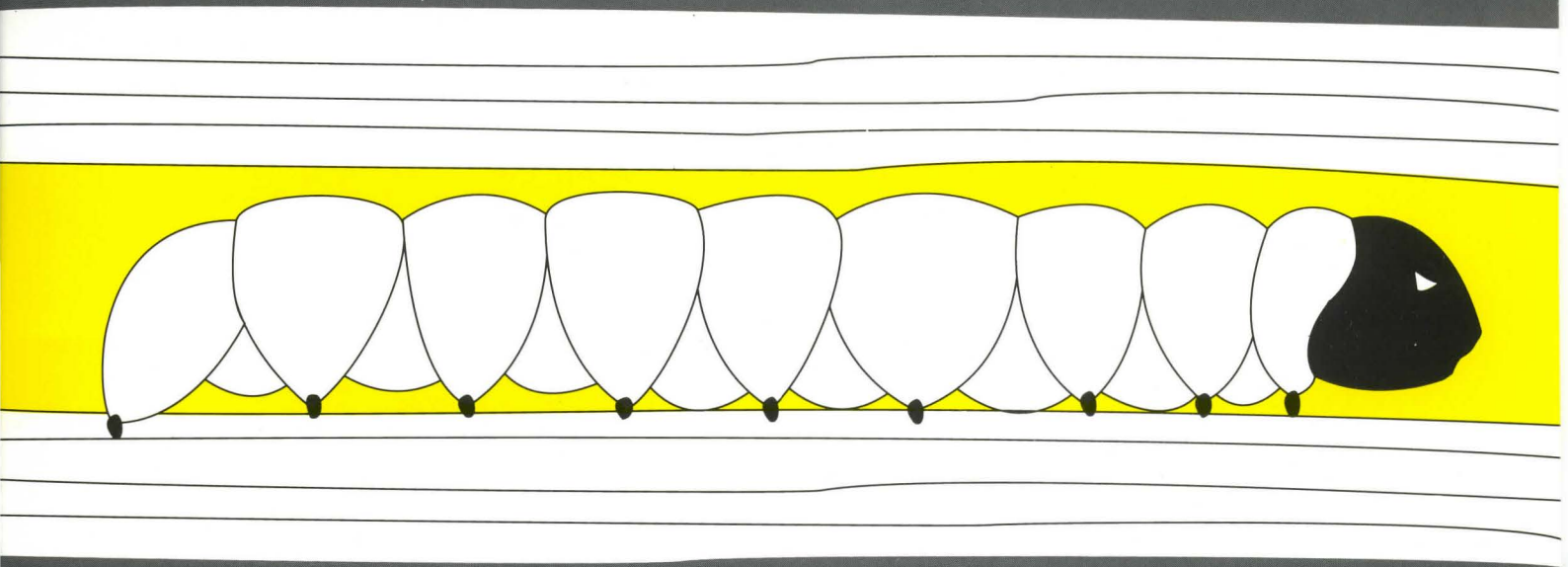
Marc BETBEDER - MATIBET

INSECT PESTS

OF FOOD CROPS IN AFRICA AND THE INDIAN OCEAN REGION



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Contents

Foreword

This publication by the IRAT department of CIRAD, is designed to help agriculturalists in Africa, Madagascar, and Mascarene islands to recognize the main insect pests of their food crops, to analyze pest status and assess damage in infested fields, and to select the most appropriate means to protect their crops. It is also intended for instructors, trainers, and students of tropical agricultural entomology, as well as professionals from the public and private sectors who are concerned with crop protection in tropical and subtropical regions.

The document is a collection of 51 factsheets on the main pests of tropical food crops and includes a certain number of texts and checklists to facilitate infestation analysis and pest management in crops.

The **first part** of the document deals with the most common species observed on different parts of plants. Each factsheet gives a description of the different stages of development of the insect, geographic distribution, plant hosts (cultivated or wild), biology, behavior, damage, and means to control the pest. In this part the reader will find basic information on the major pests.

The **second part** presents data and explanations required for a proper analysis of the pest status in a given crop. It includes color plates and checklists for a rapid determination of at least the genus of the major pest; texts and explanatory diagrams on methods for collecting, preserving, and dispatching samples and obtaining an identification of a pest species; illustrated presentation of pest survey techniques for measuring infestation and damage levels in plots. The information will help agriculturalists to make a proper analysis of the situation and to select the appropriate control strategy.

The **third part** on the judicious use insecticides against pests of food crops, discusses active ingredients, dosage, formulation, and application methods that are recommended according to the crop and infestation characteristics. It also reviews the possibilities of using other control techniques and the advantage of combining them with chemical treatments.

MAJOR PEST SPECIES

Pests of Roots and Collars

Soil pests of tropical food crops include insects, nematodes, and Myriapoda.

Insects

Orthoptera, Homoptera, Coleoptera, and Lepidoptera attack the root system, collar, or tubers of most tropical food crops. Damage can lead to:

— weakening, sometimes gradual deterioration of the plant;

— breaking and destruction of the stem, especially when the plant is young and fragile;

— deterioration of tubers or pods (groundnut).

Termites, crickets, several Coleoptera (Scarabaeoidea), and certain species of caterpillars are polyphagous. Damage increases with the density of pest populations in the rooting zone or soil surface. A deep, well-developed root system and vigorous stem base improve resistance of the host plant. The crop is therefore particularly vulnerable in the early growth stages or when poor cropping conditions (inadequate soil tillage, fertilization, water supply) make it less vigorous. Other soil pests are only harmful to certain food crops (e.g. several species of root scale insects) or a specific to one of them (e.g. sweet potato weevils).

Pests such as termites, certain Dynastidae adults, or the black cutworm (*Agrotis ipsilon*) can cause damage throughout the year. Others are only harmful during a particular, relatively short phase of their development. This is the case of certain white grubs (Melolonthidae) that only attack the root system during the second and mainly third larval stages.

The economic importance of soil pests has been rarely assessed with accuracy, except for the different species of white grub pests that used to cause or currently cause severe damage to sugarcane plantations in Africa, Madagascar, and the Mascarene islands.

Nematodes

Nematodes rarely exceed 1 mm in length. Root species live and reproduce in the roots (endoparasites) or live freely in the soil and attack surface tissue (ectoparasites). The pest can cause formation of occasionally very large root galls, and produce lesions or cracking. The weakened host is often prone to dwarfing and wilts; it may sometimes desiccate and die. Most root nematode species are polyphagous, particularly those belonging to the genera *Meloidogyne* and *Pratylenchus* that infest cereals as well as tropical Leguminosae, Cucurbitaceae, and Solanaceae.

Myriapoda

Millipedes are sometimes dangerous pests in young food crops. Although they generally live underground, they are very mobile and can climb the above-ground parts of a plant. Millipedes prefer sandy soils where they can bury themselves. They mainly cause damage in dry regions by feeding on young plants and by uprooting them while digging into the soil. Millet, sorghum, and mainly groundnuts are particularly susceptible to attacks by these diplopods.

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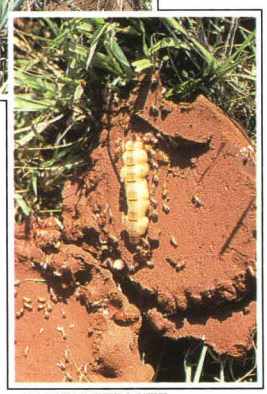
SOIL PESTS

COUNT OF WHITE GRUBS
IN A SUGAR CANE FIELD

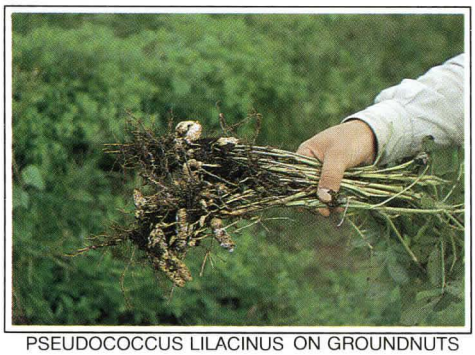
FULLY GROWN LARVA
OF EULEPIDA BAUMANNI

NEST MOUND OF TERMITES

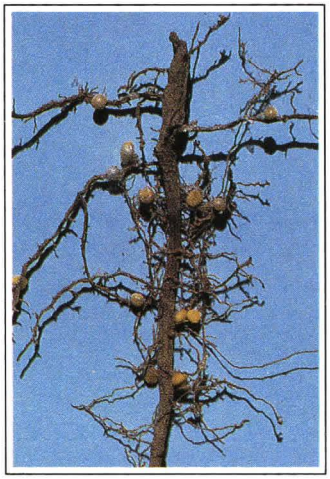


QUEEN TERMITE

CANE SHOOT DAMAGED
BY TERMITES



PSEUDOCOCCUS LILACINUS ON GROUNDNUTS



▲
GROUND PEARLS :
ENCYSTED LARVAE OF A
MARGARODID SPECIES
ON SUGAR CANE ROOTS

ADULT OF GONOCEPHALUM SP.

ADULT OF HETERONYCHUS SP.

I.R.A.T./C.I.R.A.D. – B.P. 5035 – 34032 MONTPELLIER CEDEX – Maquette: T.ERWIN – Photos: IRAT

Soil Pests of Tropical Food Crops

Main Pests

• Isoptera

Termites damage crops either by making the soil where there are termite mounds unproductive, by impeding agricultural equipment (termite mounds), or by destroying plant organs. They damage and hollow roots and collars or feed on leaves. The most common genera are *Hodotermes*, *Odontermes*, *Macrotermes*, *Microtermes*, and *Trinervitermes*. Damage is aggravated when the plants are also exposed to drought stress or poor soil fertility.

• Orthoptera

Crickets undermine plantings by burrowing beneath the soil surface or cut roots and collars of young plants. *Gryllotalpa africana* is a brown mole cricket, 40 mm long, that is very common in Africa. *Gryllus bimaculatus* and *Brachytrupes* sp. are common polyphagous African crickets.

• Homoptera

Scale insects attack roots and tubers of the host plants and weaken or destroy them. The most important are *Dysmicoccus brevipes* on groundnut and soybean; *Geococcus coffeae*, *Planococcus* sp., and *Aspidiella hartii* on yam; and several Margarodidae species on sugarcane.

Larvae of the American cercopids *Aeneolamia* spp. and *Mahanarva* spp. feed on sap from roots of cereals and sugarcane.

• Coleoptera

Tenebrionids of the genus *Gonocephalum*, during several months of their adult life, feed on collars and sometimes stems and leaves of legumes and cereals.

The African melolonthids *Shizonycha africana*, *Hoplochelus* spp., and *Eulepida baumanni* feed on roots of several tropical crops during the three larval stages (white grubs). The adults (beetles) are not harmful.

Adults of the African dynastids *Heteroligus* spp. and *Prionoryctes caniculus* (yam pests) as well as polyphagous species of the genus *Heteronychus* damage cuttings, roots, collars, and tubers. The larvae generally feed on decaying organic matter and are not harmful.

Curculionid (weevils) larvae cause damage to the underground parts of food crops in various tropical regions of the world. *Alcidodes* spp., *Cylas* spp., and *Euscepes postfasciatus* feed in sweet potato tubers, make tunnels and damage them so that they are unfit for consumption or sale. Several species of *Graphognathus* gnaw groundnut roots. In India, *Echinocnemus oryzae* attack roots of various Gramineae, including rice.

Larvae of the chrysomelids *Asbecesta* spp. and *Aulacophora africana* gnaw roots of cucurbits and certain tropical legumes and cereals.

• Lepidoptera

Caterpillars of the American pyralids *Elasmopalpus lignosellus* and *Megastes grandalis* feed on groundnut roots and pods and sweet potato tubers, respectively. Caterpillars of the highly cosmopolitan and polyphagous noctuid *Agrotis ipsilon* (black cutworm) cut seedlings at soil level.

Chemical Control Techniques

• Seed and tuber treatment

Seed dressing with an insecticide often combined with a fungicide can provide preventive protection to seedlings against most of the pests attacking roots and collars. Dipping tubers in an insecticide before planting also protects young plants from soil pests.

• Soil treatment

Soil treatment over the entire field or localized in furrows can also effectively protect food crops against soil pests, particularly termites, Coleoptera, and Lepidoptera.

• Poisoned baits

In small fields, poisoned baits are often the most efficient means for controlling black cutworms and crickets.

• Treatments on adult insects

Spraying insecticides on adults before oviposition on the crop is sometimes recommended, mainly for eradicating melolonthid adults and weevils of the genus *Cylas*.

Note: The list of available active ingredients for the four types of treatments is very long. Readers should refer to the other factsheets of this collection to identify the most suitable insecticide for controlling each of these pests.

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CANE GRUBS

Scarabaeoidea

SYMPTOMS IN A SUGAR CANE AREA

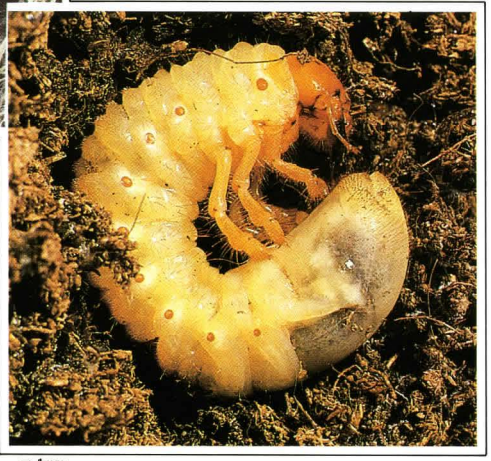
ADULT

1 mm

FOLIAGE OF CASHEW TREE WHERE BEETLES MATE AND FEED

SAMPLING IN A SUGAR CANE FIELD

LARVA IN HIS EARTHEN CELL



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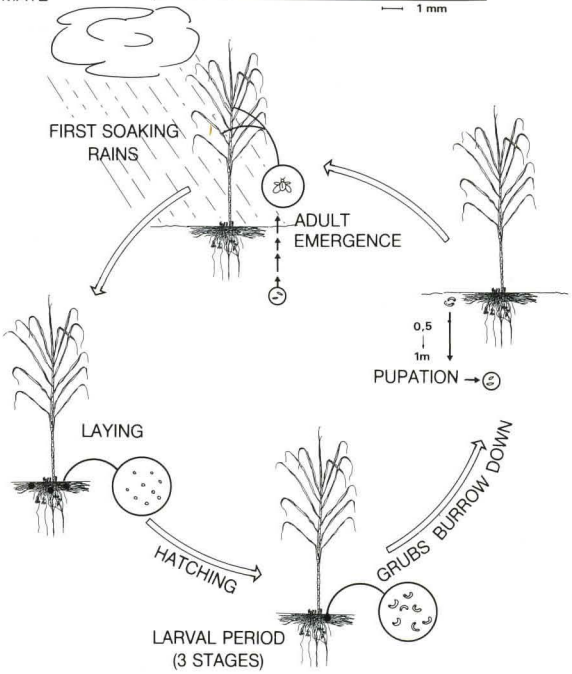


BIOLOGICAL CONTROL

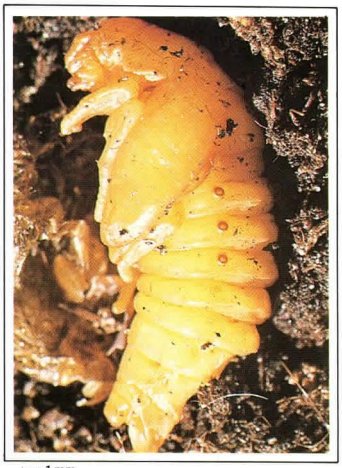
FUNGOUS DISEASE

"BLACK SPOT" DISEASE

PREDACIOUS BIRDS

LIFE CYCLE
OF A MELOLONTHID SPECIES

INCUBATION PERIOD		10-20 DAYS
LARVAL	–	7-9 MONTHS
PUPAL	–	6-8 DAYS
ADULT	–	1-2 MONTHS



1 mm

PUPA

IRAT / CIRAD - BP 5035 - 34 032 MONTPELLIER CEDEX - Maquette : T. ERWIN Photos IRAT

White Grubs of Sugarcane in Africa and the Indian Ocean Region

Identification and Distribution

The most serious pests among white grubs of sugarcane in Africa and the Indian Ocean region are Coleoptera (Scarabaeoidea) of the families Melolonthidae and Dynastidae. *Eulepida baumanni* in Burkina Faso, *Cochliotis melolonthoides* in Tanzania, *Hoplochelus rhizotrogoides* in Madagascar, *Hoplochelus marginalis* in Réunion, and *Clemora smithi* in Mauritius belong to the family Melolonthidae; while *Heteronychus licas* in South Africa and *Heteronychus plebejus* in Madagascar belong to the family Dynastidae.

Pest Biology

The beetles usually emerge from the soil after the first rains. Melolonthidae adults appear at sunset; they mate and feed on cane stools or tree foliage during the night. At dawn, they return to shelter under trash on the soil surface. Adults of certain Dynastidae remain on the soil and feed on roots of setts and base of tillers in young plantations. Eggs are oval, 2-4 mm long, white or creamy white and buried close to the soil surface. The females lay between 20 and 100 eggs, sometimes over a period of several months. Adults of certain species, (e.g. *H. plebejus*) may live for 1 year. The incubation period is 10-20 days. The grubs pass through three stages. Each of the first two stages in Melolonthidae lasts for about 1 month. The third stage involves a growth period of 2-3 months, followed by a resting period during which the grubs work their way deeper in the soil. They feed on decaying organic matter and sugarcane roots. Dynastidae larvae are mainly saprophagous. All these species have a 1-year life cycle.

Damage and Symptoms

Melolonthidae damage is mainly caused by third-stage grubs, which are heavy feeders. The extent of root damage depends on larval density. The symptoms are stress, characterized by orange-colored leaf edges and occasionally by complete desiccation of leaves; stems may also be desiccated if the root system is totally destroyed. In extreme cases, cane stools can be pulled up without any effort. Damage is aggravated when the crop is under water stress due to sandy soil, insufficient rainfall, or other factors. Symptoms may then appear even with relatively low densities of white grubs (20 000-30 000/ha). Dynastidae damage is caused mainly by beetles that destroy roots of setts and primary tillers during emergence.

Control Techniques

Tillage, particularly deep plowing during larval development, destroys a high percentage of the grub population.

Sugarcane white grubs can be eradicated by in-furrow application of insecticides before planting or side-dressing in ratoon crops. Active ingredients such as chlormephos, chlorpyrifos, and fonofos are currently replacing chlorinated hydrocarbons such as lindane or BHC where it is still permitted. In certain cases, insecticides can be sprayed over adult Melolonthidae mating and feeding sites.

Grub populations can also be reduced by soil treatment with microbial insecticides, such as the fungus *Metarhizium anisopliae*, or by releasing larval parasites such as *Campsomeris* spp.

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Stem Borers

The pests are larvae that develop within and tunnel the stem. They include Lepidoptera of the families Pyralidae and Noctuidae or Diptera of the families Diopsidae, Cecidomyiidae, and Muscidae. Table I presents certain African species that are commonly observed on cereals and sugarcane.

