bug damage on pigeonpea is reported to be significant.

Blister beetles in pigeonpea

Mylabris pustulata Thunberg

Mylabris thunbergii Billberg

Mylabris spp.

(Coleoptera: Meloidae)

Several species of genus *Mylabris* feed on pigeonpea across the world, of which *M. pustulata* is common on pigeonpea in Asia. Blister beetles are polyphagus and are flower feeders throughout their distribution.

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

The *M. pustulata* adult measures about 25 mm in length and has red and black alternating bands on the elytra (Fig. 41). 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 yet documented.

Figure 41. M. pustulata adult feeding on pigeonpea flowers.

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 or cannot provide satisfactory results 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 in important trials.

Cutworm in chickpea

Agrotis ipsilon (Hufnagel)

(Lepidoptera: Noctuidae)

The origin of black cutworm is uncertain; it is now found in many regions of the world, except in some cold areas. Cutworm is more widespread and damaging in the northern hemisphere than in the southern hemisphere. It annually reinvades temperate areas, overwintering in warmer or subtropical regions. It feeds on a number hosts including chickpeas in Asia and Africa.

Adults are large moths 40-50 mm long with brown forewings and white hind wings (Fig. 42). A female can lay up to 1500 cream-colored eggs singly or in small clusters (2-3) on

Figure 42. A. ipsilon adult.

plants or on the soil surface. The full-grown larva is up to 40 mm long and brown-black in color (Fig. 43). Larvae pass through 6-7 instars and are nocturnal, staying 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. 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.

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 43. A. ipsilon larva.

Leaf miners in chickpea

Liriomyza cicerina (Rondani)

Chromatomyia horticola *(*Goureau)

(Diptera: Agromyzidae)

Liriomyza cicerina is a common insect pest of chickpea in West Asia around the Mediterranean region. In India, *C. horticola* reportedly attacks chickpea leaflets. Besides these two species, several other *Liriomyza* spp. are reported to cause damage to chickpea in Mexico.

Adult flies are dark and shiny, measuring about 1.5 mm in length (Fig. 44). 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.

Figure 44. L. cicerina adult (magnified).

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. 45). Heavy attacks can cause leaflets to drop. Late sown crops in West Asia suffer most damage, so early sowing is recommended to escape damage. Deep plowing of the fields also reduces the emergence of adults, and is hence a feasible option.

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

Figure 45. Damage caused by leaf miner in chickpea.

Armyworm in chickpea

Spodoptera exigua (Hubner)

(Lepidoptera: Noctuidae)

S. exigua, originated in southeast Asia; however it's geographical distribution now covers most of the globe. It has a wide host range covering vegetables and field crops, including chickpea and several weeds.

The adults are medium sized, the wing span measuring 25 to 30 mm. The forewings are mottled gray and brown, and normally with an irregular banding pattern (Fig. 46). Eggs are laid in clusters of 50 to 150. An individual female can

Figure 46. S. exigua adult.

lay up to 600 eggs in its life span. Eggs are usually deposited on the lower surface of the leaf, and often near flowers and the tip of the branch. The eggs are greenish to white in colour, and covered with a layer of whitish scales that gives the egg mass a fuzzy or cottony appearance. Eggs hatch in two to three days during warm weather. There are normally five larval instars. The first and second instars are pale green or yellow in colour, but acquire pale stripes during the third instar. During the fourth instar, larvae are darker dorsally, and possess a dark lateral stripe. Larvae during the fifth instar are quite variable in appearance, tending to be green dorsally and pink or yellow colored ventrally, with a lateral white stripe. A series of dark spots are often present dorsally and dorso-laterally (Fig. 47). Pupation occurs in the soil. The pupa is light brown in color and measures about 15 to 20 mm in length. Duration of the pupal stage is six to seven days during warm weather. The total life cycle can be completed in 24 days.

Figure 47. S. exigua larva.

Larvae feed on foliage, flowers and maturing pods and are regarded as a serious defoliators, though much of the injury is induced by insecticide use that interferes with natural enemy activity as was evidenced in the southern states of India. Young larvae feed gregariously and skeletonise foliage. As they mature, larvae become solitary and make large irregular holes in foliage.

Semilooper in chickpea

Autographa nigrisigna (Walker)

(Lepidoptera: Noctuidae)

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

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. 48). Pupation occurs in the soil. A single generation lasts about 4-5 weeks.

Figure 48. A. nigrisigna larva on chickpea.

Larvae feed on leaflets and pods. Semiloopers produce ragged, irregular damage to the chickpea pod walls in contrast to the neat, round hole of *H. armigera* (Fig. 49). 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 49. Semilooper pod damage on chickpea.