Many other species are also stem borers; they mainly belong to the genus *Chilo* (*C. diffusilineus*, *C, aleniellus*, *C. agamemnon*, *C. orichalcociliellus*), the genus *Sesamia* (*S. cretica*, *S. nonagrioides botanephaga*, *S. penniseti*), and the genus *Diopsis* (*D. apicalis*). Some of them are very similar and can only be distinguished on dissection and observation of the genitalia.

Caution: Identification errors

The borers recorded in the African countries on the Mediterranean coast are not present south of the Sahara, and vice versa. Similarly, many species present in Africa are not found in Madagascar and the Mascarene islands, and vice versa.

Caution: Accidental introductions

Certain species are polyphagous (e.g. *Eldana saccharina*, *S. calamistis*), others are specific to a single cultivated Gramineae (e.g. *C. sacchariphagus*, *C. zacconius*, *D. thoracica*). Some pests such as *S. calamistis* have continuous generations, others enter diapause or quiescence during a variably long period in the year (e.g. *Busseola fusca*). They either destroy young plants by feeding on the growing point (deadheart) or bore internodes leading to stem breaking, slow growth, or reduced sugar content (sugarcane borers); occasionally they may also feed on earheads (maize borers).

Understanding the biology and behavior of the pest is indispensable for selecting the best control strategy

When the plant is not destroyed but only weakened by stem borer damage, it is often difficult to evaluate probable loss (grain yield loss for cereals) in order to decide whether a treatment should be carried out. While selecting a protective treatment, its impact on the large number of beneficial parasites and predators should also be carefully considered.

The stem borer status in a crop should therefore be analyzed as accurately as possible.

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Table I. Host crops[1] and geographic distribution of certain stem borers of Gramineae.

	Lepidoptera								Diptera		
	Pyralidae						Noctuidae				
	Eldana saccharina	*Acigona ignefusalis*	*Maliarpha separatella*	*Chilo zacconius*	*Chilo partellus*	*Chilo sacchariphagus*	*Sesamia calamistis*	*Busseola fusca*	*Diopsis thoracica*	*Orseolia oryzivora*	*Atherigona soccata*
Rice	+		+ +	+ +	+		+ +		+ +	+ +	
Maize	+ +	+			+ +		+ +	+ +			
Millet	+ +	+ +					+ +	+ +			+
Sorghum	+ +	+ +			+ +		+ +	+ +			+ +
Sugarcane	+ +				+	+	+ +				
Africa	×	×	×	×	×		×	×	×	×	×
Madagascar			×		×	×	×				
Réunion						×	×				
Mauritius						×	×				
Other continent(s)			×		×	×					×

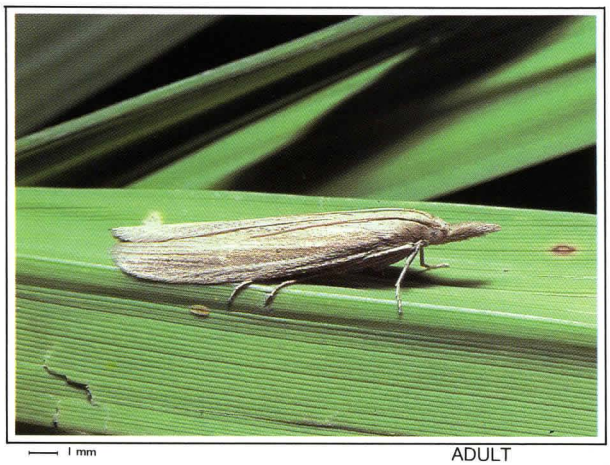
Legend: + + Common host crop.
+ Occasional host crop.
× Location.

[1]. Host crops listed here are those on which the pest passes its entire life cycle. Eggs and young larvae are sometimes found on other plants, but do not complete their life cycle on them.

MALIARPHA SEPARATELLA *Ragonot*

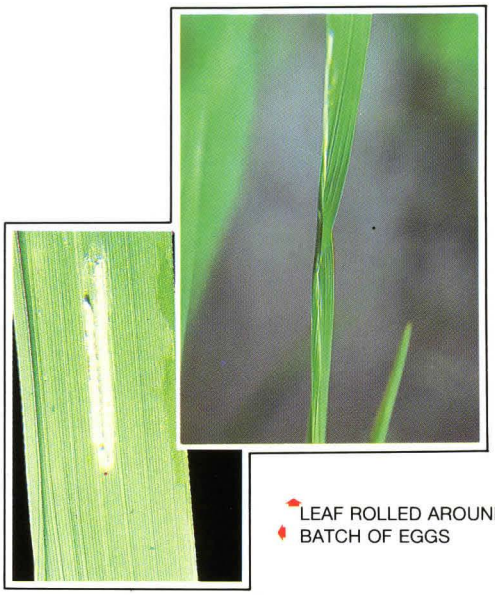
Pyralidae

WHITE RICE BORER



1 mm

ADULT



LEAF ROLLED AROUND EGGS
BATCH OF EGGS

1 mm

PUPA *IN SITU*

DAMAGE :
WHITE HEAD

LIFE CYCLE

INCUBATION PERIOD	8	DAYS	
LARVAL	–	20-70	–
PUPAL	–	10-60	–

1 mm

LAST-STAGE LARVA

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Maliarpha separatella

Description

The adult *Maliarpha separatella* Ragonot (Lepidoptera: Pyralidae) is 13-15 mm long and light brown in color. The leading edge of the fore wing carries a dark stripe. Eggs are laid in overlapping rows in a characteristic leaf fold. The larva is white in color and the pupa (approximately 20 mm long) is light brown.

Distribution and Host Plants

M. separatella occurs in most countries of Africa south and east of the Sahara, Madagascar, certain Asian countries (Burma, China, India, Sri Lanka), and Papua New Guinea.

All the known host plants belong to the genus *Oryza* (wild and cultivated rice).

Biology and Damage

Adults reach sexual maturity 1 or 2 days after emergence. The female deposits about 40 eggs 7-8 times during its life cycle, on the leaf blades of plants during tillering or stem elongation. The incubation period is about 8 days. Young larvae begin to feed on the leaf blade at the oviposition site, forming longitudinal stripes. Suspended on silk threads, they are later blown onto neighboring plants. They immediately penetrate between the leaf sheath and stem, and bore a hole in the stem to reach the median cavity where they complete their development. The larvae feed on the pith parenchyma and bore the nodes while migrating to another internode; vessels are not usually damaged, however. The larval period may last between 20 and 70 days. Pupation occurs in the first large internode above the collar, after the larva has formed a silk cocoon with an exit hole at one end for the adult to emerge. The pupal period varies between 10 and 60 days in duration. Several generations may be completed during the rice cropping season. During the dry season, the insects enter into quiescence on stalks at the last larval stage.

The borer is frequent only in irrigated rice fields. Damage during tillering, including deadhearts and destroyed tillers, is rare. During stem elongation and heading, the presence of larvae in the stems may cause panicle abortion; but the main effect is reduced average panicle and 1000-grain weight, resulting in low yields.

Control Techniques

Economic incidence of the borer can be high in certain countries such as Madagascar. Rice crops can be protected against *M. separatella* by adding granular insecticides in the water. Insecticides include lindane (1.5-2 kg a.i./ha), carbofuran (800 g/ha), and diazinon (1.5 kg/ha).

Chemical control may not be necessary in the case of low attacks—especially if they occur at a late stage of crop development—as the borer population is kept in check by a large insect parasite complex. Destruction of stalks by burning or burying, is recommended for eliminating quiescent larval carryover.

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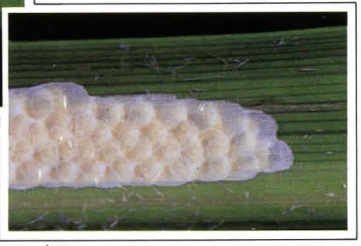
CHILO ZACCONIUS *Bleszynski*

Pyralidae

AFRICAN RICE BORER

FEMALE LAYING EGGS

EGG MASS



1 mm

LIFE CYCLE
25 °C

INCUBATION (5 DAYS)

1 mm

ADULTS

♂ ♀

ADULT EMERGENCE

HATCHING

PUPA (8 DAYS)

DAMAGE : "WHITE HEADS"

1 mm

PUPA "IN SITU"

PUPATION

5-7 LARVAL STAGES (20 DAYS)

1 mm

NEW-HATCHED LARVAE

1 mm

LAST-STAGE LARVA

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Chilo zacconius

Description

Adults of *Chilo zacconius* (Lepidoptera: Pyralidae, Crambinae) have orange-brown fore wings with black spots. Larvae are 15-20 mm long. The head and prothoracic plate are black, and the body is ivory-colored with purplish-red longitudinal bands. Pupae are initially brown, then black. This species should not be confused with *Chilo diffusilineus*.

Distribution and Host Plants

C. zacconius is present throughout the Sahelian region and wet tropics in West Africa. It is essentially a rice borer, but is also found on other Gramineae (e.g. maize) and weeds (e.g. *Echinochloa stagnina*, *Oryza barthii*, *Sorghum arundinaceum*).

Biology and Damage

Most adults mate upon emergence and eggs are laid within the next 5 days. The yellowish eggs are deposited on the leaf blades of rice plants, in batches of about 80 eggs that overlap like fish scales.

On young plants during tillering, larvae initially develop on the leaf surface and feed on the leaf epidermis. During the second and third stages, they pierce the leaf sheaths and tunnel the stem base, causing basal leaves to desiccate. Deadheart symptoms occur when the whorl desiccates.

On young plants during stem elongation, after the external stage, the larvae bore upwards in the stem, feeding on the stem pith. Tiller development, flowering, and heading are affected. Grain production is low to nil resulting in a white head. The same symptom can be observed when a late second generation of young larvae penetrates and bores the spike, causing the panicle to desiccate. Several larvae may be present together on the same stem, but a single larva may migrate to a number of stems. The incubation period is 4-5 days, and the larval period 3-4 weeks (5-7 stages). The larvae finally spin a cocoon and pupate in the stem cavity. The pupal period is about 1 week. During the dry season, larvae are capable of completing development in stubble and regrowth after the rice harvest.

Control Techniques

Chemical control is only justified for infestations of high-yielding rice crops. In Africa, this mainly applies to rice crops with inputs and controlled irrigation. Granular insecticides, such as lindane (2 kg a.i./ha per treatment), carbofuran (800 g/ha), or chlorfenvinphos (2 kg/ha), are recommended for such situations. The insecticides are spread two or three times in the water between tillering and heading.

Reflooding the rice fields after harvest makes it possible to eliminate larval and pupal carryover in rice stubble and regrowth.

Preservation of natural enemies of *C. zacconius* is the best form of preventive control. It is for this reason that adding granular insecticides to the water is preferred to spraying, whenever insecticide protection is necessary.

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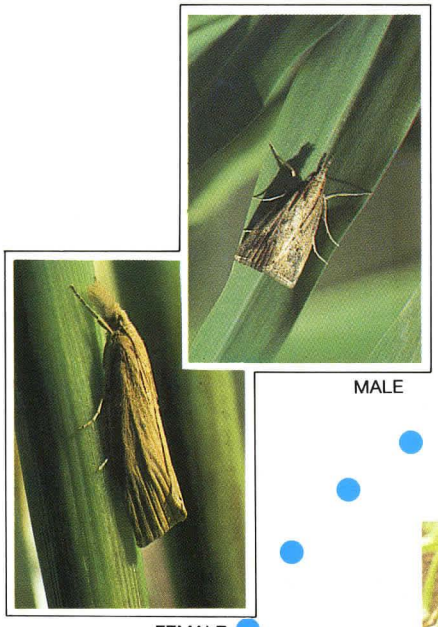
CHILO PARTELLUS *(Swinhoe)*

Pyralidae

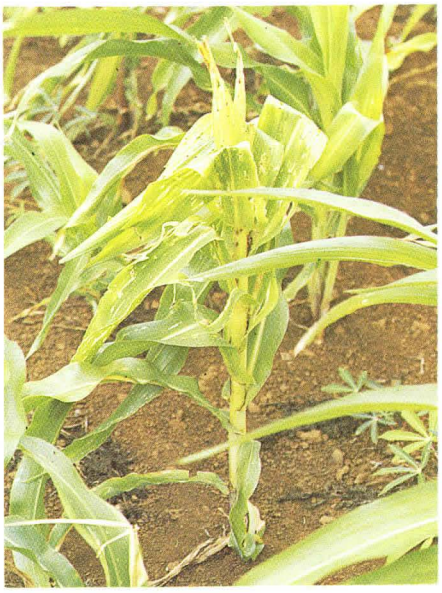
MAIZE STEM BORER



MALE

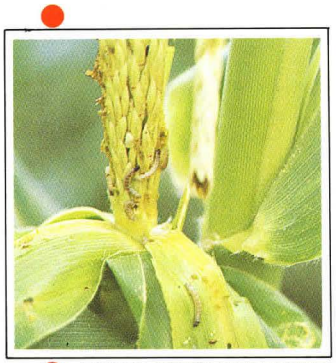
FEMALE

EGG MASS



DAMAGED LEAVES

DAMAGE



LARVAE IN INFLORESCENCE OF MAIZE

DAMAGED MAIZE COB

PUPAE IN A MAIZE STEM

LIFE CYCLE
AT 25 °C

INCUBATION PERIOD		5	DAYS
LARVAL	–	25	–
PUPAL	–	8	–
ADULT	–	8	–

LAST-STAGE LARVA

I.R.A.T/ C.I.R.A.D. – B.P 5035 – 34032 MONTPELLIER CEDEX- Maquette et photos : D.BORDAT T.ERWIN

Chilo partellus

Description

The stem borer *Chilo partellus* belongs to the family Pyralidae. Eggs are oval, flat, and white at the beginning of incubation. Larvae have spots on the dorsal side of their segments.

Distribution

The borer occurs in Asia (particularly India and Indonesia) and East Africa.

Host Plants

Maize and sorghum are the main host plants of *C. partellus*. Rice, sugarcane, and other cultivated and wild grasses may also support the pest.

Biology and Damage

The female deposits a total of 200-300 eggs in masses with a variable number of eggs on any green part, such as the stem, sheath, and leaf blades. They total 200-300 and are easily visible when they are located close to the midrib of a leaf. The incubation period is about 6 days. Young larvae initially feed on the unfurled whorl leaves. They then penetrate the major veins of older leaves, through which they often bore up to the stem internodes where they complete development. The larvae tunnel upwards and occasionally destroy the growing point. In late attacks, larvae may complete development by feeding on maize heads. During the hot season, the larval stage is 3-4 weeks. Pupation takes place inside the bored stems and lasts for about 8 days.

A part of the larval population is capable of surviving in maize stubble during the cold season. Development is temporarily arrested, and is completed during the following rainy season.

Symptoms of *C. partellus* attack are the appearance of shot-holes on leaf blades and an occasional drying of the leaf whorl. Developed internodes are also perforated. Damage produces deadhearts among young plants when the growing point is destroyed. Growth is retarded in maize, and intense boring of internodes may cause them to break. Malformation of maize heads or partial destruction may also occur. *C. partellus* infestation often coincides with that by other maize stem borers such as *Sesamia* spp. and *Eldana saccharina*.

Control Techniques

The date of treatment determines the effectiveness of chemical control operations. Insecticides should be applied when the majority of the *C. partellus* population is at egg or early larval (leaf-blade feeding) stage. Application of granular insecticides in the leaf axis and whorl ensures longest persistence. It is also the best way to preserve parasites and predators of borer larvae and eggs. Endosulfan, diazinon, carbofuran, and deltamethrin are some of the recommended insecticides.

Burning or plowing in of maize stubble eliminates overwintering larvae and is an important preventive measure.

The use of maize varieties with resistance to the stem borer is a solution that will be commonly adopted in the future, mainly for less intensive smallholder crops.

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CHILO SACCHARIPHAGUS

BÖJER *Pyralidae*

SUGAR CANE STEM BORER

⟵ 1 mm ADULT

LIFE CYCLE AT 25°C

LAYING

INCUBATION 6-7 days

EGGS ⟵ 1mm

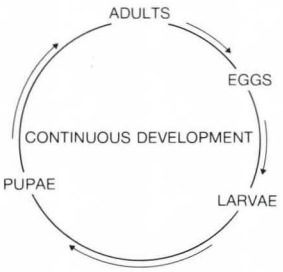
EXIT HOLES

BORED INTERNODES

EXTERNAL

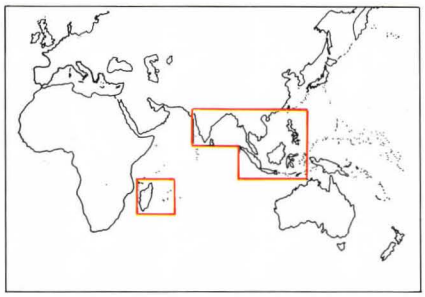
INTERNAL

DAMAGE



EGGS PARASITIZED BY TRICHOGRAMMA SP.

HATCHING



SPOTTED CATERPILLAR ⟵ 1 mm

LARVAL LIFE 45-70 days

PUPATION

7-10 days

EMERGENCE

PUPA ⟵ 1mm

IRAT/CIRAD - B.P 5035 - 34032 MONTPELLIER CEDEX Maquette : T ERWIN Photos : IRAT

Chilo sacchariphagus

Description

Chilo sacchariphagus Bojer (Lepidoptera: Pyralidae) is a sugarcane stalk borer that was first described 130 years ago under the name *Proceras sacchariphagus*. The adult is a moth with a wingspan of 3-4 cm. It is straw-colored, similar to dried leaves of the host plant. The female deposits batches of 20-40 eggs arranged in two overlapping rows. Eggs are oval and 1.6 mm long. Larvae are creamy white with purple longitudinal bands and brown dorsal spots. Fully grown larvae are about 25 mm long. Pupae are enclosed in a fragile cocoon 1.5 cm long.

Distribution and Host Plants

C. sacchariphagus originated in Southeast Asia and was accidentally introduced into the Mascarene islands. It is present in India, Indonesia, China, Philippines, Taiwan, Mauritius, Réunion, Madagascar, and perhaps Mozambique. The genus *Saccharum* is the only known host on which the borer can complete its life cycle.

Biology and Damage

Females generally deposit batches of eggs on green leaf blades. Between 300 and 850 eggs are laid within a few days. Young larvae rapidly disperse and either seek shelter in the leaf whorl, where they feed on the epidermis of unfurled leaves, or tunnel the midribs of older leaves. Third- or fourth-stage larvae abandon the leaves and penetrate between the stems and sheaths and into the internodes. They bore through the internode by feeding on the pith parenchyma. At the end of the sixth stage, the larvae generally leave the stem, making a small hollow on the inner side of the sheath of a dry leaf, spin a fragile cocoon of fine threads, and pupate. Occasionally pupation occurs in a tunnel bored in the internode. At 25°C, the incubation period is 6-7 days, the larval period 45-70 days, and the pupal period 7-10 days. Generations are produced in succession throughout the year, without diapause or quiescence.

The borer mainly damages the internodes; pol % cane and purity are reduced, resulting in poor quality stalks. Yield loss in terms of tons of cane/ha due to borer damage is generally low. However, early infestations can cause large-scale destruction of young tillers, and infested setts can lead to poor emergence. The percentage of bored stalks or internodes varies considerably, depending on the region, variety, and cultural techniques.

Protection of Sugarcane Plantations

C. sacchariphagus populations are reduced by a complex of indigenous or introduced parasites that destroy *C. sacchariphagus* eggs (e.g. *Trichogramma australicum*), larvae (e.g. *Apanteles flavipes*), and pupae (e.g. *Tetrastichus atriclavus*).

However, there is a high carryover from each generation that has the potential for causing large-scale damage; occasionally, up to 20-30% of the internodes are bored.

Chemical control is currently too costly or not feasible. Infestation risks can be reduced by integrated pest management based on the use of tolerant varieties, release of new parasites, and appropriate cultural techniques (establishment of nurseries, shorter crop cycle, early harvest).

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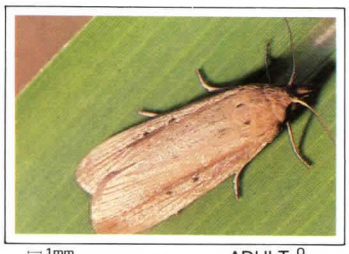
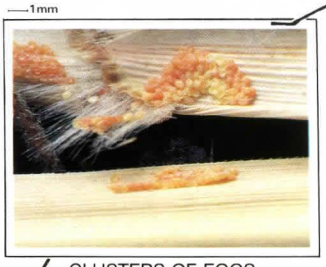
ELDANA SACCHARINA *Walker*

SUGAR CANE STALK BORER



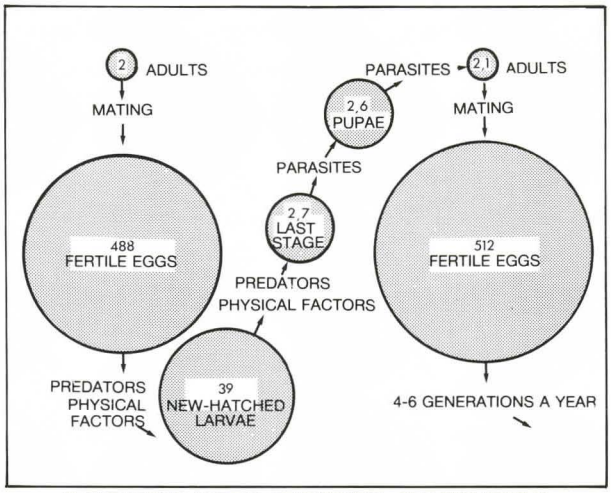
1mm

ADULT ♀



1mm

CLUSTERS OF EGGS
ON DRY LEAVES



DESTRUCTIVE ACTION OF PHYSICAL AND BIOLOGICAL FACTORS ON ELDANA SACCHARINA POPULATIONS

LIFE CYCLE
ON SUGAR CANE

INCUBATION PERIOD		10	DAYS
LARVAL	–	40-60	–
PUPAL	–	10	–

1mm

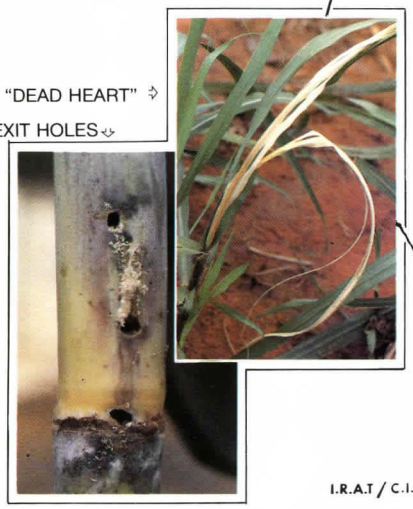
LARVA WITHIN AN
INTERNODE

MAIZE EAR DAMAGE

"DEAD HEART"

EXIT HOLES

SYMPTOMS
ON SUGAR CANE



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Eldana saccharina

Identification

Eldana saccharina Walker, a stem borer of sugarcane and tropical cereals, belongs to the subfamily Galleriinae of the family Pyralidae.

Distribution

The stem borer occurs only in Africa, throughout the tropical and equatorial zones (between 15°N and 30°S).

Host Plants

Sugarcane and maize are the two main host crops of this pest. Sorghum, millet, and certain weeds, including several species of the genus *Cyperus*, may also be attacked.

Biology and Damage

In 8 days, the female lays 450-500 eggs in batches of 50-100 that are often deposited on dry leaves at the base of the stem. The incubation period lasts for approximately 6 days. On sugarcane, young larvae start development on the plant surface and feed on epidermal tissue between the sheath and stem. During the second or third larval stage, they usually bore a tunnel close to a node to penetrate the stem. The larvae continue to develop within the plant until they pupate in the internodes. On maize, the larvae also bore into the head. Duration of the larval period varies considerably, ranging from 1 to 2 months, depending on the host, plant organ, and maturity of the internode. Pupation generally takes place within the stem and lasts for about 10 days. In sugarcane plantations, 4-6 generations are recorded per year.

In sugarcane, boring by the larvae in the stem pith reduces the sugar content. The percentage of sugar loss depends on that of bored internodes. It varies between 40% and 70% of the internode infestation rate, depending on the resistance of the varieties. Sugar loss due to *E. saccharina* is currently 2-8% in West African commercial plantations.

In maize, boring of the internodes causes them to break, particularly in windy locations, and retards head development and maturation. Grain feeding by the borers reduces market value.

Control Techniques

More than 95% of the population of each generation is destroyed by natural predators (ants, spiders, etc.) and parasites, and adverse physical factors (rain, wind, etc.). Pest control is therefore primarily based on maintaining or improving this biological balance so that it is unfavorable to the borer.

Chemical control of this species in sugarcane plantations is not very effective, both in terms of actual results and costs. Biological control by releasing insect parasites does not give satisfactory results. Priority should therefore be given to damage prevention by planting healthy or lindane-treated setts, adopting short crop cycles (12 months, if possible), and using resistant or tolerant varieties.

Maize crops can be protected against *E. saccharina* by spraying insecticides or applying granular insecticides at the leaf axis and in whorls. Active ingredients such as carbofuran, chlorpyrifos, fenitrothion, and certain synthetic pyrethroids are effective in controlling both *E. saccharina* and other pyralid and noctuid species that attack maize.

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ACIGONA IGNEFUSALIS

Pyralidae *(Hampson)*

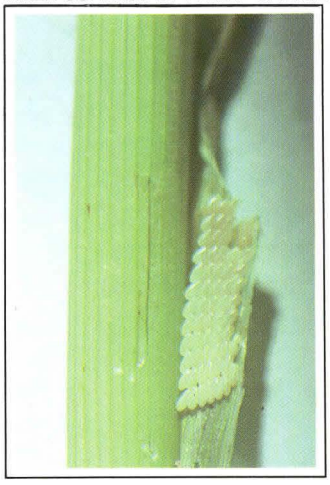
PEARL MILLET AND SORGHUM STEM BORER

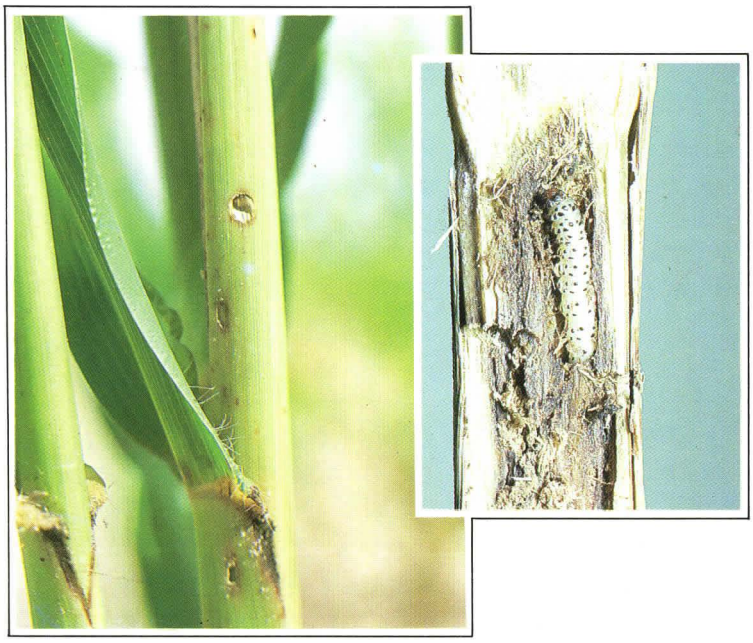
LIFE CYCLE

INCUBATION PERIOD		7-10	DAYS
LARVAL	–	28-35	–
PUPAL	–	10-11	–

ADULT

CLUSTER OF EGGS ON THE INNER SURFACE OF A LEAF-SHEATH



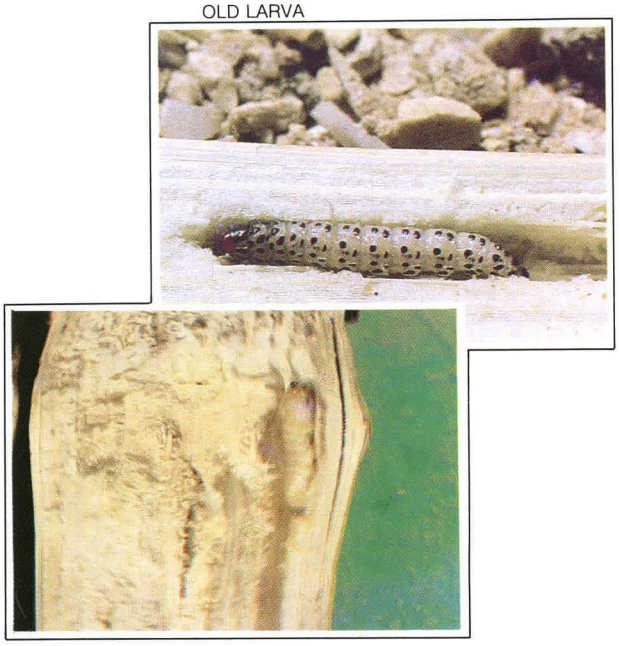


INTERNODE TUNNELLED BY A LARVA

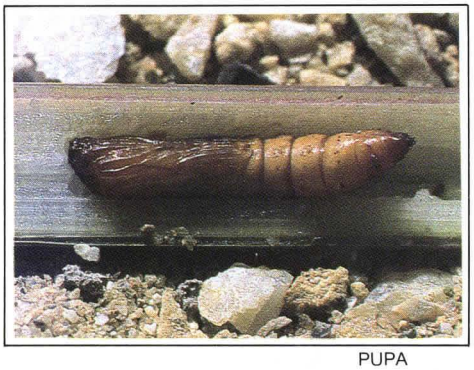
DAMAGE

SYMPTOM : BORED STALK

OLD LARVA



DIAPAUSING LARVA INSIDE A STUBBLE PEARL MILLET



PUPA

IRAT· CIRAD–B.P. 5035–34032 MONTPELLIER CEDEX– Maquette:T.ERWIN Photos: IRAT

Acigona ignefusalis

Description

The adult *Acigona ignefusalis* Hampson (Lepidoptera: Pyralidae) is a moth with a wingspan of 20-25 mm depending on the sex. The body and fore wings are fawn colored, the hind wings are white. Eggs are oval (0.8 x 0.5 mm) and without ornamentation. Larvae are milky white, with black oval spots; they measure 18-22 mm in length when fully grown. Pupae are slender (18-20 mm), with spines and sculptured appendages on the cremaster.

Distribution and Host Plants

The species is only found in West Africa. The main host plant is millet, but *A. ignefusalis* is sometimes found on sorghum, maize, and several wild grasses of the genus *Pennisetum*.

Biology and Damage

The female lays batches of 20-80 eggs placed close together in regular rows, under the upper part of leaf sheaths or the undersurface of young leaves. The incubation period is 7-10 days. Young larvae are initially gregarious; they perforate the leaf whorl and generally disperse at the third stage. They then insert themselves in the leaf sheath and begin to bore the internodes. The growing point is sometimes destroyed causing the plant to perish. The larvae then abandon the destroyed plant and continue to develop in the neighboring stems. They bore the stems and tunnel upwards, feeding on the parenchyma. The larval period lasts 4-5 weeks. Pupation takes place in the stem and lasts for 10-11 days in the rainy season. Duration of the life cycle is 45-50 days. There are three generations per year. A part of the second-generation larval population and all the third-generation larvae enter into diapause in millet stems during the dry season. The diapause may be broken from the month of April the next year, but pupation only starts after the first rains (at least 5-10 mm) of the next wet season.

Damage is characterized by a reduction of stem density in the case of early attacks, and a decrease in the percentage of productive tillers. The stems or spike may also be broken in the case of early millets. Symptoms of *A. ignefusalis* may coincide with those of other borers such as *Sesamia* sp., *Eldana saccharina*, and *Chilo* sp. The effect of *A. ignefusalis* attack on millet yields is sometimes low, in spite of a high percentage of bored stems.

Control Techniques

Early and simultaneous plantings in a millet-growing area reduce risk of high infestation. Destruction of stalks that support larval carryover, is an effective preventive measure; but it is not usually carried out since the straw is used for constructing roofs and hedges.

Use of thick-stemmed early varieties (90-95 days) can improve tolerance. Indigenous predators, such as *Syzeuctus* sp., *Euvipio* sp., *Goniozus* sp., are generally not sufficiently efficient; however, insecticide treatments are often not justified because they are not practical and cost-effective.

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SESAMIA CALAMISTIS *Hampson*

Noctuidae

PINK STALK BORER

LIFE CYCLE AT 25 °C			
INCUBATION PERIOD	–	5	DAYS
LARVAL	–	35-60	–
PUPAL	–	10-12	–
ADULT	–	3-5	–

1 mm ⟵ ADULT

BREAK OF A MAIZE STEM BORED BY A LARVA

DAMAGE

- ON MAIZE ⟹
- ON SUGAR CANE SHOOTS ⟹

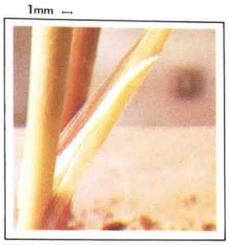
① EXIT HOLE ON A SUGAR CANE SHOOT
② SYMPTOMS OF "DEAD HEART"

1mm ⟵ PUPA

SERIOUS DAMAGE
ON YOUNG SHOOTS

1mm ⟵ LARVA WITHIN A SHOOT

1mm ⟵



CLUSTER OF EGGS ON
THE INNER SURFACE OF
A LEAF-SHEATH

I.R.A.T / C.I.R.A.D - B.P 5035 - 34032 MONTPELLIER CEDEX - Maquette : T. ERWIN Photos : IRAT

Sesamia calamistis

Description

The adult *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae) is a moth with a wingspan of 22-36 mm. The head and thorax are covered with long hairs and the fore wings are ocher-colored. Eggs are spherical but flattened at both poles and measure about 0.7 mm in diameter. They have lateral streaks and change from light yellow to pink during the incubation period. Larvae are pink and reach about 35 mm in length. Pupae are bare and measure about 20 mm.

Distribution and Host Plants

S. calamistis is present throughout sub-Saharan Africa and in Madagascar, Réunion, Mauritius, and Comoro. The main host crop is maize; however, other cereals such as sorghum and rice, sugarcane, and several wild grasses are also attacked by this stem borer.

Biology and Damage

The female lays up to 350 eggs in 3-5 days. The eggs are deposited in batches of 10-40 eggs that are arranged in 2-4 contiguous rows and inserted between the lower leaf sheaths and stems. Several hours after hatching, the larvae leave the oviposition site to penetrate the stems either directly or after feeding on the leaf sheath. The larval period lasts for 30-60 days depending on climatic conditions and usually involves 5-6 molts. Larvae may successively attack a number of young stems if the stems die before the larvae complete development. Only one mature larva is observed per young stem or tiller. Pupation generally takes place in the stem, and rarely between the sheath and stem. The pupal period lasts for 10-12 days at 25°C. Under tropical conditions 5-6 generations are completed per year.

S. calamistis mainly damages young plants or young tillers. The borer tunnels upwards and feeds on the growing point. The stem is destroyed and the whorl desiccates. The economic incidence is measured in terms of the number of plants (maize, sorghum) or tillers (rice, sugarcane) destroyed per hectare. Infested rice and sugarcane plants produce side tillers to compensate for the loss. In older plants, stem tunnelling can cause head sterility (white heads in rice), or stem breaking (maize, sorghum), particularly in windy locations.

Control Techniques

Vigorous plants or those with many tillers are more resistant to the borers. Shredding, burning, or plowing in of stubble after harvest eliminates carryover.

Chemical control serves two purposes:

— As a preventive measure, the insecticide is added to the water in the field or in the furrows. Granular carbofuran (1-1.5 kg a.i./ha) or granular lindane (1.5-2 kg/ha) are recommended for treatments after transplanting rice or before planting maize and sorghum.

— As a curative treatment, the insecticide is sprayed on young plants when most of the eggs hatch, or granular insecticides are deposited in the leaf whorl. Carbaryl (100 g/hl), endosulfan (500 g/ha), or trichlorfon (150 g/hl) are used for spraying, while carbofuran (1 kg/ha), diazinon (150 g/ha), or fenitrothion (800 g/ha) are used for whorl treatments.

In Africa, indigenous natural enemies such as *Apanteles sesamiae* attack *S. calamistis* larvae, whereas *Pediobius furvum* destroy the pupae. These two insect parasites were introduced and are now established in Madagascar and certain Mascarene islands.

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BUSSEOLA FUSCA

MAIZE AND SORGHUM STEM BORER

ADULT

LIFE CYCLE

INCUBATION PERIOD		6-6 DAYS
LARVAL	"	30-45 DAYS
PUPAL	"	10-20 DAYS

CLUSTER OF EGGS ON THE INNER SURFACE OF A LEAF SHEATH

STALK MINED BY A LARVA

FULLY GROWN LARVA

PUPA

PUPATION

PUPATION

DIAPAUSE

DIAPAUSING LARVA INSIDE A DRIED STEM

IRAT / CIRAD - B.P 5035 - 34032 MONTPELLIER CEDEX - Maquette et photos : T.ERWIN

Busseola fusca

Description

The adult *Busseola fusca* (Lepidoptera: Noctuidae) is a butterfly with a wingspan that can exceed 40 mm in the female. Fore wings are brown and edged with small black spots; hind wings are gray-white and without spots. Newly laid eggs are hemispherical, striped, white-cream in color, and about 0.8 mm in diameter. Caterpillars are yellowish-white with a dark longitudinal band on each side of the body, and measure about 4 cm in length when fully developed. Pupae are bare.

Distribution and Host Plants

B. fusca occurs only on the African continent. It was recorded in most countries except those bordering the Mediterranean. In West Africa, populations of this noctuid are higher in the humid tropical regions than in the savannah. In East Africa, infestation is heaviest in high-altitude regions.