Pod borers in chickpea and pigeonpea

Helicoverpa (Heliothis) armigera (Hübner)

Helicoverpa assulta (Guenee)

Helicoverpa zea (Boddie)

Heliothis viriplaca (Hufnagel)

Heliothis virescens (F.)

Heliothis peltigera (Denis & Schiffermuller)

(Lepidoptera: Noctuidae)

H. 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 occasionally reported in chickpea in India. Corn earworm, *H. zea and* tobacco budworm *H. virescens* are common throughout North America.

The adults of these species have a wing span of about 40 mm, and dull brown forewings (Fig. 50, 51 and 52). The creamy colored eggs are laid singly on young leaves and flower buds (Fig. 53). The larvae are morphologically similar to the tobacco caterpillar and pass through six instars, but do not have black spots on the thorax. Most larvae are dark greenish brown, but they can also be pink, cream, or almost black (Fig. 54, 55 and 56). Larvae develop through six growth stages (instars) and become fully grown in 2-3 weeks in summer or 4-6 weeks in winter.

Figure 50. H. armigera adult.

Figure 51. H. zea adult.

Figure 52. H. virescens adult.


Figure 53. H. armigera egg.

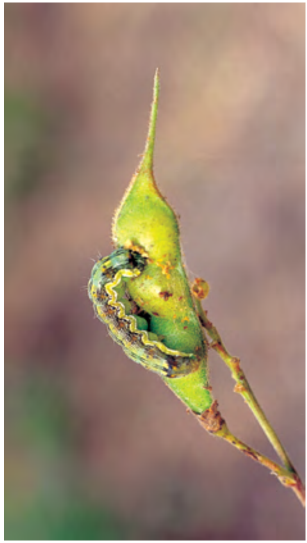
Figure 54. H. armigera larva.


Figure 55. H. zea larva.


Figure 56. H. virescens larva.

These can be distinguished from tobacco caterpillars by their conspicuous setae on the body and they do not hide in soil during the day as do tobacco caterpillars. *H. armigera* can complete seven or more generations a year in the southern parts of India and 3-4 generations per year in the northern states. Pupation takes place in the soil. 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.

Blue butterflies in pigeonpea

Lampides boeticus **(**L.)

Catochrysops strabo (Fabricius)

(Lepidoptera: Lycaenidae)

Both of these species are widely distributed in Asia and Africa. Larvae feed on pigeonpea and on several other cultivated and wild legumes. These species have been reported to occur in North Africa and Mediterranean Europe. These are highly migratory and can reach northwards up to North Germany. They are occasionally observed in south England as well.

L. boeticus adults are slender, bluish-gray with a wingspan of 30 mm (Fig. 57). Pale blue eggs are laid singly on buds (Fig. 58). Larvae are about 12 mm long, green, oval, flat and slug-like (Fig. 59). 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. The larvae chew leaves, buds, flowers and pods.

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 57. L. boeticus adult.

Figure 58. L. boeticus eggs.

Figure 59. Blue butterfly larva on pigeonpea.

Legume pod borer in pigeonpea

Maruca vitrata (testulalis) (Fabricius)

(Lepidoptera: Pyralidae)

The legume pod borer, *M. vitrata* Fabricius (Syn: *Maruca testulalis*), is distributed throughout the tropical and subtropical regions of the world. The geographic range of *M. vitrata* is from northern Australia and East Asia through sub-Saharan Africa to the Caribbean, Central America and Hawaii. Though there were some reports from Texas (USA), it has now been eradicated there.

M. vitrata is a serious pest of grain legumes particularly pigeonpea in Asia and Africa because of its extensive host range. It is a serious pest of cowpea, pigeonpea, black gram (Urd bean), green gram, mung bean, beans and soybeans, throughout its distribution. In the absence of host plants in the off-season, the populations can survive on alternative plants such as wild leguminous shrubs and trees.

M. vitrata females normally lay eggs on floral buds and flowers, although oviposition on leaves, leaf axils, terminal shoots and pods has also been recorded. A female may lay up to 400 eggs in batches of 2-16. Eggs are light yellow, translucent, and measure 0.65 x 0.45 mm. The incubation period ranges from 2 to 4 days. Mature larvae are 15-20 mm long. The head is light to dark brown, with irregular brownish black spots. The larvae pass through five instars during 8-16 days. Early instars are dull white, but the later instars are black-headed, with irregularly shaped brown or black spots on the dorsal, lateral and ventral surfaces of each body segment. Pupation takes place inside a cocoon within the web or inside the soil, and lasts 5-10 days. Pupae are 11.5 x 2.5 mm, within a silken cocoon. The adult moth has light brown forewings with white patches, and white hind wings with an irregular brown border. It often rests with the wings outspread measuring up to 25 mm (Fig. 60). They are inactive during the day and can be found at rest with outspread wings under the lower leaves of the host plants. The life cycle is completed in 18-35 days, depending upon temperature.