The two main cultivated hosts of the borer are maize and sorghum. Many wild grasses of genera such as *Pennisetum*, *Panicum*, *Saccharum*, can also support this pest.

Biology and Damage

In 3 or 4 nights, the female can lay several hundreds of eggs in batches of 30-50, inserted between the sheath and stem. Incubation lasts about 1 week. Young larvae feed first on the young blades of the leaf whorl and then, suspended from silk strands, they spread to neighboring plants. They penetrate into the stems by boring through the whorl base. They generally destroy the growing point and tunnel downward. The larvae pass through 6-8 stages in 30-45 days. Before pupation in the tunnels, they pierce an outlet for the adult. Pupation lasts 10-20 days. Up to four generations are produced per year. At the end of the rainy season the larvae of the last generation enter into diapause in maize and sorghum stubble or in wild grasses. They pupate a few months later just before the start of the following rainy season.

When the larva destroys the growing point of a young stem, the plant dies. The leaf whorl desiccates, producing the classic deadheart symptom. Damage intensity is thus measured by the number of destroyed stems. In an older crop, larvae do not always feed on the growing point, but bore internodes so that stem growth and earhead formation and maturation are retarded. Wind may cause stems to break. Larvae of the last generation may feed on grain on the earhead. Yield losses due to *B. fusca* therefore vary according to the region and year. They sometimes exceed 50%.

Control Techniques

As in the case of other noctuid cereal stem borers, *B. fusca* populations are destroyed by several parasites and predators. However, in most cases preventive measures or control treatments are required to reduce damage.

Stalks are buried or burned to eliminate diapausing larvae. Careful selection of planting dates by taking into account adult population dynamics, is another cultural technique that has proved to be effective.

When insecticide treatments are cost-effective, maize or sorghum crops can be protected by:

- **Preventive treatments**, using an insecticide that is absorbed by the roots and circulated through the young plant, for incorporation in the soil or plant furrow. Carbofuran granules are recommended in this case.
- **Control treatments**, through foliar sprays or application of granules in the leaf whorl and axil, when density of newly hatched larvae is highest. Carbaryl, endosulfan, trichlorphon, and fenitrothion are recommended for both types of applications.

Development of maize and sorghum varieties with resistance to stem borers, particularly *B. fusca*, is under way in Africa.

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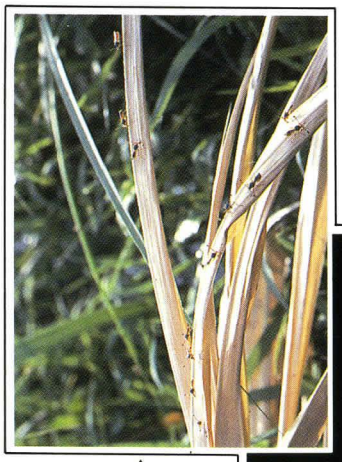
DIOPSIS THORACICA *Westwood*

Diopsidae

STALK-EYED RICE BORER

SWARM OF ADULTS ON WEEDS



INCUBATION 2-3 DAYS

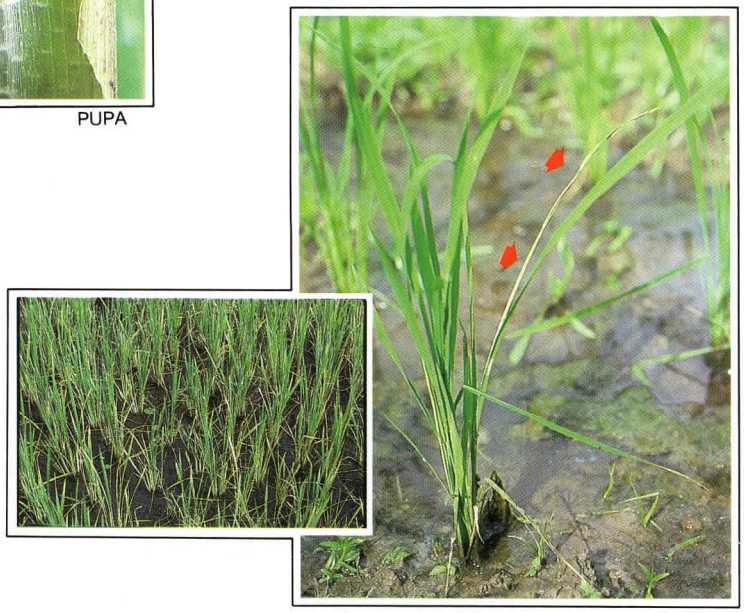
OLD LARVA

LARVAL PERIOD : 25-33 DAYS

PUPA

PUPATION 10-12 DAYS

LIFE CYCLE - 25 °C



DAMAGE

- "DEAD HEART"
- AFFECTED PADDY FIELD

IRAT / CIRAD - B.P. 5035 - 34032 MONTPELLIER CEDEX Maquette : T. ERWIN Photos : B. SAUPHANOR

Diopsis macrophthalma (= D. thoracica)

Description

The adult *Diopsis macrophthalma* (Diptera: Diopsidae) is 8-10 mm long and is easily identified by its pedunculate eyes. The thorax is shiny black and the rest of the body reddish. Eggs are elongate and ribbed. Larvae (maggots) may grow to a length of 17 mm. They are white and transparent, with elongated appendages at the anal extremity. Pupae are reddish-brown and 10 mm long.

Another species, *Diopsis apicalis*, is also commonly found in rice fields, but is less destructive. It can be distinguished by a smoky spot at the end of each wing.

Distribution and Host Plants

D. macrophthalma is widespread in Africa, mainly in the wet tropics and equatorial regions.

The pest only attacks cultivated and semiwild rice species. It is more frequent in irrigated rice crops, than in upland crops.

Biology and Damage

In the off-season, adults gather in swarms on weedy vegetation bordering the rice fields, where the females undergo an ovarian pause. Sexual maturity is attained with the onset of the rainy season, and females begin laying isolated eggs on the upper surface of leaves of young nursery plants, and later at the base of tiller sheaths in rice fields. They lay an average of about 30 eggs. Newly hatched larvae penetrate the stem through the whorl, and destroy the growing point. Early symptoms are yellowing of the terminal leaves on the tiller, followed by deadhearts, leading to loss of the tiller. Pupation takes place between the sheath and stem of the last tiller infested by the larvae.

A larva may successively attack 2-3 tillers, or more on young plants, and finally destroy the entire rice plant. In staggered plantings, the pest population moves from the oldest plots to younger plots, which are best suited for their development. Infestation generally reaches a peak 30-40 days after transplanting. Late attacks can often cause grain abortion (white heads).

The incubation period is 2-3 days, larval period 25-35 days, and pupation 8-12 days.

Control Techniques

Preventive chemical control is recommended in regions within the pest range. Granular insecticides should be applied 1 week and 1 month after transplanting. Lindane (2 kg a.i./ha), diazinon (2 kg/ha), carbofuran (800 g/ha), or isofenphos (1 kg/ha) can be used. The first posttransplanting treatment can be replaced by a double-dose treatment in the nursery; the system is equally effective but costs less.

Application of insecticides on border vegetation that supports adult swarms during the off-season, can be useful in the case of small irrigated rice crops.

Varieties with abundant tillering, which are capable of producing compensatory tillers after early destruction of the original tillers, should be recommended in areas where this pest usually causes heavy damage.

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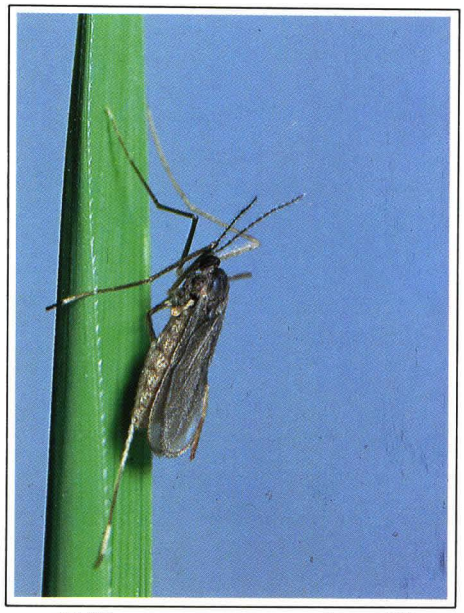
ORSEOLIA ORYZIVORA

Cecidomyiidae *Harris et Gagné*

AFRICAN RICE GALL MIDGE

LIFE CYCLE

INCUBATION PERIOD	2-5	DAYS
LARVAL "	10-20	DAYS
PUPAL "	3-5	DAYS



ADULT — 1mm

PUPA INSIDE THE TUBULAR GALL — 1mm

DAMAGE

SYMPTOMS OF REDUCED LEAF LAMINA

RICE TILLERS TRANSFORMED INTO TYPICAL "ONION SHOOTS"

PUPAL EXUVIUM PROTRUDING IN THE UPPER PART OF THE GALL

I.R.A.T./C.I.R.A.D. - B.P. 5035 - 34032 MONTPELLIER CEDEX - Maquette : T.ERWIN Photos : IRAT

Orseolia oryzivora

Description

The adult *Orseolia oryzivora* (Diptera: Cecidomyidae) is an African species that was long confused with the Asian species *Orseolia oryzae* (syn. *Pachydiplosis oryzae*). It measures 4-5 mm in length and is red but the antennae, eyes, and thorax are a dark brown. Eggs are elongate (0.5 mm), white, and turn yellow just before hatching. The larva is vermiform, white, with two pairs of terminal spines in the first two stages of development. The pupa is pink, with rows of inclined spines on its back.

Distribution and Host Plants

The midge is only found in Africa, in 15 countries mainly located in West Africa. It attacks cultivated and wild species of the genus *Oryza*.

Biology and Damage

The female deposits between 100 and 200 eggs, singly or in clusters of 3-5 eggs, at the base of the rice stems, on ligules and the undersurface of leaf sheaths, and sometimes on the water surface. The incubation period is 2-5 days. Young maggots enter between the sheath and stem to penetrate the stem by tearing the tissue. It then descends to the collar and produces a gall where it completes development (10-20 days). The upper portion of the gall is a hollow, white, and sometimes very long tube that resembles an onion shoot. The larva pupates in the tube and 3-5 days later the pupa works its way into the upper part of the tube and hatches. The pupal skin generally remains in the tube. There is only one larva per gall, but it may attack other tillers simultaneously or in succession.

A typical symptom is the appearance of onion shoots that slowly turn yellow and die. Each of these represents a destroyed stem. Crops at tillering stage, 20-40 days after transplanting, are most susceptible. Damage is generally higher in irrigated crops compared with floating and rainfed crops. Proximity of crops with a wide range of planting dates creates an environment that is favorable to pest development.

Successive generations of *O. oryzivora* are produced throughout the rainy season. During the dry season, a large part of the midge population overwinters as larvae in cropped or wild rice regrowths. The galls in which they diapause are buried in the soil.

Control Techniques

In Africa, *O. oryzivora* populations are reduced by a large complex of indigenous predators and parasites, some of which can destroy more than 50% of the midge larvae at the end of the cropping season. The main crop protection measure is therefore preservation of beneficial auxiliary fauna.

Chemical control of the pest is included in a global strategy for controlling rice stem borers. Treatment of rice field water with granular insecticides such as carbofuran (800 g a.i./ha), diazinon (1.5 kg/ha), or lindane (1.5-2 kg/ha) is recommended. Immersion of young plants, just before transplanting, in a solution of one of these insecticides is also recommended as a preventive measure.

In Africa, midge resistance is not included as a selection criterion for variety development because it is a sporadic pest.

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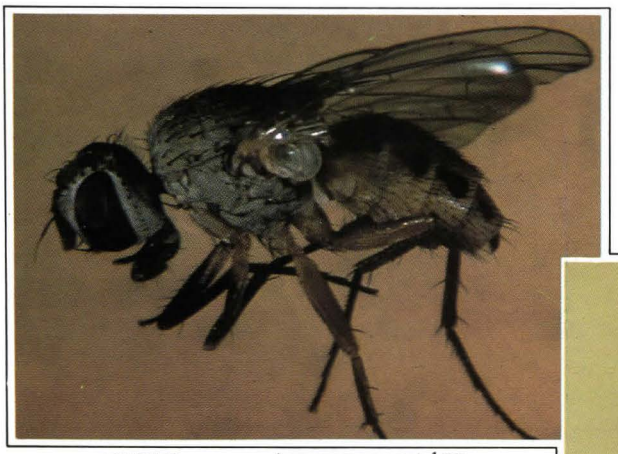
ATHERIGONA SOCCATA

Muscidae *Rondani*

SORGHUM SHOOT FLY



FEMALE 1 mm

EGGS ON A SORGHUM LEAF

MATURE LARVA IN A SORGHUM STEM 1 mm

1 mm

EGG

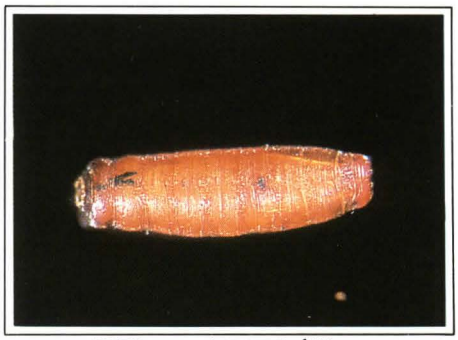
DAMAGE

"DEAD HEART"

SORGHUM SHOOT

PEARL MILLET SHOOT

LIFE CYCLE AT 25 °C			
INCUBATION PERIOD		2-3	DAYS
LARVAL	–	6-15	–
PUPAL	–	6-8	–



PUPA 1 mm

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Atherigona soccata

Description

The adult *Atherigona soccata* Rondani (Diptera: Muscidae) is a small gray fly, 3-4 mm long. Eggs are cylindrical and white. The larvae are maggots that change from pale to clear yellow as they grow. Fully grown larvae measure 6-8 mm in length. Pupae are small (4-5 mm long), barrel-shaped, brownish-red, with a truncated anterior end.

Distribution and Host Plants

The pest mainly occurs in Africa, India, Thailand, and southern China. But it was also reported in northern Italy. It is not present in the New World, Indonesia, and Oceania.

A. soccata mainly infests several species of the genus *Sorghum*, including the cultivated species *S. bicolor*. It is also found on other crops, such as millet, or certain wild grasses.

Biology and Damage

The female deposits eggs singly on the undersurface of leaves of young sorghum plants. The maggots hatch 2-3 days later. They bore the whorl and tunnel through the stem, destroying the growing point. They pass through three development stages in 8-15 days and feed on healthy and decaying tissue. Pupation generally takes place in the stem, and sometimes in the soil. The pupal period is almost 1 week. During the rainy season, a single generation may last 3-4 weeks. Up to 10 generations are produced in a single year.

Sorghum plants are exposed to attack from the seedling stage, 4-6 days after emergence, until almost 1 month later. Symptoms are desiccation of the leaf whorl and deadhearts. Sufficiently vigorous plants may produce side tillers that are also liable to be attacked. Late sorghum plantings are the most susceptible. Sometimes the percentage of young plants destroyed is very high and flowering is seriously delayed.

Control Techniques

Early and simultaneous planting throughout a sorghum-growing area and dense crop stands reduce risk of *A. soccata* infestations. Adequate fertilization increases plant vigor and the ability to produce side tillers.

Preventive chemical control is only justified in relatively intense cropping situations. Seed dressing (1 g diethion or carbofuran/kg of seed) or soil application of granular systemic insecticides (disulfoton, carbofuran, diethion, etc.) is recommended in this case.

Breeding programs, based on antibiosis and nonpreference for oviposition, have led to the development of shoot fly-resistant lines. These are currently being used in sorghum variety improvement programs in Africa and India.

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Foliage Feeders

Several species of insects feed on leaves of tropical food crops. The damage can have two types of consequences:

— either it retards growth and the plant may die when it is young and fragile or a large part of the leaf area is destroyed;

— or it reduces the quality and market value of leaves that are sold as vegetables (salads, cabbage, etc.).

Foliage feeders belong to four orders: Orthoptera, Lepidoptera, Coleoptera, Diptera.

Orthoptera

Grasshoppers and locusts are known to be heavy feeders. In the gregarious phase, a locust can consume the equivalent of its weight of leaves and other plant organs in a day. Grasshoppers also massively destroy leaves during an outbreak.

Lepidoptera

Many species are polyphagous, but they mainly destroy leaves of Gramineae, Leguminosae, and Cruciferae (Table II). Most of them are noctuids, such as *Spodoptera* spp. and *Trichoplusia ni*, but other caterpillars are specific to a single plant family such as the pyralid *Crocidolomia binotalis* that is only found on Cruciferae or *Palpita* spp. on Cucurbitaceae.

Almost all Lepidoptera consume the entire leaf blade, leaving only the main veins. Some, however, are leaf miners such as *Phthorimaea operculella* and only leave one epidermis or both. Most stem boring pyralids and noctuids of Gramineae feed on young leaves folded in the whorl during the first larval stages.

Coleoptera

Species of ladybirds, chrysomelid beetles, and weevils are leaf feeders. Generally, both larvae and adults are capable of causing damage. They are less voracious and harmful than grasshoppers and locusts or Lepidoptera. However, several hispa species are among the most serious rice pests in certain regions. Certain weevil species are big feeders of legume or tuber crop leaves.

Diptera

Several agromyzid larvae are leaf miners. The genus *Liriomyza* includes several species that attack Leguminosae, Solanaceae, and Cucurbitaceae. Larvae of the species *Ophiomyia phaseoli* mine leaf blades of legumes.

Incidence of all foliage feeders on yield levels varies over time and across locations. Damage is heavy and unpredictable, but also sporadic and localized, especially in the case of certain migrating species such as *Spodoptera* spp.

In other cases, such as many leaf-feeding ladybirds, the pests are commonly observed but do not affect plant growth. However, as in the case of *Plutella xylostella* on cabbage, almost regular treatments are required to protect potential hosts. Damage can be catastrophic as in locust invasions.

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Table II. Host families and geographic distribution of leaf-feeding Lepidoptera.