After hatching, the young larvae of *M. vitrata* (1st, 2nd and 3rd instars) injure the terminal shoots and the flower buds, whereas the older larvae (4th and 5th larval instars) particularly damage the open flowers and the pods of leguminous crops (Fig. 61). Larvae feed from inside a webbed mass of leaves, buds and pods. This behaviour makes *Maruca* a foliage feeder as well as a pod borer. Though its economic importance is not well documented on pigeonpea, it is necessary to keep track of this species considering the nature of its damage on pigeonpea.

Figure 60. M. vitrata adult.

Figure 61. M. vitrata damage on pigeonpea and larva on insert.

Plume moth in pigeonpea

Exelastis atomosa (Walsingham)

(Lepidoptera: Pterophoridae)

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

Adult plume moths measure 10 mm in length and have fringed wings that are held perpendicular to the body at rest (Fig. 62). 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. 63). An egg to egg cycle can be accomplished in about 4 weeks. Plume moth caterpillars are more rampant during the postrainy season

Figure 62. E. atomosa adult.

Figure 63. E. atomosa larva and pupa.

than during the rainy season. Larvae feed on buds, flowers, and pods, resulting in reduced yields.

Exelastis atomosa can be quelled by the same insecticides suggested for the management of *H. armigera*.

Lima bean pod borer in pigeonpea

Etiella zinckenella Treitschke

(Lepidoptera: Pyralidae)

This species is widely distributed on several legumes across the globe, particularly pigeonpea in Asia and Africa.

Adults are small, brown moths with a wingspan of about 20 mm (Fig. 64). 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. 65). 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.

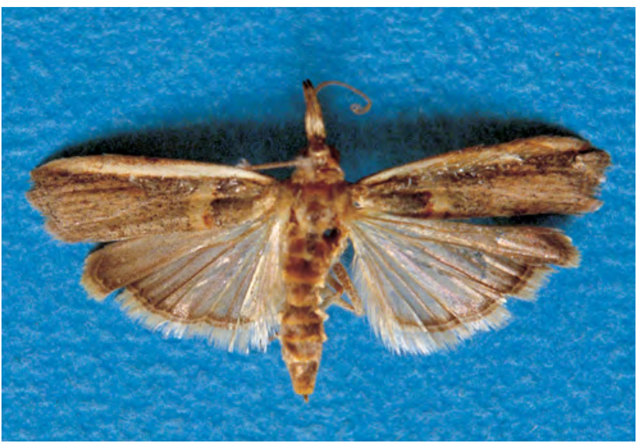

Figure 64. E. zinckenella adult.

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, and webbing in the pod is an indication of *Etiella* infestation.

In Asia, *E. zinckenella* is not ranked a noteworthy pest of pigeonpea, therefore not deserving any explicit course of action.

Figure 65. E. zinckenella larvae infesting pigeonpea.

Podfly in pigeonpea

Melanagromyza obtusa Malloch

Melanagromyza chalcosoma Spencer

(Diptera: Agromyzidae)

M. obtusa is widespread in distribution covering Asia, Oceania, Florida in north America (Florida) and in central America. It is a major pest of pigeonpea in Asia, while *M. chalcosoma* is of prime concern for pigeonpea in Africa. It has a narrow host range and only feeds on pigeonpea and closely related species such as mung bean, urd bean and cowpea.

The small, black fly (Fig. 66) 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. 67). 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.

Figure 66. M. obtusa adult.

Podfly infested pods do not show external evidence of damage until the fully grown larvae make 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.

No specific control strategy has been universally implemented for podfly management. However, use of systemic insecticides can lessen the extent of podfly damage. Application of neem fruit extract around the podding stage proved effective in reducing the incidence by avoiding oviposition.

Figure 67. M. obtusa maggots, puparia in a damaged pigeonpea pod.

Pod wasp in pigeonpea

Tanaostigmodes cajaninae La Salle

(Hymenoptera: Tanaostigmatidae)

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

Adults are small, only 2 mm long, and shiny-black in color (Fig. 68). 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. 69). The wasp pupates in the same locule where it fed. One generation of pod wasps can be completed in 3 weeks.

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

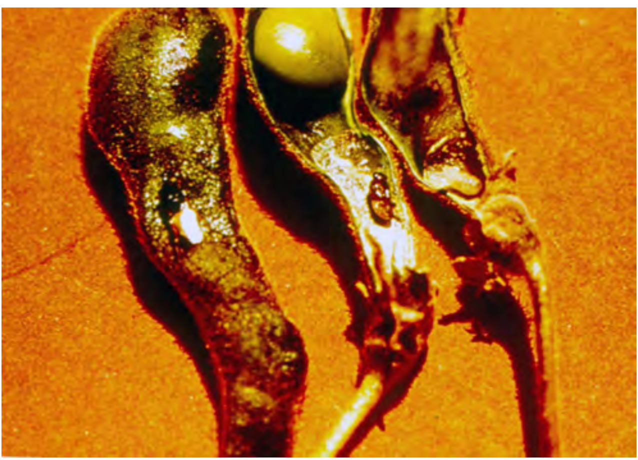

Figure 68. T. cajaninae adult and infested pods.

Figure 69. T. cajaninae grubs feeding on maturing pigeonpea seeds.

locules containing pod wasp remain undeveloped giving an abnormal appearance to the pod (Fig. 70). Pod wasp exit holes are smaller than those of podfly.

Figure 70. Pod wasp infested pods with abnormal development.

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.

Management of foliage and pod feeders

H. armigera is one of the key pests of chickpea and pigeonpea 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 suppression are listed below.

Cultivar option: A number of chickpea and pigeonpea genotypes with resistance and/or tolerance to *H. armigera* have been developed. These genotypes, though effective, have not been adopted on a large scale in farmers fields. The reasons include lack of access to quality seed and susceptibility of cultivars to diseases.

Natural enemies: A large number of natural enemies of *H. armigera* exist, though many are less effective in pigeonpea and chickpea than in other crops. Some success in restriction of damage 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 across regions. However, adoption of sunflower as a trap crop in the management of *Helicoverpa* in chickpea was successful in many countries.

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

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 fruit, tephrosia, pongamia, chili, garlic and others. Plant protection operations should be initiated in pigeonpea when one notices pests during the flowering and podding stage.

- 1 small larva or 3 eggs per plant in short-duration plants
- 3 small larvae or 5 eggs per plant in medium-duration plants
- 5 small larvae or 10 eggs per plant in long-duration plants

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 fruit powder suspension.
- Applying HNPV at a rate of 500 larval equivalents (LE) ha $^{-1}$ in pigeonpea, and 250 LE in chickpea at egg hatch is potent. This application can be repeated at 15-20 days intervals.

- 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 insecticide resistance, resurgence and creation of secondary pests, synthetic insecticides should be used only as a last resort.

Maruca is another upcoming pest of pigeonpea and other grain legumes in many areas of Asia. Indeterminate pigeonpea genotypes suffer less damage than the determinate-types. 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 on *M. vitrata*. Chemical control is complicated by the fact that larvae live in well-protected webs.

If these management options fail to keep the populations below the economic threshold levels (ETL), then apply any one of the following insecticides against the young caterpillars: Indoxacarb 20 mL a.i. ha^{-1} or Spinosad 45 mL a.i. ha^{-1} or Fenvalerate @ 100 mL a.i. ha^{-1}.

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 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.

In the case of leaf miner in chickpea and podfly in pigeonpea, application of neem fruit powder extract @ 12 kg ha^{-1} can provide effective reduction of oviposition when adults are noticed in the field. If these are unsatisfactory, then spray with insecticides, preferably dimethoate @200-250 mL a.i. ha^{-1} or Imidacloprid @ 20 mL a.i. ha^{-1}.

In general, mite attack by itself does not pose an economic problem in pigeonpea. 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 or sprinkler irrigation can also substantially reduce mite populations. If the above options are not satisfactory, then chemical sprays are advised. Mix 2-3 ml of Sticker (Sandovit, if not available, 2-3 g of surf powder / detergent $liter^{-1}$ of spray fluid) with the chemical sprays. Among chemicals Wettable Sulfur 2-3 gms, or Kelthane 2 ml, or Karathane 2-3 gms, Pegasis @ 1 gm $liter^{-1}$ or Vertemic @ 0.5 ml $liter^{-1}$ or thiovit @ 2 gms $litre^{-1}$ water as foliar spray, can provide effective control. Use 200-250 liters of spray fluid to cover one ha of chickpea and 400-500 liters for pigeonpea using motorized low volume sprayers.

Insects of post-harvest importance in chickpea and pigeonpea

Bruchids

Callosobruchus analis (Fabricius)

Callosobruchus chinensis (L.)

Callosobruchus maculatus (Fabricius)

(Coleoptera: Bruchidae)

Apart from field pests, storage pests form the major constraint, causing severe loss of pulses in storage. Most stored-produce insects are cosmopolitan, having been distributed throughout the world. Storage losses are complete, and there is no compensation for damage. The major pests of pulses in storage are bruchids (*Callosobruchus* spp.). *C. chinensis* (L.) and *C. maculatus* (Fab.) are widespread across the globe while *C. analis* (Fabricius) is limited to Southeast Asia. Though they are widely distributed, they are considered as most important in tropical and subtropical regions.