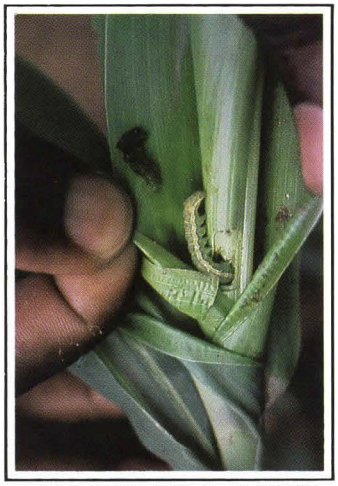
	Phthorimaea operculella	*Hymenia recurvalis*	*Marasmia trapezalis*	*Parapoynx stagnalis*	*Plutella xylostella*	*Crocidolomia binotalis*	*Hellula undalis*	*Palpita indica*	*Eublemma gayneri*	*Selepa docilis*	*Mythimna loreyi*	*Spodoptera littoralis*	*Spodoptera exigua*	*Spodoptera exempta*	*Spodoptera mauritia*	*Trichoplusia ni*	*Chrysodeixis chalcites*	*Agrotis ipsilon*	*Amsacta moloneyi*
Gramineae		•	•	•					•		•	•	•	•	•		•	•	•
Solanaceae	•									•		•	•			•	•	•	•
Cruciferae					•	•	•					•	•		•	•	•	•	
Cucurbitaceae		•						•		•		•	•			•	•		
Leguminosae												•	•			•	•	•	•
Africa	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Madagascar	×	×	×	×	×	×	×	×	×			×	×	×	×	×	×	×	
Réunion	×	×	×		×	×	×	×				×	×		×	×	×	×	
Mauritius	×	×	×	×	×	×	×	×			×	×	×		×		×	×	
Other continent(s)	×	×	×	×	×		×				×	×	×	×	×	×	×	×	

LEAF-FEEDING CATERPILLARS

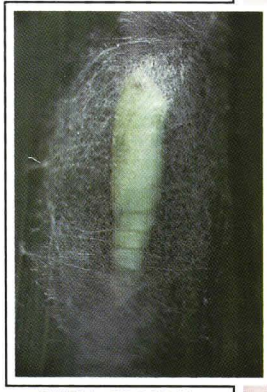
LARVA

DAMAGE ON BEAN LEAVES

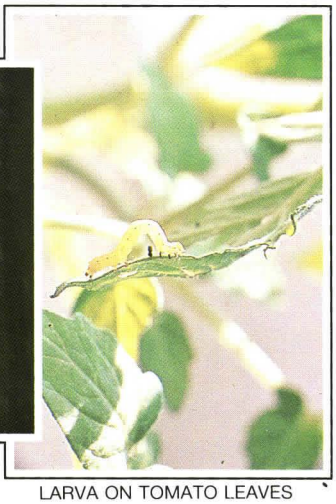
SPODOPTERA SP.



LARVA OF HELIOTHIS ARMIGERA
IN A MAIZE WHORL



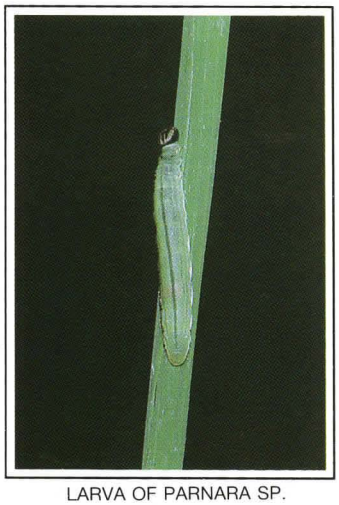
PUPAL COCOON



LARVA ON TOMATO LEAVES

CHRYSODEIXIS CHALCITES

LARVA OF MARASMIA TRAPEZALIS
ON A MAIZE LEAF



LARVA OF PARNARA SP.
ON A RICE LEAF

LARVA OF SPILOSOMA SP. ON A RICE LEAF

LARVA OF AMSACTA SP.
ON A COWPEA LEAF

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Polyphagous Leaf-feeding Caterpillars of Tropical Food Crops

Major Pest Species

Most of the polyphagous leaf-feeding caterpillars of tropical food crops belong to the family Noctuidae and some to the other Lepidoptera families, mainly Pyralidae.

• Noctuidae

Several species of the genus *Spodoptera* (*S. littoralis*, *S. litura*, *S. exempta*, *S. exigua*, *S. frugiperda*) attack cereals and legumes (see factsheet "*Spodoptera* spp. Pests of Leguminosae"). The sudden appearance of migrating adults makes it difficult to predict a pest attack. Groups of several hundreds of eggs covered with scales are laid on leaves. Fully grown caterpillars can be between 30 and 40 mm in length; they are voracious feeders and sometimes eat the entire leaf except the midrib.

Mythimna spp. (syn. *Cirphis*) lays batches of eggs in the leaf whorls or between the sheaths and stems of cereals and wild grasses. Fully grown caterpillars are brown-gray and about 30 mm long. They become gregarious and feed voraciously on the host until it is destroyed. They pupate in a white silk cocoon in the soil.

Chrysodeixis chalcites (syn. *Plusia*) develops on Gramineae, Solanaceae, Cruciferae, and Leguminosae. Caterpillars are green, slender, and 3 cm long when fully grown. They move by looping and feed on leaf blades producing irregular holes.

Trichoplusia ni is mainly found on Leguminosae, Solanaceae, Cruciferae, and Cucurbitaceae. Caterpillars resemble those of *C. chalcites* and cause the same type of damage.

• Pyralidae

Marasmia trapezalis lives on cultivated and wild Gramineae. Caterpillars are green-yellow and 20 mm long. They produce a characteristic refuge by joining the two edges of leaf tips with silk strands. They feed on the leaf parenchyma and cause leaf tips to dry.

Hymenia recurvalis is mainly found on cereals and cucurbits. Caterpillars are initially green, then turn brown-orange. They bind several leaves together with silk strands and feed on palisade tissue. They pupate in a cocoon in the soil.

• Arctiidae

The most common genus that is observed on legumes or cereals is *Amsacta*. Caterpillars of *A. moloneyi* are very hairy and yellow, with brown specks. They feed heavily on leaves and pupate in the soil.

Control Techniques

The presence of leaf-feeding caterpillars in food crops does not always warrant crop protection treatments. No treatment is required when leaf damage is low or late and has therefore no significant effect on yields. If, however, a severe attack weakens the plant or reduces production, especially when the leaves are sold or consumed (cabbage, salads), the crop should be protected against leaf pests.

In this case, the most common practice is to spray leaves with insecticide. Low-persistence insecticides are used when the leaves are consumed as vegetables. Some of the recommended active ingredients are endosulfan (500 g a.i./ha), methomyl (40 g/hl), synthetic pyrethroids (3-8 g/hl, according to product), or *Bacillus thuringiensis* (for certain noctuids).

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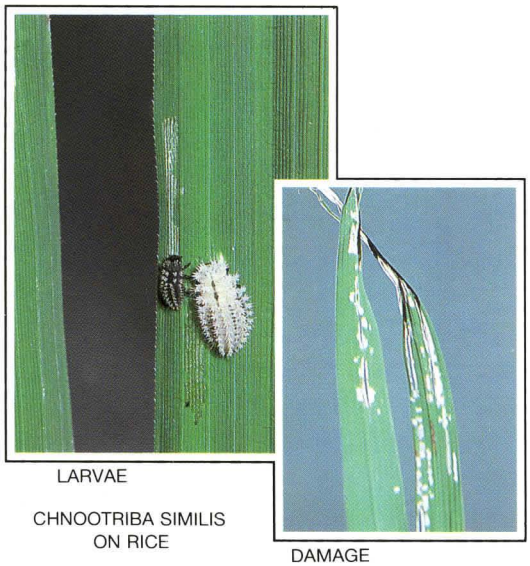
LEAF-FEEDING COLEOPTERA

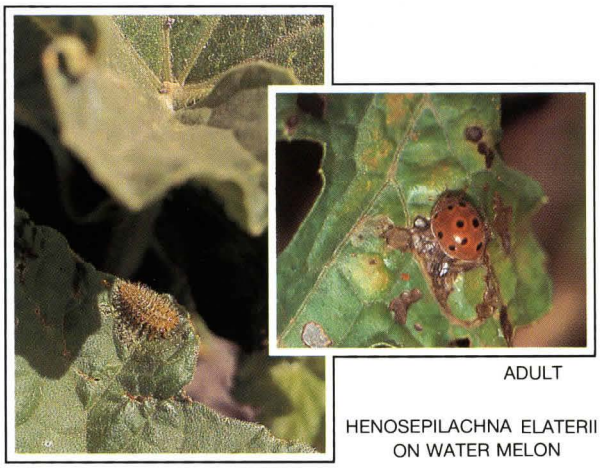


LARVAE

CHNOOTRIBA SIMILIS
ON RICE

DAMAGE

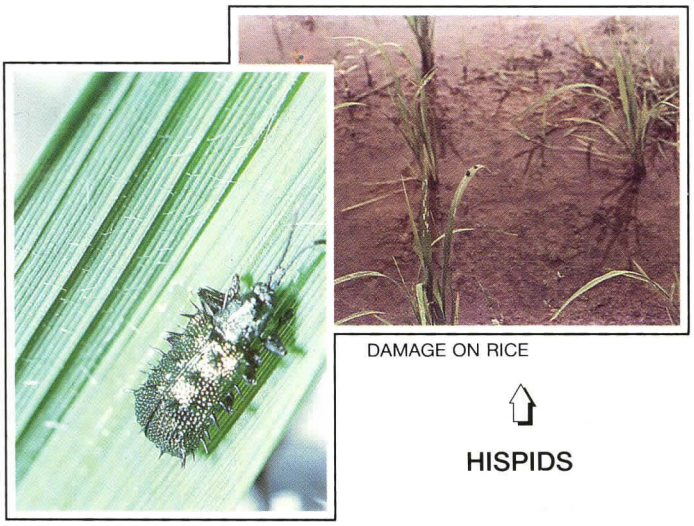
COCCINELLIDS



LARVA

ADULT

HENOSEPILACHNA ELATERII
ON WATER MELON

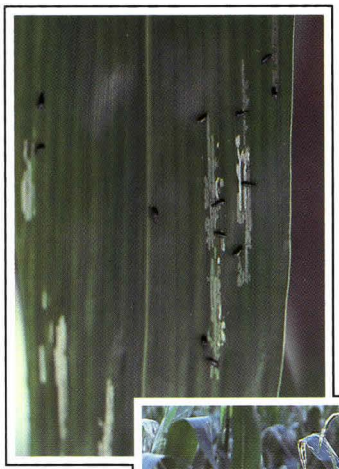


ADULT OF HISPA VIRIDICYANEA

DAMAGE ON RICE

HISPIDS

CHRYSOMELIDS

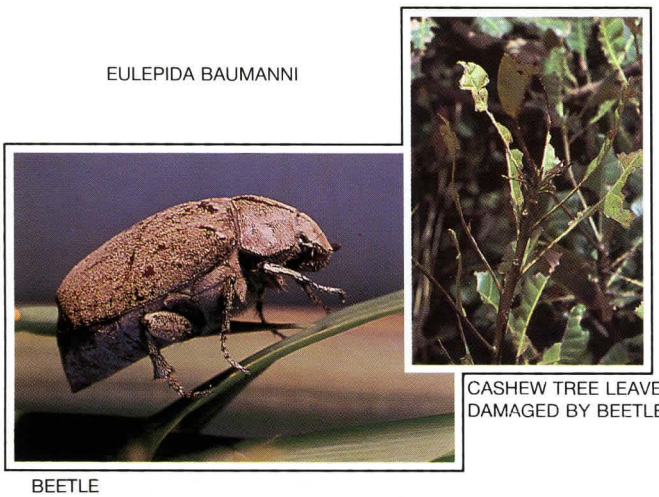


ADULTS

SESSELIA FLAVICINCTA

DAMAGE IN A MAIZE FIELD

MELOLONTHIDS



BEETLE

EULEPIDA BAUMANNI

CASHEW TREE LEAVES
DAMAGED BY BEETLES

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Leaf-feeding Coleoptera of Tropical Food Crops

Major Pest Species

A certain number of coleopteran leaf pests are commonly found in tropical food crops. Generally, both larvae and adults feed on the leaves.

• Coccinellidae

Chnootriba similis is a red-orange ladybird with large black spots. The larva is first brown then white, with tufts of white bristles. It is mainly found on leaves of cereals where it feeds on the surface leaving only one epidermis and the veins intact. The damaged parts of the leaves become transparent patches and a large number of such patches can cause the leaves to desiccate completely.

Henosepilachna elaterii is a pest of Cucurbitaceae. The adult is red, with 12 circular black points. Larvae are yellow-orange, with long bristles arranged in six longitudinal rows. Damage on leaves is similar to that caused by *C. similis*. The leaf blades turn gray and desiccate. Young plants are often destroyed in case of a severe attack.

Other species of leaf-feeding ladybirds of tropical food crops are: *Solanophila pavonia* on Solanaceae and *Epilachna* spp. on Leguminosae.

• Chrysomelidae

Several hispa species feed on leaves of Gramineae, particularly rice. The most common rice hispa are *Trichispa sericea*, which have brown-black adults with green pubescence, and *Dicladispa* spp. whose adults have spines on the thorax and elytra. The larvae mine the leaf parenchyma parallel to the leaf veins, whereas the adults feed on epidermal tissue. This causes a more or less pronounced drying of rice leaves. Growth is thus retarded and sometimes inhibited. Damage can be very high, especially in irrigated rice nurseries.

Chrysomelid beetles commonly found in Africa or Madagascar include *Lema* spp. on millet, *Asbecesta transversa* on millet and cucurbits, *Chaetocnema* spp. on millet or rice, *Podagrica sjöstedti* on Gramineae plants or Leguminosae, *Sesselia flavicincta* on maize, *Lilioceris livida* on yam, and *Aspidomorpha apicalis* on sweet potato.

• Curculionidae

Apoderus humeralis and *Catalalus lateritius* are weevils found in Madagascar. The adult *A. humeralis* is yellow and black, measuring 6-9 mm in length; that of *C. lateritius* is gray-brown and only measures 4 mm in length. They feed on leaves of various Leguminosae.

Cylas cyanescens, *Cylas formicarius*, and *Cylas puncticollis* are weevils whose adults are black or blue-black and measure 6-7 mm in length. They feed on sweet potato leaves.

• Scarabeidae

They mainly cause damage at larval stage and destroy root systems of crops, but the adults are often voracious leaf feeders of certain food crops.

Control Techniques

If the infestation level justifies control treatments, the best technique is to spray the leaves of infested crops with insecticides such as lindane (500 g a.i./ha), endosulfan (250 g/ha), malathion (500 g/ha), carbaryl (75 g/hl), or a synthetic pyrethroid (7-40 g/ha, according to the active ingredient).

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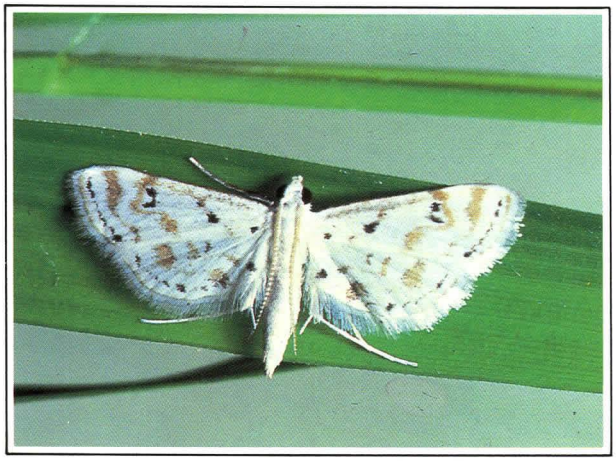
NYMPHULA SP.

PYRALIDAE

RICE CASEWORM

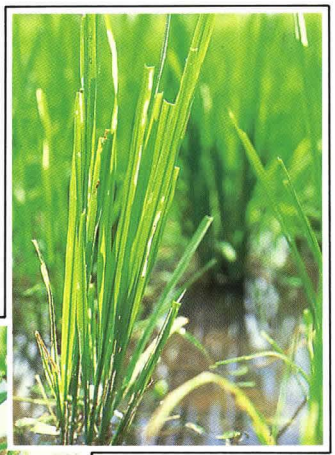


ADULT — 1 mm

LARVA AT THE FOOT OF A RICE TILLER — 1 mm

DAMAGE

INFESTED RICE FIELD



DAMAGED BUNCH OF TILLERS

CASES PROTECTING LARVAE

LARVA IN HIS CASE

LIFE CYCLE

INCUBATION PERIOD		3-6	DAYS
LARVAL	–	15-20	–
PUPAL	–	4-7	–

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Nymphula depunctalis

Description

The genus *Nymphula* (Lepidoptera: Pyralidae) includes several species of rice pests, the most common being *N. depunctalis*. The adult is a small pearly white moth, 10-12 mm in length. Larvae are light green, transparent, and measure about 15 mm when fully grown. Pupae are light brown and 8-10 mm long.

Distribution and Host Plants

N. depunctalis is a cosmopolitan pest found in Asia, Australia, South America, and several African countries. It is a pest of swamp rice.

Biology and Damage

The female deposits the eggs in compact regular rows along the leaves. After 3-6 days, the newly hatched larvae climb to the leaf tip and cut transverse sections of the blade that are still attached to the leaf by a thin fragment. When they dry the leaf sections roll around the young larvae to form a cylindrical case. The larvae reinforce the cases with silk threads leaving one end open. They then cut the portion attaching the case, which falls in the water. Protected by the leaf cover, the larva is transported on the water surface until it reaches a rice tiller. It climbs the tiller and begins feeding on the leaves. During the six development stages which last for 15-20 days, the larvae move to several rice tillers forming several leaf cases. They pupate in the last case after closing both ends. The pupal period lasts for 4-7 days.

The life cycle of this pyralid ranges between 3 weeks and 1 month. Two successive generations may develop on a single rice crop.

It is easy to recognize damage by *N. depunctalis*. The leaves are cut into strips and the water surface is covered by leaf debris. Infestation occurs in patches in the rice field. High populations of the insect may almost destroy the entire crop; but usually they reduce plant growth in swamp rice and cause variable yield loss. Rice crops are most susceptible soon after transplanting or up to 1 month after planting.

Control Techniques

The *N. depunctalis* larvae are semiaquatic; temporary draining (at least 3 days) of the rice field, if possible, is an effective cultural technique when carried out at the start of infestation.

When infestation is detected at an early stage, the crop should be sprayed with lindane, carbofuran, carbaryl, fenitrothion, or endosulfan. Treatment of rice field water with granular insecticides is less polluting but it has a slower effect; this can be a disadvantage if infestation develops rapidly.

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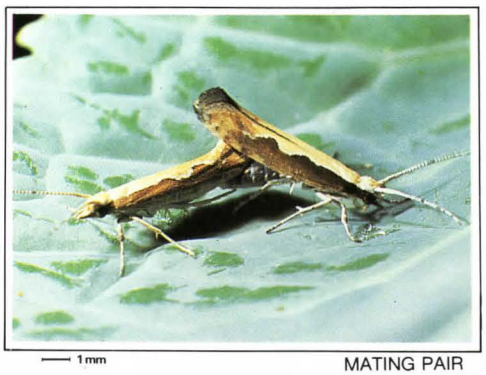
PLUTELLA XYLOSTELLA (Linné)

DIAMONDBACK MOTH



MATING PAIR

FEMALE

EGGS

DAMAGE ON CABBAGE

COCOONS

FIRST DAMAGE

"WINDOWS" ON LEAVES

LARVAE

LIFE CYCLE AT 25 °C

INCUBATION PERIOD		2	DAYS
LARVAL	–	10	–
PUPAL	–	4	–
ADULT	–	10	–

I.R.A.T. / C.I.R.A.D. – B.P. 5035 – 34 032 MONTPELLIER CEDEX – Maquette et photos : T. ERWIN D. BORDAT

Plutella xylostella

Description

Plutella xylostella is a Lepidoptera of the family Plutellidae. Eggs are creamy white and oval. Fully grown larvae are 10-12 mm long and their color varies from yellow to green. Pupae are lodged in a spindle-shaped cocoon made up of fine threads.

Distribution

The species originated in western Europe and spread throughout the five continents following the development of crucifer crops.

Host Plants

This moth infests cultivated and wild crucifers, particularly species of the genus *Brassica* (cauliflower, cabbage, Chinese cabbage, etc.)

Biology and Damage

The female deposits an average of 160 eggs, either singly or in groups of a maximum of 10 eggs, on leaf blades. The incubation period is about 2 days. Newly hatched larvae penetrate leaf tissue and bore a mine 3-4 mm long, without damaging the two epidermal layers. During the second stage, they emerge from the mine to feed on sections of the leaf blade, leaving one epidermis intact. During the external phase of development, the larva characteristically suspends itself by a thread and retreats in jerking movements when disturbed. At the end of the fourth larval stage, it forms a cocoon and pupates on the leaf. At 25°C, one generation takes about 20 days. Depending on climatic conditions, 3-12 generations are produced in a single year.

Early symptoms are small white comma-shaped spots on the leaf blades. Subsequently, transparent windows of variable shape develop on the leaf. The windows grow larger and the transparent epidermal layer later tears, giving the leaves a lace-like appearance.

Damage results in reduced market value and retarded plant growth. Plants may also perish if pest attacks are severe.

Control Techniques

P. xylostella control is part of the overall strategy to protect crucifers against various species of leaf feeders. It is mainly based on insecticide treatments.

Bacterial insecticides (*Bacillus thuringiensis*, serotypes 3A and 3B) have proved to be effective when sprayed as soon as the leaves show window symptoms. Such insecticides have the advantage of not being toxic to crops or human beings, and do not affect natural enemies of the pest.

Several chemical insecticides, such as bromophos, carbaryl, endosulfan, and synthetic pyrethroids can be used. A wetting agent should be added when spraying cabbage. Treatments should be repeated every 8-15 days, but indications regarding the spray-free period before harvest should be followed strictly.

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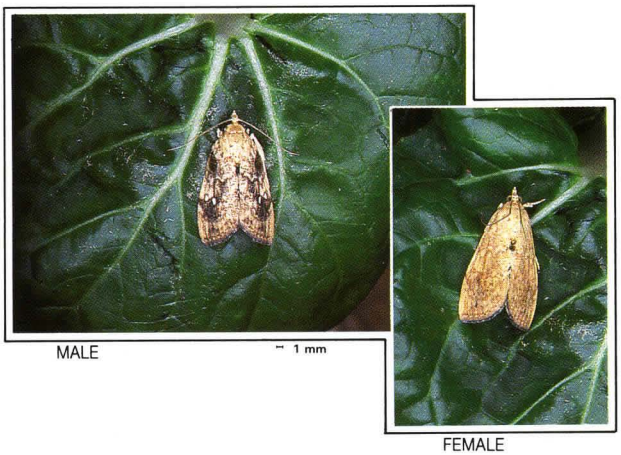
CROCIDOLOMIA BINOTALIS

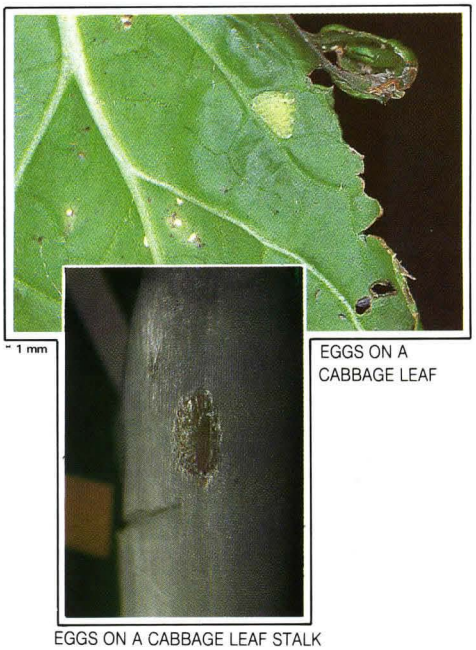
Pyralidae *ZELLER*

CABBAGE CLUSTER CATERPILLAR



MALE — 1 mm

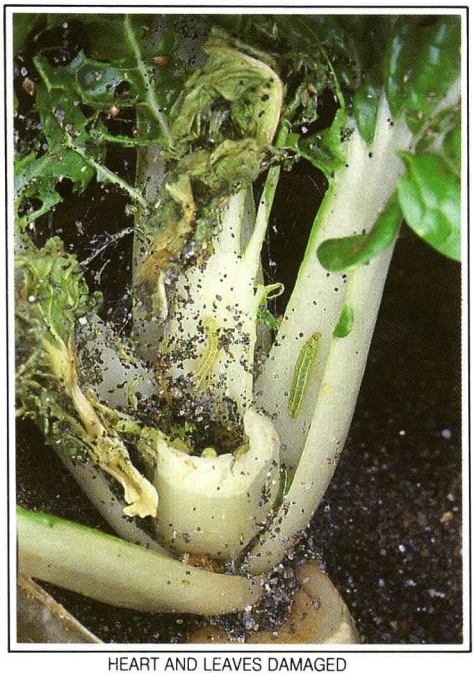
FEMALE



— 1 mm

EGGS ON A CABBAGE LEAF

EGGS ON A CABBAGE LEAF STALK



HEART AND LEAVES DAMAGED

DAMAGE

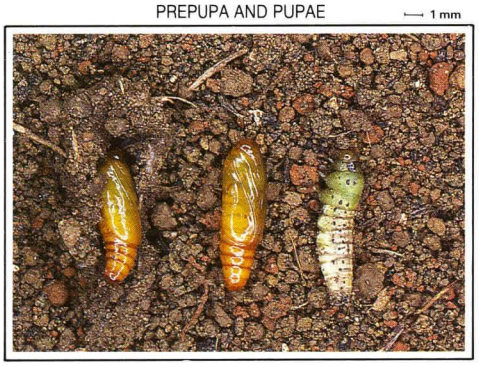
NEW-HATCHED LARVAE

LAST-STAGE LARVA — 1 mm

LIFE CYCLE AT 25 °C

INCUBATION PERIOD		5-7	DAYS
LARVAL	–	10-13	–
PUPAL	–	8-11	–
ADULT	–	6-8	–

PREPUPA AND PUPAE — 1 mm



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Crocidolomia binotalis

Description

The adult *Crocidolomia binotalis* (Lepidoptera: Pyralidae) is a moth that reaches 15 mm in length. The wingspan is 24-28 mm. The fore wings are brown, lighter in the female than in the male, with white spots and raised brown to black scales; the front edge carries a fringe of thick hair. Eggs are flattened (1.0 mm x 0.75 mm), with a honeycomb pattern. Newly hatched larvae are light green. Older larvae have white mediodorsal lines and lateral violet bands with white borders; each segment has two or three black spots. Fully grown larvae reach 20 mm in length. The pupa measures 8-10 mm; it is protected by a cocoon made of earthen particles bound together by a network of silk threads.

Distribution and Host Plants

The pest is found in the subtropical and equatorial regions of Africa, Asia, and Oceania. Host plants belong to the family Cruciferae, mainly cabbage, but also radish, mustard, rapeseed, etc.

Biology and Damage

The female deposits between 100 and 300 eggs in 2 or 3 days. They are laid in clusters of 30-60 eggs, on the undersurface of leaves or petioles. Newly hatched larvae group around the chorions for 2 days and then spread over the leaves or to the central shoot, suspended on a silk thread. During the five development stages, they feed on the lower epidermis of the leaf blades of the same plant, leaving the major leaf veins. They weave a loose network of threads which holds larval waste. Duration of the life cycle is 25-30 days at 25°C.

Symptoms in young crucifer plants include increasingly large lace-like patches on the leaves, which are no longer fit for consumption. On older plants, buds, flowers, and pods may be partially destroyed, resulting in reduced grain yield.

Control Techniques

Crucifer crops are frequently attacked by *C. binotalis*. Plants can be protected by insecticide application at 15-day intervals, on observation of the first signs of an infestation. A wetting agent is added for spraying cabbage crops. Recommended treatments are: synthetic pyrethroids (3-7.5 g/hl, depending on a.i.), *Bacillus thuringiensis*, acephate (500 g/ha), chlorpyrifos (300 g/ha), fenitrothion (600 g/ha), fenthion (600 g/ha), endosulfan (600 g/ha), quinalphos (250 g/ha), carbaryl (700 g/ha), phosalone (600 g/ha), diazinon (300 g/ha).

The use of insect parasites, such as tachinid flies and braconid wasps, does not significantly reduce *C. binotalis* populations, except at the end of the cropping season.

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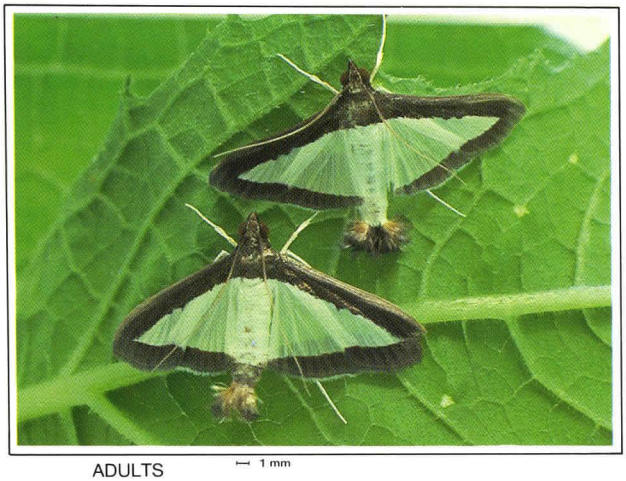
PALPITA SPP.

Pyralidae

CUCURBIT CATERPILLAR



ADULTS — 1 mm

OLD LARVA

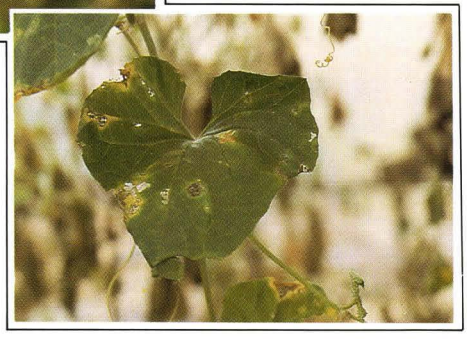
1 mm

LARVA WEAVING HIS COCOON

LIFE CYCLE

INCUBATION PERIOD		2-3	DAYS
LARVAL	–	21-28	–
PUPAL	–	8-12	–

DAMAGE
on :
CUCUMBER
MELON



1 mm

PUPATION
PUPA
COCOON

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Palpita spp.

Description

The adults of *Palpita* spp. (Lepidoptera: Pyralidae) are pearly white moths, with a wing span of 20-25 mm. The wings are edged with a brown band and the abdomen tip is covered by a tuft of orange-colored hair that "palpitate." The whitish eggs are oval in shape. When they hatch, the young larvae are transparent, but change to green as they grow older. Two white dorsal stripes run lengthwise on the body. Fully grown larvae reach a length of 15-25 mm. Pupae are brownish-black.

Distribution and Host Plants

P. hyalinata Linnaeus and *P. nitidalis* Cramer occur in the Americas and West Indies. A related species, *P. indica* Saunders, is present in Africa.

The Pyralidae species attack plants of the family Cucurbitaceae. They are found mainly on melons as well as zucchini and cucumbers, under shelter and in the open.

Biology and Damage

The female lays a large number of isolated eggs, generally on the undersurface of leaves. On hatching, the young larvae cluster around the main veins and begin to feed on adjacent portions of the leaf blade. Early symptoms are the appearance and development of lace-like patches, showing a network of small leaf veins that were left intact. Damage is most serious in the early stages of fruit formation, when the pest feeds on and punctures the skin of young fruit, usually where they touch leaves or soil. The fruit may fall or rot. Pupation takes place within a leaf folding. Duration of the life cycle is 30-40 days and of the larval period, 3-4 weeks.

Control Techniques

Damage may be sudden at flowering or early stages of fruit formation in Cucurbitaceae. Effective control mainly consists of careful surveillance to detect the larvae as soon as they start hatching, for early insecticide treatments. Several insecticides are recommended for application on leaves and young fruit. These include methomyl, endosulfan or synthetic pyrethroids. The bacterium *Bacillus thuringiensis* is also effective in controlling *Palpita* spp.

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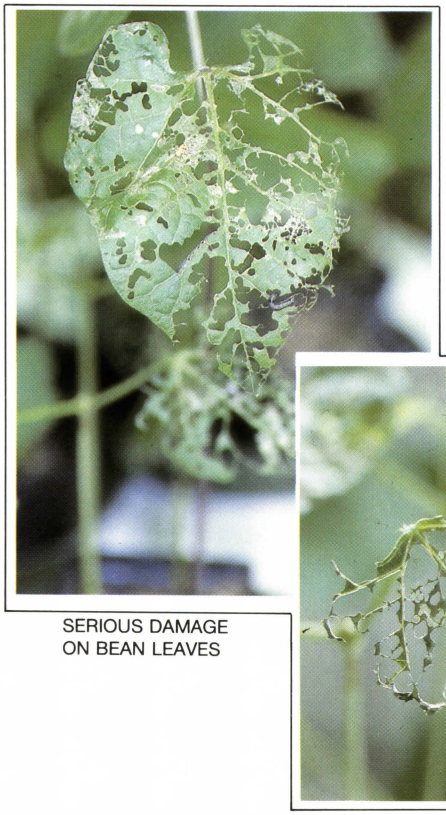
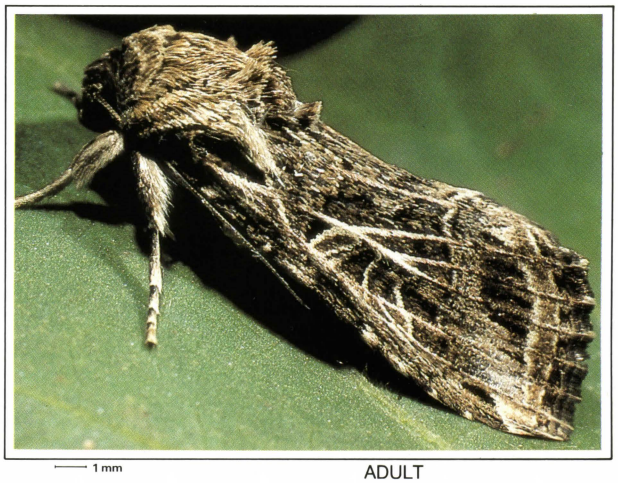
SPODOPTERA SPP.

Noctuidae

ARMYWORMS ON LEGUMINOSAE



SERIOUS DAMAGE ON BEAN LEAVES



1 mm

ADULT

LIFE CYCLE AT 25 °C

ADULT EMERGENCE

MATING

LAYING

INCUBATION PERIOD 4-6 DAYS

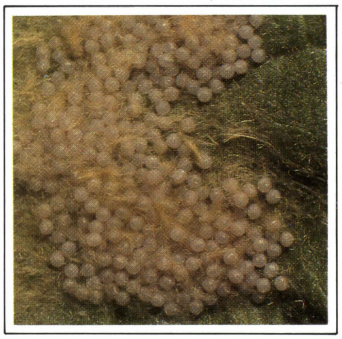
HATCHING

6 LARVAL STAGES : 15-21 DAYS

PUPATION

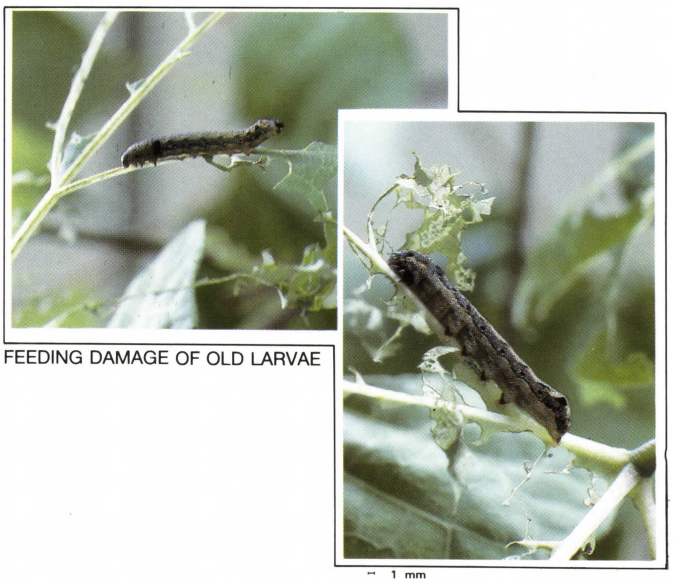
PUPAL PERIOD : 10 DAYS

EGG MASS



1 mm

PUPAE



FEEDING DAMAGE OF OLD LARVAE

1 mm

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Spodoptera spp.
Pests of Leguminosae

Description

The genus *Spodoptera* (Lepidoptera: Noctuidae) comprises a large number of species, including *S. littoralis*, *S. exigua*, *S. litura*, and *S. frugiperda* that infest Leguminosae. The adults are grayish-brown moths with yellow ocher spots on the fore wings and brown-edged white hind wings. Eggs are usually spherical, grooved, pearly white to green, and about 0.5 mm in diameter. Larvae are greenish when young and vary from bright green to dark brown in the last stages. *S. littoralis* has black triangles along the ocher dorsal lines. Pupae are brown and measure about 15 mm in length.

Distribution and Host Plants

S. littoralis occurs in the Mediterranean basin, Middle East, and Africa; *S. exigua* on all continents; *S. litura* in Asia (mainly India) and Australia; *S. frugiperda* in the Americas.

Spodoptera spp. are highly polyphagous insects that attack most tropical grass or bush crops. Groundnut, soybean, beans, and cowpea are common legume hosts. Several weeds also serve as hosts.

Biology and Damage

The female lays from several hundred up to 4000 eggs that are generally deposited in several layers, usually on the undersurface of leaves. The batches are covered with piliform scales. The incubation period ranges from 1 to 10 days depending on the temperature. Young larvae feed on the lower epidermis of leaves; they are initially gregarious but then disperse. The larvae secrete silk threads that enable them to migrate from one plant to another. They start feeding heavily on leaf tissue, leaving only the main veins. Older larvae are essentially active at night. During the day they burrow under leaves or into the soil. The larvae usually pass through six development stages that last about 2-3 weeks. They pupate in the soil close to the surface. The adult emerges 10 days later.

The first symptoms of attack are small, transparent and then brown leaf spots produced by young larvae while feeding. This is followed by defoliation of variable intensity; sometimes the veins and petioles are the only leaf parts that remain, giving the plants a skeletal appearance. Damage is sudden, unpredictable, and rapid as crops are often attacked unexpectedly by migrating adults. Another reason is that the voracious larvae often escape notice because they feed at night. Damage is striking but often localized and of short duration as adults of the following generation continue their migrations.