Adults are small, 3 mm long brown beetles with black spots on the elytra. Eggs are laid singly 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. 71). After eggs hatch (5-7 days), the young

Figure 71. Bruchid infestation on pigeonpea in the field.

grub burrows directly into the seed. At 25°-30°C, pupation and emergence of an adult beetle occur 25-35 days after an egg is deposited. Adults are mature 24-36 hours after emergence, but they do not need to feed. Under these circumstances, adults may live for an average of 12-14 days during which time mating and oviposition occurs. Adult sexes can be distinguished by means of readily observed morphological differences that are easily seen with the naked eye. The females can be easily identified by the presence of dark stripes on each side of the elytra, which are not found in males. Each adult can lay up to 100 eggs in its life span. The grubs feed and pupate entirely within the seed. One generation is completed in 4-5 weeks under optimum conditions.

In case of pigeonpea, infestations begin in the field, while chickpea pods are seldom infested in the field. Pigeonpea seeds are prone to invasion by *C. maculatus,* whereas chickpea seeds are infested by *C. analis*. Infested seeds lose their viability and are unfit for human consumption (Fig. 72 and 73).

Figure 72. Bruchid damaged pigeonpea seed.

Figure 73. Bruchid damaged chickpea seed.

Management of insect pests in storage

The amount of damage inflicted by insect pests during post-harvest processing and storage depends upon the several factors such as moisture content in the product, the form in which it is stored, level of maturity at harvest, the sanitation of the storage space and the material. In addition to the above, the storage structure also influences the rate of deterioration through its physical environment. The post-harvest process of legumes before storage (threshing, cleaning and drying) has significant influence on the insect behavior and their establishment in the store.

Prevention of infestation: Several factors are involved in the protection of seeds against bruchid attack. It is very important to harvest at the right time to reduce the post-harvest losses and to maintain the quality of the produce during long-term storage. Cleaning seed and storing in sealed containers guards against initial attack in storage. Moisture content of the seed should be less than 7%. Sun-drying the produce in a clean space before storing can ensure reduction of moisture. Chickpea and pigeonpea seed split for dhal, is unattractive to ovipositing female bruchids and is safe from attack. Store the produce in clean, disinfested gunny bags (if old bags are used they must first be sprayed with dichlorvos 0.05%). Stake the bags on wooden platforms away from the walls to avoid contact from moisture during storage. Monitor (once in a fortnight) stored produce for bruchid adults to initiate further management strategies, if needed.

- Treat the storage structures and storage material with chemicals such as malathion or fenvalerate dust (5%) or dichlorvos (0.05%) spray as a preventive measure.
- Mixing seed with an inert substance such as attapulgite- based clay dust (ABCD) or fine ash @ 1:10 can help to minimize storage insect problems.

Management of established infestation: When infestation is noticed in the stocks, the most effective method of disinfestation is by fumigation. This involves application of gaseous formulations in the deeper layers of the stocks by preparing an airtight space around the stock. Chemicals used in this process such as celphos (aluminum phosphide) @ 3 g bag^{-1} (40 kg bag) are highly toxic to human beings. This should therefore be used under the supervision of well-trained personnel. In such cases, the entire store can be effectively sealed to prevent leakage of gas during the treatment. The stock must be covered with polythene (at least 0.13 mm thick) sheets. If more than one sheet is required to cover the stock, the sheets should be joined and sealed with tape with a good overlap. Prevent the leakage of gas from the edges by placing sand or taping around the floor. After 5 days of fumigation, the produce should be thoroughly aired with an exhaust fan and the leftover fumigant powder should be removed. This can be easily achieved if the fumigant is placed in paper envelopes. The disadvantage of this procedure is that once the tube carrying the celphos tablets is opened, all of them should be used during that application and the remaining cannot be stored for future use. If properly carried out, this fumigation can take care of all the stages of insect pests without affecting the viability of the seed; however, it does not offer any protection from residues.

Storage for seed purpose: If seeds are to be stored, they should be stored under low temperature conditions. In general, the lower the temperature, the longer is the expected storage life of the seeds. The seed quality of any legumes stored with 7% moisture content can be maintained for at least one year at 1 to 5°C and 65 to 70% relative humidity.

(Note: Celphos treatment does not affect the viability of seed. Fumigation should not be done in residential areas).

Integrated Pest Management (IPM)

There is an increasing pressure on the agriculture sector to produce more food to meet the demand from the growing populations all around the world. With increasing demand for food production, increased need for intensive plant protection is also stepped up. This means increased use of pesticides, leading to complex environmental implications. Several national and international agencies and non-governmental organizations are presently engaged in supporting research, and the application of eco-friendly approaches for crop protection for a sustainable environment.

The basic concept of IPM is the containment of a pest below economically damaging levels, using a combination of control measures. Two fundamental principles to keep in mind are, i) individual pest control methods are often not successful alone, and ii) pests only need to be managed if their populations are high enough to cause economic damage. IPM relies on the integration of various plant protection options 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 as follows:

1. Host plant resistance
2. Manipulation of the farming system
3. Enhanced bio-control processes
4. Selective use of bio-rational and/or synthetic pesticides

Requirements

A thorough and fundamental knowledge of the ecology of the farming system is a prerequisite to the development of successful IPM programs, and its importance cannot be overemphasized. This knowledge base includes the results of strategic research, eg, 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.

Economic threshold

As mentioned earlier, pests only need to be regulated when their population reaches levels that endanger the economy. This is generally referred to as the economic threshold level (ETL), 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 options need to be initiated to prevent economic damage. The diversity of pests attacking these crops, the variety of cropping systems in which these crops are grown, and the incomplete knowledge of input costs make it difficult to develop useful and realistic action thresholds for key pests. However, based on the experience of several workers, the ETL for key insect pests of pigeonpea and chickpea have been developed and shared. Since ETLs are dynamic and depend on a number of factors, these need to be further evaluated in individual locations before wider adoption.

Economic threshold levels (ETL) of important insect pests of chickpea and pigeonpea		
Common name	Scientific name	ETL
Chickpea		
Pod borer	*Helicoverpa armigera* (Hubner)	3 eggs or 2 small larvae per plant
Cutworm	*Agrotis ipsilon* (Hufnagel)	5% plant mortality
Aphids	*Aphis craccivora* Koch	25% of plants infestation (>50 aphids plant^{-1}) at seedling stage.
Pigeonpea (medium duration)		
Pod borer	*Helicoverpa armigera* (Hubner)	5 eggs or 3 small larvae plant^{-1}
Podfly	*Melanagromyza obtusa* (Malloch)	In all endemic locations (where 10% seed damage is common)
Leaf webber	*Maruca vitrata* (Fabricius)	5 webs plant^{-1}
Pod sucking bugs	*Clavigralla gibbosa* (Spinola)	One egg mass plant^{-1}

Host-plant resistance: A total of 14,957 germplasm accessions of both chickpea and pigeonpea have been evaluated at research stations over many years under high pest pressure. A number of genotypes associated with resistance to one or more pest species have been identified. A few genotypes that are tolerant to insect pests have been reported, but do not show high levels of resistance. The pursuit of pigeonpea and chickpea that can endure high incidence of insect pests will continue. Hence, current pest management programs should include the selective use of recently developed, high-yielding, and pest- 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 sowing arrangement. These practices 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 to attract the natural enemies. In many countries *Helicoverpa* in chickpea was managed successfully with sunflower as trap crop (Fig 74). In contrast, pigeonpea is often intercropped with cereals, legumes, or fiber crops. Altering sowing time, or the row 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 mungbean reduces the influence of *H. armigera* on pigeonpea. Similarly, intercropping linseed or coriander with chickpea may provide nectar sources for adult parasitoids improving

Figure 74. Sunflower as trap crop in chickpea.

natural control of *H. armigera* in chickpea (Fig. 75). When heavily infested, manually shaking pigeonpea plants to dislodge larvae of *Helicoverpa* is often resorted in the southern states of India (Fig. 76).

Figure 75. Chickpea intercrop with linseed.

Figure 76. 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 need to eat more than one prey to sustain themselves. In contrast, parasitoids live on or in the body of their host, and need only a single host for sustenance. Another important feature that distinguishes predators from parasitoids is size; predators are larger than their prey while parasitoids are of the same size 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 bulletin. 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 in the literature.

Predators: Many predators (Figs. 77-83) 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 and vertebrates also feed on *H. armigera*. The mobility of these predators makes it difficult to manipulate their populations in the field. An increasingly popular strategy is to install bird perches in the field to attract predatory birds. The perches provide a resting-place and facilitate preying by birds.

Figure 77. Praying mantis, a generalist predator.

Figure 78. Dragonfly, a common predator of Helicoverpa and Jassids.

Figure 79. Spider, a generalist predator.