Control Techniques

Immediate detection of early symptoms is required for effectively controlling the pest. Populations of young larvae can be destroyed by spraying foliage with insecticides. Endosulfan (500 g/ha), trichlorfon (300 g/ha), and synthetic pyrethroids (2-3 g/hl) are some of the active ingredients that are recommended.

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LIRIOMYZA SPP.

(Agromyzidae)

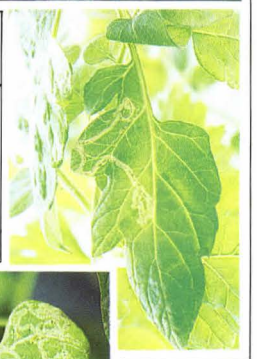
LEAFMINER FLIES

MATING PAIR

FEEDING POINTS (ADULTS)
YOUNG MINES (LARVAE)

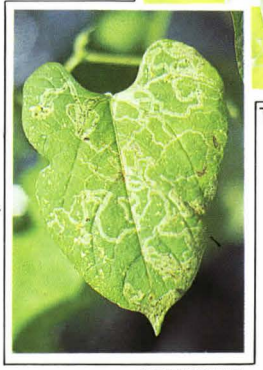
CELERY LEAF

DAMAGE



TOMATO LEAF

LAYING

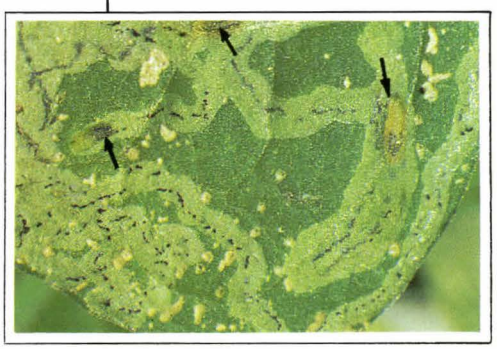


BEAN LEAF

PUPAE

LIFE CYCLE
AT 25 °C

INCUBATION PERIOD		3	DAYS
LARVAL	–	5	DAYS
PUPAL	–	9	DAYS
ADULT	–	15	DAYS



LAST-STAGE LARVAE

I.R.A.T. /C.T.R.A.D BP 5035 - 34032 MONTPELLIER CEDEX - Photos : ERWIN T. - BORDAT D.

Liriomyza spp.

Identification

Liriomyza belong to the family Agromyzidae of Diptera. Some of the economically important species in the tropics are: *L. trifolii*, *L. sativae*, and *L. huidobrensis*.

Distribution

The genus is present on all continents.

Host Plants

Liriomyza species are polyphagous pests. *L. trifolii* and *L. huidobrensis* attack a large number of vegetable and horticultural crops (Solanaceae, Leguminosae, chrysanthemums, etc.). *L. sativae* mainly occurs on Cucurbitaceae and Solanaceae.

Biology and Damage

Females pierce the leaves and deposit eggs singly under the epidermis. The eggs hatch 2-5 days after oviposition, and the newly hatched larvae start to mine the leaf blade, leaving the epidermis intact. The larva completes development in 4-7 days after boring an increasingly wide, winding mine. *L. huidobrensis* pupates in the leaf. The two other species pupate on the leaves or in the soil. The pupal period varies from several days to several months in duration, depending on climatic conditions.

Damage is characterized by a variably dense network of mines in leaf tissue. Photosynthetic activity is reduced, leaves may dry and fall, and there is a risk of flower bud and fruit scorching. The market value of the produce decreases, particularly for flower and green leaf crops.

Control Techniques

Excessive use of chemical treatments in the field and greenhouses, has made the borer resistant to several insecticides. The treatments have destabilized the biological environment and affected the natural enemies of *Liriomyza*. Effective control requires an integration of different methods:

— **Agronomic methods** include burning of haulms after harvest and destroying weeds (e.g. groundsels, nettles, amaranths). The weeds serve as secondary hosts for pest populations between cropping seasons.

— **Chemical methods** include soil disinfection combined with nematicidal treatment, and leaf application of insecticides. Fenthion is commonly used against larvae; while dichlorvos, sulfotep, and bioresmethrin are used against adults. Avermectin B1 (not yet authorized in France) has given satisfactory results for controlling adults in USA.

— **Biological methods** include the establishment of an appropriate treatment schedule that preserves natural enemies, such as *Hemiptarsenus simialbiclavus*, *Diglyphus* sp., and *Chrysocharis* sp. for larvae; *Dacnusa* sp. for pupae.

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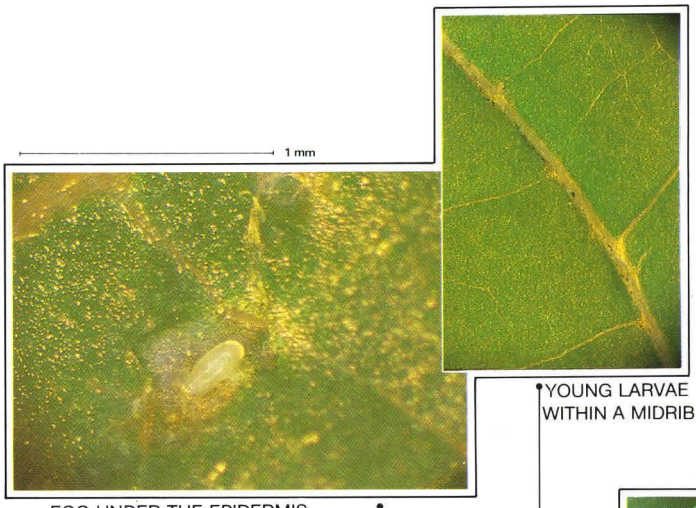
OPHIOMYIA PHASEOLI TRYON

Agromyzidae

BEAN FLY

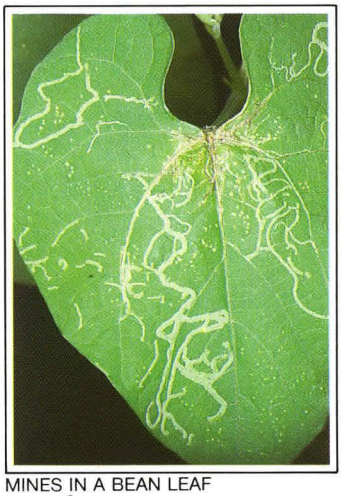
FEMALE 1 mm



1 mm

EGG UNDER THE EPIDERMIS OF A BEAN LEAF

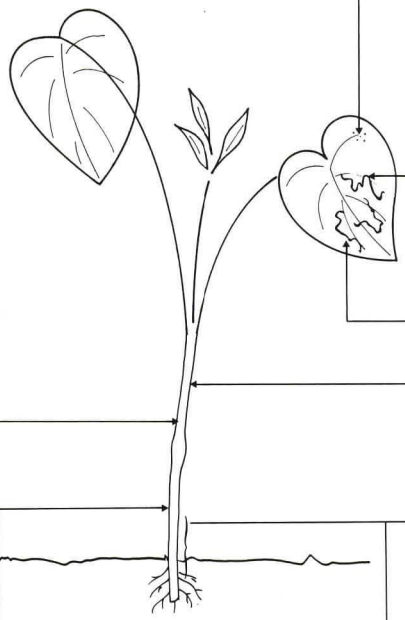
YOUNG LARVAE WITHIN A MIDRIB



MINES IN A BEAN LEAF

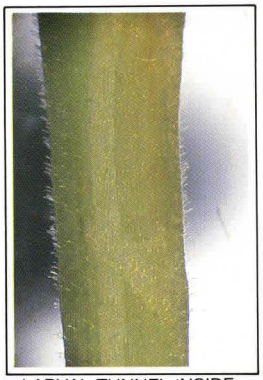
LIFE CYCLE
AT 25 °C

INCUBATION PERIOD		2-4	DAYS
LARVAL	–	6-9	–
PUPAL	–	8-10	–

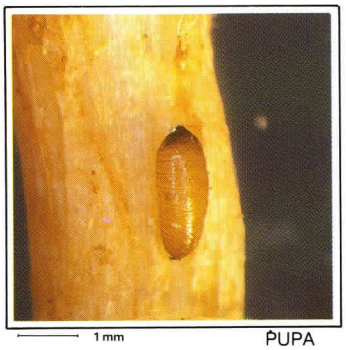


1 mm

OLD LARVA UNDER THE EPIDERMIS OF A BEAN STEM

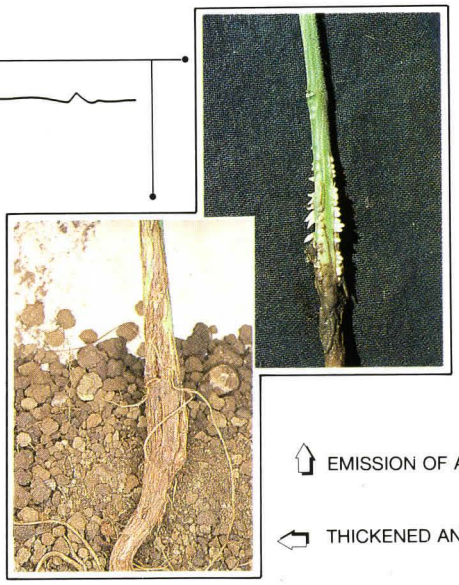


LARVAL TUNNEL INSIDE A BEAN STEM



1 mm

PUPA



EMISSION OF ADVENTIVE ROOTS

THICKENED AND CRACKED STEM

I.R.A.T. / C.I.R.A.D. – B.P. 5035 – 34032 MONTPELLIER CEDEX – Maquette : T.ERWIN – Photos : B.VERCAMBRE

Ophiomyia phaseoli

Description

The adult *Ophiomyia phaseoli* (Diptera: Agromyzidae) is a small shiny black fly, 1.6-2.5 mm long, that should not be confused with those of the species *O. centosematis* and *O. spencerella*. Eggs (0.35 mm x 0.14 mm) are white and opaque. Larvae (maggots) are yellowish-white and measure 2.5-3 mm when fully grown. The pupa appears as a small brown cylinder, 2-2.5 mm in length.

Distribution and Host Plants

O. phaseoli is widespread in Africa, Asia, and Oceania, but it has not been recorded in the Americas. The pest attacks Leguminosae with preference for the genera *Phaseolus*, *Vigna*, *Cajanus*, *Macroptilium*, *Crotalaria*, and *Glycine*.

Biology and Damage

The female pierces the aqueous tissues of leaves with its ovipositor and feeds on the extracted liquid. The life cycle is 3-5 weeks, during which the female lays 200-300 eggs that it inserts one by one under the leaf epidermis. Most newly hatched larvae mine through a leaf vein and petiole to reach the stem. They then bore a whitish tunnel under the epidermis up to the collar. Some larvae, however, may complete their development in the leaf blade itself. Pupation generally takes place in the collar. At 25°C, the life cycle is 19-24 days.

On seedlings, the symptoms are a yellowing and desiccation of the first leaves. The external tissue at the base of the stem then detaches and ruptures causing a characteristic thickening of the collar. The plant produces adventitious roots. Damage is more serious when infestation occurs at an early stage. It takes between 5 and 10 larvae to destroy a young plant. Plants may continue to grow in case of less severe attacks, but vigor and production are reduced. In the case of late infestations, economic incidence of the parasite is negligible.

Control Techniques

O. phaseoli control in Leguminosae crops is based on appropriate cropping techniques: timely planting, use of early and/or tolerant varieties, ridging to enable the development of adventitious roots, and removal of dead plants.

Preventive insecticide treatments should be carried out in high-risk areas. Insecticides recommended for in-furrow application are: carbofuran (400-600 g a.i./ha), diazinon (1000 g/ha), chlorpyrifos-ethyl (400 g/ha), chlorfenvinphos (1200 g/ha).

Curative treatments involve two or three weekly sprayings of insecticides. The first application should be carried out when the plant is at two-leaf stage. Recommended active ingredients are: dimethoate (300 g/ha), diazinon (300 g/ha), quinalphos (500 g/ha), formothion (500 g/ha), fenitrothion (500 g/ha), avermectin (18 g/ha).

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Stem- and Leaf-sucking Insects

Thrips, bugs, leafhoppers, whiteflies, aphids, and scale insects are leaf- and stem-sucking insects. Many species simultaneously or successively attack flowers, earheads, pods, and fruit on the same host. They feed by sucking and cause two types of damage (Table III):

— either they destroy plant organs by removing sap, emptying cells, or injecting toxic substances;

— or they encourage the establishment and development of diseases, or serve as vectors of pathogens.

Several species of **thrips** are recorded in Africa and the Indian Ocean region. They cause leaf discoloration and desiccation in heavily infested vegetable as well as cereal and legume crops. *Thrips tabaci* is the most cosmopolitan and important species. *Thrips palmi* was recently observed in Réunion and Mauritius but has not yet been recorded in Africa.

Many **bugs** mainly belonging to the families Coreidae and Pentatomidae are generally polyphagous and cosmopolitan. They suck sap from stems and leaves of most tropical food crops. At high densities, they cause wilting and withering of the attacked organs. Some bugs inject toxic substances that can affect growth. Penetration sites of the stylets serve as favorable entry points for several plant pathogens. But bugs are mainly earhead and pod pests.

In tropical countries, most **leafhoppers** mainly attack cereals. In Africa, direct damage due to removal of sap and cell contents is generally low. Some leafhoppers are actually obligatory vectors of serious virus diseases. Several species of the genus *Cicadulina* transmit the maize streak virus; *Peregrinus maidis* is a vector of the maize stripe virus and the maize mosaic virus and *Perkinsiella saccharicida* of the Fiji disease of sugarcane.

Whiteflies suck cell contents and inject toxins in plant tissue. Several tropical species are also vectors of virus diseases; for example, *Bemisia tabaci*, a cosmopolitan and polyphagous whitefly, is a known vector of cassava mosaic disease.

Aphid colonies cause severe damage to various tropical food crops, particularly fruits and vegetables. Sap removal weakens the host and mildew secretions encourage development of sooty mold (black fungus that inhibits chlorophyll assimilation). The most important family, Aphididae, includes several polyphagous species, such as those of the genus *Aphis*, that are found on Leguminosae and Solanaceae as well as Cucurbitaceae and Cruciferae. Many of these Homoptera are also disease vectors; groundnut rosette is transmitted by *Aphis craccivora* and several virus diseases of maize and sugarcane by *Rhopalosiphum maidis*.

Scale insects are found on most food crops. *Phenacoccus manihoti*, the main cassava pest, has the highest economic incidence. Scale insects specific to sugarcane sometimes cause heavy damage in nurseries and on young shoots. Similar to aphids, scale insects suck sap and secrete honeydew that encourages sooty mold development.

Among other arthropod pests, are mites that puncture leaves of various garden vegetables.

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Table III. Host plants of certain stem- and leaf-sucking insects and some of the diseases transmitted by the insects.

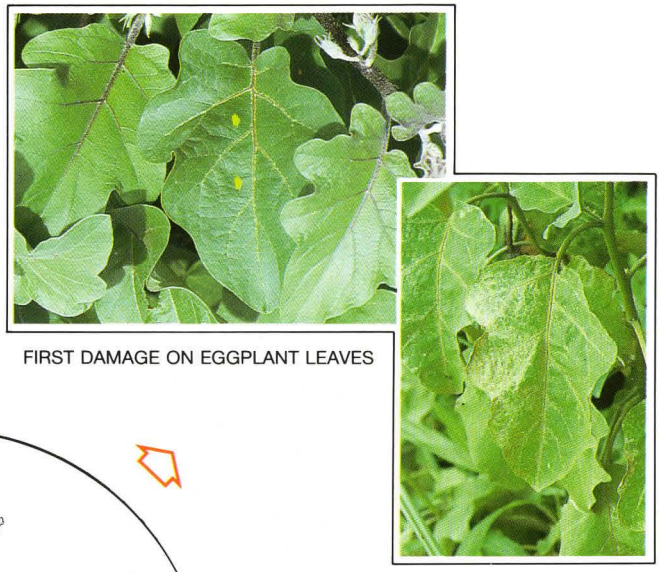
Pests	Host plants: Cereals	Sugarcane	Leguminosae	Solanaceae	Cruciferae	Cucurbitaceae	Yam	Cassava	Diseases transmitted
Thrips									
Thrips tabaci			•	•	•	•			Russet disease (tomato)
Thrips palmi			•	•	•	•			
Frankliniella schulzei			•	•					Russet disease (tomato)
Bugs									
Pentatomidae*	•	•	•	•	•	•			
Coreidae*	•	•	•	•	•	•	•	•	
Miridae*	•	•	•	•	•	•			
Hoppers									
Peregrinus maidis	•	•							Stripe and mosaic (maize)
Perkinsiella saccharicida		•							Fiji disease (sugarcane)
Locris spp.	•								
Cicadulina spp.	•	•							Streak (maize)
Empoasca sp.			•	•		•			
Nephotettix spp.	•								
Whitefly									
Bemisia tabaci			•	•	•	•		•	Mosaic (cassava)
Aphids									
Aphis craccivora			•	•		•			Virus diseases including:
Aphis gossypii				•		•			rosette (groundnut) and mosaic (yam)
Aphis fabae			•	•	•				Several virus diseases
Brevicoryne brassicae					•				Several virus diseases
Lipaphis erysimi			•	•	•	•			
Macrosiphum euphorbiae	•		•	•	•	•			Several virus diseases
Melanaphis sacchari	•	•							Several virus diseases
Myzus persicae			•	•	•				
Rhopalosiphum maidis	•	•		•					Virus diseases including: mosaic (sugarcane and yam)
Schizaphis graminum	•	•							Several virus diseases
Scale insects and mealybugs									
Dysmicoccus brevipes	•	•	•						
Ferrisia virgata		•	•	•			•	•	
Phenacoccus manihoti				•				•	
Aonidomytilus albus			•					•	
Aspidiella hartii									

* Also see Table IV, p. 64.