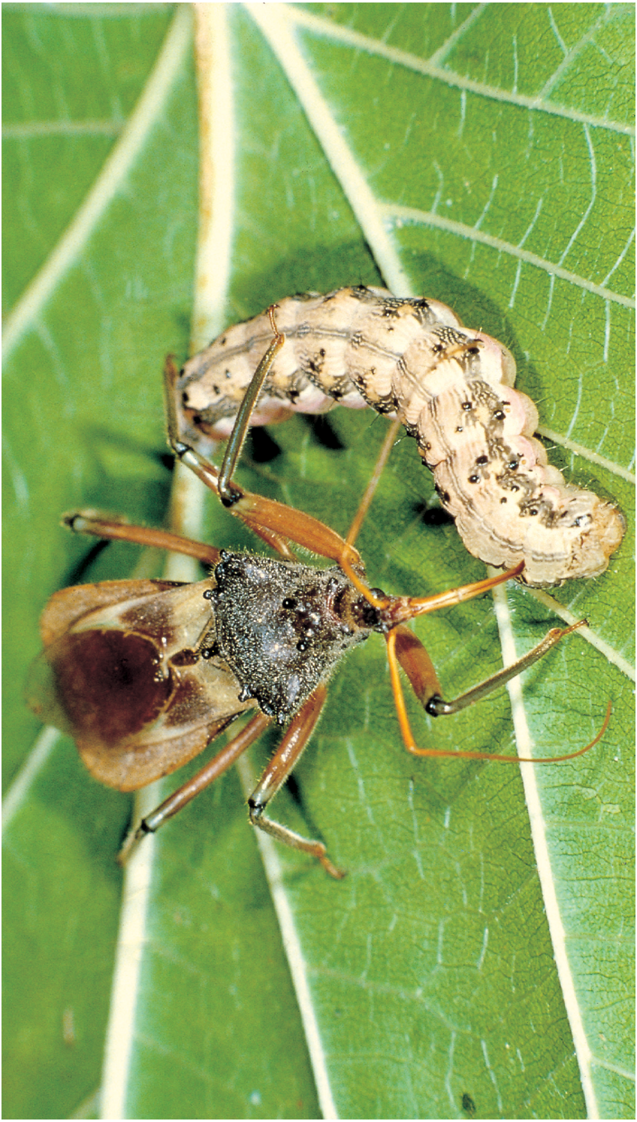

Figure 80. Reduvid bug feeding on Helicoverpa larva.

Figure 81. Cheilomenes sexmaculatus an aphid predator.

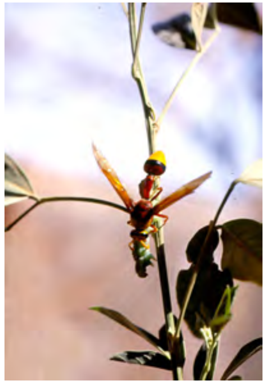

Figure 82. Mud wasp carrying Helicoverpa larva.

Figure 83. Cattle egrets feeding on caterpillars in a chickpea field.

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. 84-85). Some parasitoids can be mass-reared, and released into infested fields. In addition, a number of organizations are marketing parasitoids, the most common

Figure 84. Pupa of Campoletis chlorideae, a parasitoid of Helicoverpa, on chickpea.

Figure 85. Pupae of Apanteles (wasp), a parasite of Helicoverpa larva.

being the egg parasitoids *Trichogramma* spp., which attack eggs of *H. armigera* and other lepidopterans. Though they are found effective in a number of crops, the releases in chickpea fields was found ineffective due to the presence of sticky acid exudates on the foliage.

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: 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. *H. armigera* larvae are sometimes infected with nematodes, especially in the rainy season. These nematodes, *Ovomermis albicans* (Fig. 86) grow to a length of 10 cm or more. As they grow, they coil up inside *H. armigera* larvae, killing them before they

Figure 86. O. albicans, a nematode parasitoid in Helicoverpa larva.

can pupate by consuming and disrupting their internal organs.

Among 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. 87). 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 causing any significant damage to the crop. Larvae infected later (>3rd instar) may take a week or more and may cause some damage. Hence application of HNPV at egg eclosion will reduce *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 87. H. armigera larva infected by nuclear polyhedrosis virus.

Bio-rational and synthetic pesticides

The term covers a range of alternatives to synthetic chemical pesticides. Their main feature is specificity to avoid non-target mortality and associated problems. The use of bio-pesticides is an important component of the IPM strategy for all major crops. The best-known examples are the neem-based products, which have shown to be effective against a number of pests, NPV being used for control of important pests like *Helicoverpa armigera* and *Spodoptera* spp. In addition, *Bacillus thuringiensis* (Bt) has gained importance in suppressing pest populations in crops like cotton and vegetables.

There are several bio-pesticides that are commercially available to farmers. According to recent information there were approximately 175 registered bio-pesticide active ingredients and 700 products globally.

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, and are beneficial for the environment. Among various biorational products, neem and HNPV 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, farmers are encouraged to procure their own neem seed and prepare their own spray of 5% neem-fruit-powder extract using the following procedure.

Preparation and spraying of neem fruit extract

1. Collect enough quantity of neem fruits (100-200 kg).
2. Dry the fruits under shade
3. Make a powder from dried fruits and store
4. Spray neem fruit powder extract (NFPE) when needed
5. It can be used for all the crops, particularly against lepidopteran pests
6. Concentration: 25 kg powder ha^{-1} in 500 liters of water for big crops like pigeonpea, cotton and castor. Use 12.5 kg ha^{-1} for small crops like chickpea and groundnut in 250 liters of water (when high volume sprayers are used)

Method of preparation:

- Soak 10 kg neem fruit powder in 20 liters of water over night
- Filter the extract with muslin cloth
- This extract (20 liters) should be sprayed after diluting with required quantity of water depending upon crop
- Add 1 ml of soap liquid $liter^{-1}$ of spray fluid ie,15 ml per spray tank for smooth flow of spray solution and also to act as an adjuvant
- Neem fruit extract acts as oviposional deterrent and anti-feedant for most of the borers, so should be sprayed as a preventive measure.

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
2. Infect larvae with virus
5. Extract virus
6. Store virus

3. Rear infected larvae
4. Harvest virus
7. Apply virus

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

- Collect healthy fourth-instar larvae, 1 - 1.5 cm long, from the field
- 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 6×10^9 polyhedral ocular bodies (POB).
- Place 2-3 inoculated chickpea seeds in each container with a larva (Use plastic trays with individual compartments for easy larval handling)
- Change the food on day 3
- Collect the dead larvae starting at day 5 after inoculation and keep refrigerated.
- Homogenize dead larvae in a blender with distilled water, if necessary.
- Filter the mixture through muslin cloth.
- Centrifuge for about 15 minutes at 5000 rpm.
- Discard the supernatant liquid, and preserve the virus-containing sediment.
- Check the quality using a haemocytometer to observe a POB count.
- Preserve the viral solution in a refrigerator.
- Mix the UV protectant , Robin blue^{R} @ one ml per one liter of spray solution, at the time of application
- Spray @ 250 Larval Equivalents (LE) ha^{-1} 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 bio-rational 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. 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 cloth on the ground 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. 88). 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.

Sticky traps: Coating a surface with any sticky substance will ensnare insects. The surfaces may be flat, triangular,

Figure 88. Light trap.

or cylindrical and colored, or treated with a chemical attractant to increase the catch (Fig. 89). 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 89. 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. 90). 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 90. 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 septum, usually of rubber or polyethylene, placed in a trap (Fig. 91). 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

Figure 91. Pheromone trap.

obtained from these traps helps predict infestations and assists in the timely use of control measures. At this stage pheromones traps by themselves cannot control/ check pigeonpea or chickpea pests, hence they can be an excellent monitoring tool.

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. 92). 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 the pest population.

Figure 92. De Vac.

IPM program for pigeonpea and chickpea

The following IPM strategy has been developed for arthropod pests on chickpea and pigeonpea crops. 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
- Use of tolerant /resistant varieties for wilt disease in endemic areas
- Follow optimum spacing based on the duration and growth habit of the variety
- Installation of *H. armigera* pheromone traps at the time of sowing for intensive monitoring and tuning of control strategies
- 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 fruit extract at flower initiation
- Application of HNPV @ 500 LE ha^{-1} for pigeonpea and 250 LE ha^{-1} 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 populations below levels of economic damage.

Conclusion

Insect pests are the most serious constraint to pigeonpea and chickpea production across the globe. Farmers use (and often misuse) synthetic pesticides on these crops. Misuse has led to heightened levels of insecticide resistance, creation of secondary pests, loss of bio-diversity, and 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.

About **ICRISAT**

ICRISAT Science with a human face

International Crops Research Institute for the Semi-Arid Tropics

ICRISAT is a member of the CGIAR Consortium

The **International Crops Research Institute for the Semi-Arid Tropics** (ICRISAT) is a non-profit, non-political organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid tropics have over 2 billion people, of whom 644 million are the poorest of the poor. ICRISAT innovations help the dryland poor move from poverty to prosperity by harnessing markets while managing risks – a strategy called Inclusive Market-Oriented Development (IMOD).

ICRISAT is headquartered in Patancheru near Hyderabad, Andhra Pradesh, India, with two regional hubs and five country offices in sub-Saharan Africa. It is a member of the CGIAR Consortium. CGIAR is a global research partnership for a food secure future.

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