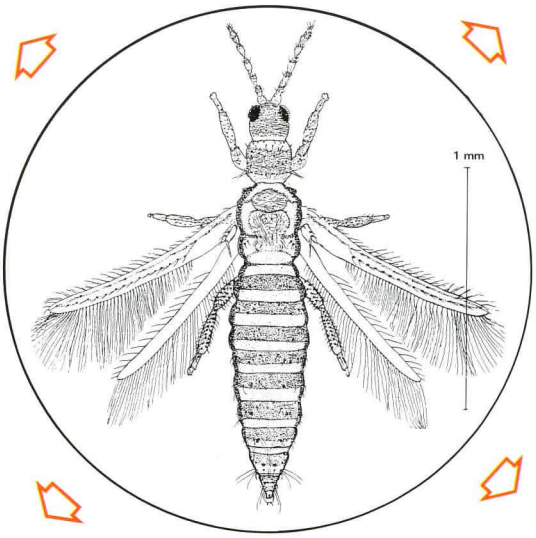
THRIPS

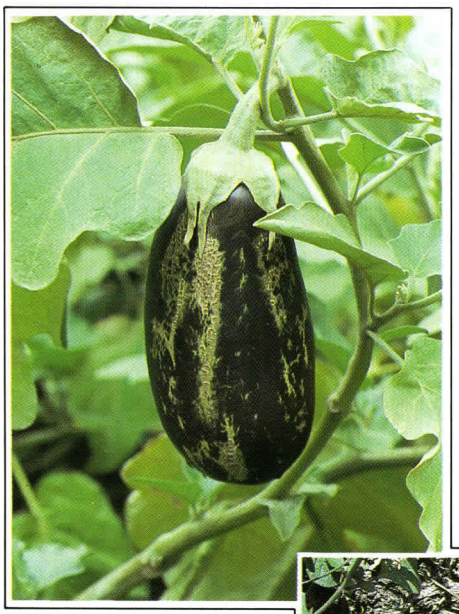
ON VEGETABLES

DAMAGE ON EGGPLANT SEEDLINGS



FIRST DAMAGE ON EGGPLANT LEAVES





EGGPLANT
WATER MELON
CUCUMBER

DAMAGE ON FRUITS

DAMAGE ON MELON SEEDLINGS

SERIOUS DAMAGE ON MELONS

DAMAGE ON ONIONS

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Thrips Pests of Vegetable Crops

Description

Thrips (Thysanoptera) are small (about 1 mm) sucking insects. They can be recognized by their elongated shape and thin wings fringed with long bristles. The light-colored larvae are wingless and smaller than the adults.

Among the species that cause considerable damage in vegetable crops, the most important are: *Thrips tabaci* Lindemann, *T. palmi* Karny, and *Frankliniella schulzei* Trybom. *Sericothrips occipitalis* Hood and *Megalurothrips sjöstedti* Trybom are generally less harmful.

Distribution

All these species are present in Africa, except *T. palmi*, which occurs in Asia, the Indian Ocean region, New Caledonia, Japan, and, recently, in the French West Indies.

Host Plants

T. tabaci is found on several families of vegetable plants. *T. palmi* occurs only on Solanaceae, Leguminosae, and Cucurbitaceae, and *F. schulzei* on beans and tomatoes.

Biology and Damage

The females of the three species lay 50-80 eggs that are inserted under the leaf epidermis. There are two larval stages. The nymph stage (prenymph and nymph) often develops in the soil. Duration of the life cycle is 2-5 weeks, depending on the temperature.

T. palmi pierces leaf blade cells and feeds on the contents. The cells then fill with air, giving a "pearly" color to the foliage. The leaves subsequently decay and desiccate. However, the thrips mainly damage the fruit; puncturing causes suberization of the epidermis in developing fruit, thus reducing their market value.

T. tabaci causes similar damage on onion and leek leaves, which take on a silver shade; leaf tips also desiccate. High populations or early attacks can retard development of onion plants and may also destroy them.

F. schulzei mostly attacks flowers. Young leaves are infested at a very early stage and flowers as soon as they bloom. Fruit development is also retarded.

T. tabaci and *F. schulzei* are particularly dangerous because they can also transmit the tomato spotted wilt virus (TSWV).

Control Techniques

Genetic and agronomic control. Postharvest tillage destroys nymphs in the soil. Sprinkler or gravity irrigation lowers infestation levels. As a preventive measure planting dates should be delayed, if possible, to avoid peak activity periods. The choice of resistant or less susceptible varieties, particularly for onions, reduces the risk of crop destruction.

Chemical control. The first insecticide treatment should be carried out as soon as 5-10 adults are observed per plant. Endosulfan (190 ml a.i./100 l of water), diazinon (30 ml/hl), and dimethoate (75 ml/hl) are recommended. A wetting agent should be added to the commercial product, particularly for treating onions. The insecticide is applied on the upper and lower leaf surfaces. Insecticides are applied at the rate of 700-1200 l of solution/ha, using a sprayer if possible.

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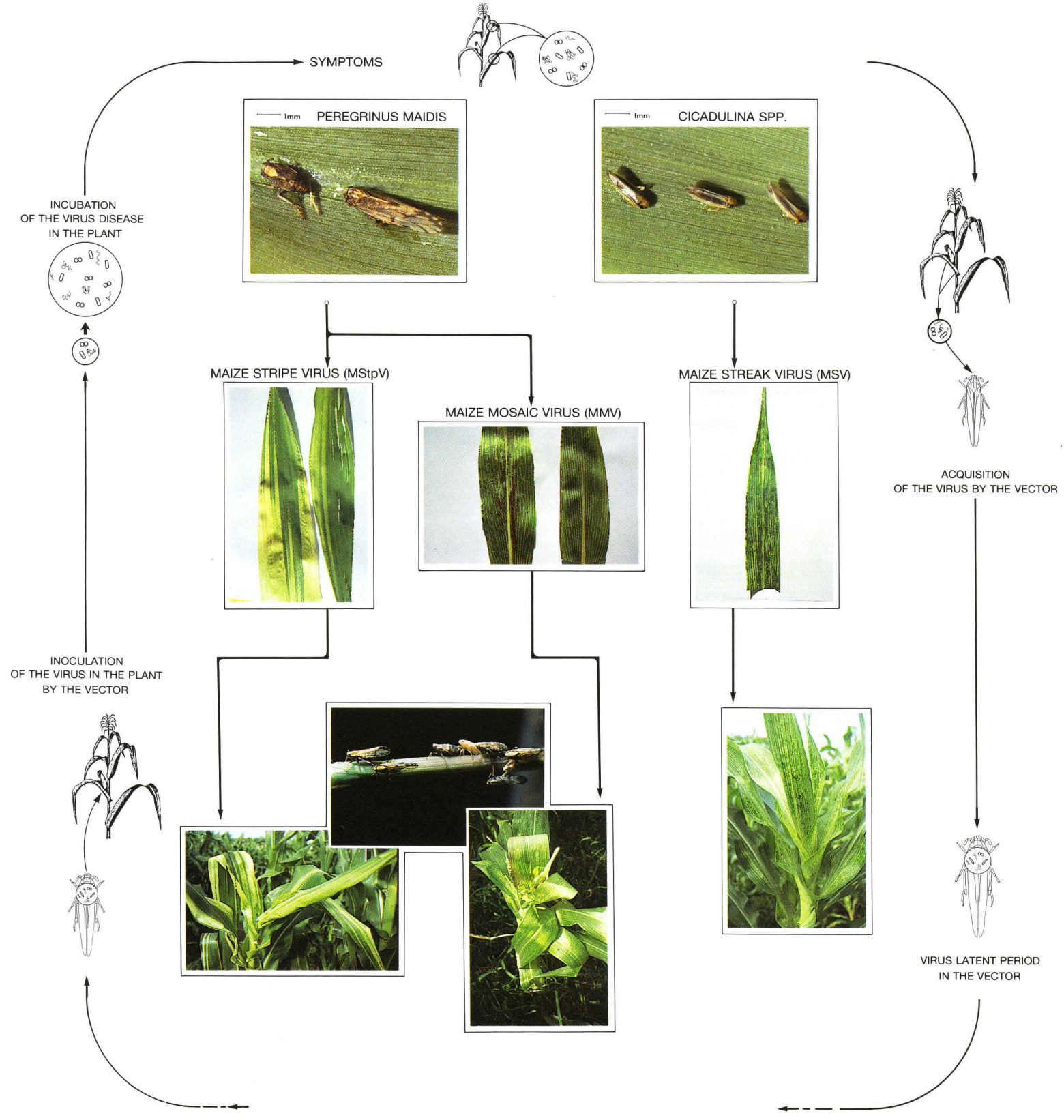
VECTORS OF SOME VIRUS DISEASES OF MAIZE

IN AFRICA AND MASCARENE ISLANDS



I.R.A.T./C.I.R.A.D - B.P 5035 - 34032 MONTPELLIER CEDEX - Maquette : T. ERWIN Photos : IRAT

Insect Vectors of Maize Virus Diseases in Africa and the Mascarene Islands

Maize Virus Diseases

The three main maize virus diseases in Africa and the Mascarene islands are maize streak virus (MSV), maize mosaic virus (MMV), and maize stripe virus (MStpV).

MSV is the most common maize virus disease in Africa and the Mascarene islands, causing large-scale damage to crops. None of the three diseases can be transmitted mechanically (injury, rubbing). Leafhoppers are the obligatory vectors of the viruses.

Vector Species

The genus *Cicadulina* (Homoptera: Cicadellidae) is the obligatory vector of MSV. Six vector species have been identified: *C. mbila*, *C. bipunctella zeae*, *C. parazeae*, *C. latens*, *C. storeyi*, and *C. triangula*.

Cicadulina adults average 3 mm in length and have two distinctive black points above the eyes. In *C. mbila*, the head and ventral side are yellow. The female lives for several weeks and lays more than 100 eggs that are inserted into the maize leaf blades or sheaths. The incubation period is 7-10 days and the larval period (5 stages for *C. mbila*), 15-20 days, depending on climatic conditions. Both adults and larvae can acquire the virus while feeding on an infected plant (in a few seconds for *C. mbila*). The insect vector becomes infective only after the virus completes a latent period of several hours to several days, during which it circulates within the insect. The leafhopper can then inoculate the pathogen into healthy plants; the process takes a few minutes. The vector usually remains infective throughout its life. Initial MSV symptoms appear on the inoculated maize plants after an incubation period, which varies according to the development stage of the host at the time of inoculation.

Peregrinus maidis (Homoptera: Delphacidae) is the only known vector of MMV and MStpV. Adults may be brachypterous (truncated wings) or macropterous (wings longer than the body). The macropterous adults are about 5 mm long. Females may live more than 1 month and lay more than 100 eggs that are usually inserted, in pairs, into leaf blades or sheaths. The incubation period is 8-9 days and the larval period (also 5 stages), 25-30 days. It is not certain whether all larval and adult stages can transmit MStpV and that the first two larval stages can acquire MMV. The acquisition and latent periods of the two viruses are a minimum of 4 hours and 10 days, respectively. *P. maidis* may remain infective for its lifetime. Progeny may acquire MStpV by transovarian transmission.

Virus Disease Control

There are two ways of protecting maize crops against virus diseases:

— By treating young plants with systemic insecticides to reduce leafhopper populations. However, the ability of the vectors to migrate, proximity of other plant species that can serve as virus reservoirs (particulary other Poaceae), and extensive cropping of maize in Africa tend to reduce the effectiveness and cost/benefit ratio of this type of control.

— By developing and adopting virus-resistant varieties. In Africa, development of MSV-resistant material is under way. In the Indian Ocean region, work has been initiated for developing MMV and MStpV resistance tests.

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SCALE INSECTS AND MEALYBUGS

OF SUGAR CANE

COLONY ON A YOUNG SHOOT

SOME NYMPHAL STAGES

COLONY ON A STALK

AULACASPIS TEGALENSIS ⇨

PREDACEOUS COCCINELLIDS

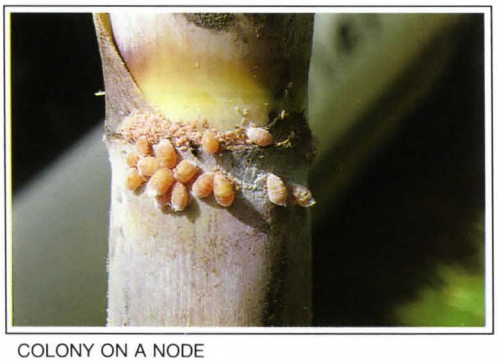
CANE DESTROYED

⇦ PULVINARIA ICERYI

COLONY ON ROOTS

ROOT SCALE ⇨

DAMAGE ON YOUNG SHOOTS



COLONY ON A NODE

⇦ SACCHARICOCCUS SACCHARI

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Scale Insects and Mealy Bugs of Sugarcane

Major Pest Species

Roots, stems, and leaves of sugarcane are attacked by scale insects belonging to several families.

• Coccidae

Several species of the genus *Pulvinaria* infest sugarcane. The most common is *P. iceryi* reported in Africa, Réunion, Mauritius, China, USA, and Australia. The preferred hosts are wild grasses; but it can infest sugarcane if these grasses have been destroyed (mainly by drought). The pest then multiplies on sugarcane leaves which turn yellow, desiccate and are covered with sooty mold. Even at low infestation rates, the damage results in a slowing of stem growth and shortening of internodes; it may also destroy infested stubble.

Several species of the genera *Coccus* and *Lecanium* are also observed on sugarcane.

• Pseudococcidae

The most widespread species, *Saccharicoccus sacchari*, is found on all five continents. It is a pink, globular mealybug with a soft, segmented integument, covered in white waxy meal. All hosts are Gramineae. On sugarcane, colonies are established on stem nodes under the leaf sheaths. The insect feeds on sap and weakens the host plant. It secretes honeydew which affects the quality of cane juice. Germination of infested cuttings is difficult and delayed. But damage is serious only in case of heavy infestation and when the stems are attacked at an early stage of growth.

Other Pseudococcidae species that develop on sugarcane mainly belong to the genera *Pseudococcus*, *Dysmicoccus*, *Planococcus*, *Ripersia*, and *Trionymus*.

• Diaspididae

The genus *Aulacaspis* includes several species that are harmful to sugarcane. *A. tegalensis* is present in Asia, Africa, Madagascar, and the Mascarene islands where it is often accompanied by *P. iceryi*. The female adult is pale yellow to pink, under a rounded white scale. Colonies of this species mainly develop on the part of the internode that is protected by the leaf sheath, but also on leaves. Infestation increases on stems during the final growth stages. Infestation does not generally affect yields very much, but the sucrose content of infested stems can diminish considerably. *A. madiunensis*, with a greenish to gray scale, has been recorded in Asia, Africa, and Australia where it causes the same type of damage.

Melanaspis glomerata which occurs under the leaf sheath is commonly found in India. It reduces cane yields and sucrose content.

Aspidiella sacchari, *Odonaspis* spp.and *Chionaspis* spp. are also listed as sugarcane pests in different regions.

• Aclerdidae

Several species of the genus *Aclerda*, including *A. takahashii*, in Mauritius and Réunion develop on stems under the leaf sheaths.

• Margarodidae

Eumargarodes laingi in Australia and *Margarodes cadeti* in Africa are species whose larvae live in cysts attached to sugarcane roots. Their spherical shape, size (diameter 2 mm), and white or pearly yellow color have earned them the name of "ground pearls." They can slow down growth of ratoons after harvest.

Control Techniques

Scale insect populations are decimated by a large number of parasites and predators. Many of the parasites are Hymenoptera of the families Encyrtidae, Aphelinidae, or Eulophidae; others are Diptera belonging to the family Cecidomyiidae. Ladybirds are the most common predators; but drosophilids, bugs, and chrysopids, also help check pest populations. Fungi, including several species of the genus *Aspergillus*, also destroy the pests. Beneficial fauna should therefore be protected.

The most effective preventive measure is to plant clean cuttings. Scale insects are destroyed by heat treatment of cuttings against diseases or by immersion in a fungicide-insecticide dip. Chemical control on an infested crop is rarely warranted. If the attack is detected at an early stage, localized insecticide spraying at the edge of infestation sites can be useful to prevent it from spreading. Biological control by introducing exotic parasites and predators can be developed against the most harmful species.

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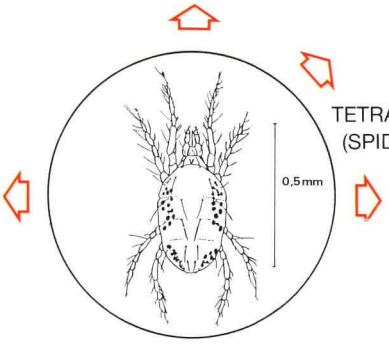
MITE PESTS

ON VEGETABLES

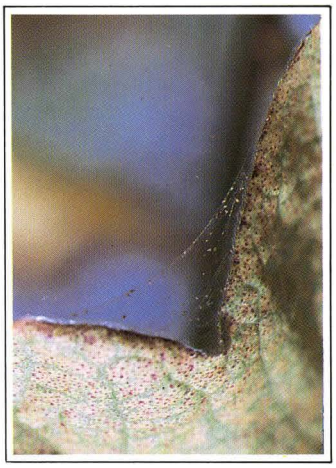
VERY SERIOUS DAMAGE ON TOMATO LEAVES

TETRANYCHUS SP. ON CELERY

TETRANYCHUS SP. ON TOMATO

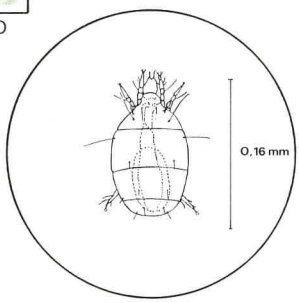


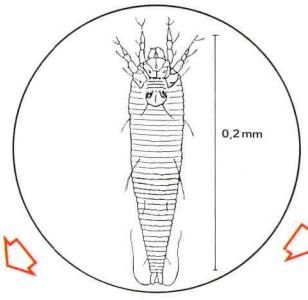
TETRANYCHIDAE
(SPIDER MITES)



TETRANYCHUS SP. WEB

TARSONEMIDAE

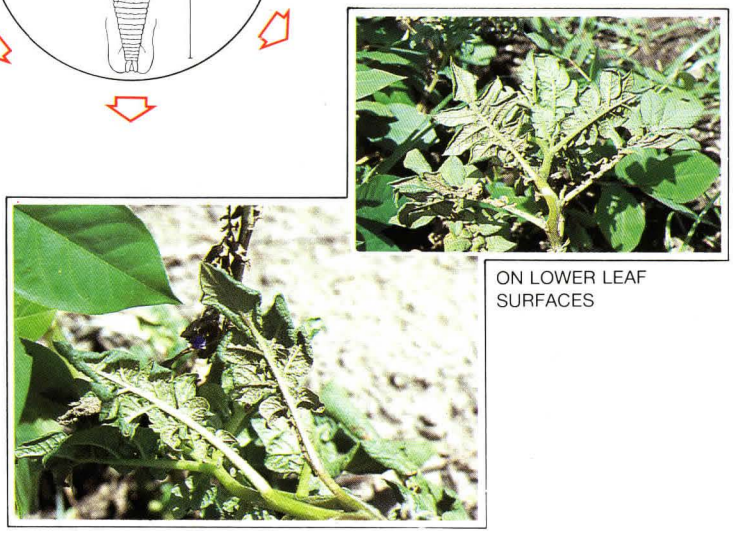




ERIOPHYIDAE
(GALL MITES)

ON UPPER LEAF SURFACES

TOMATO RUSSET MITE
ON POTATO



ON LOWER LEAF
SURFACES

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Mites of Vegetable Crops

Description

Mites are small arthropods closely related to spiders. They belong to three distinct families:

— Eriophyidae. One of the major species is *Aculops lycopersici* Massee (tomato russet mite). The small vermiform pests are not visible to the naked eye (0.25 mm). They are initially white, then brown. Eggs are spherical, yellow, and smooth.

— Tarsonemidae. One of the major species is *Polyphagotarsonemus latus* Banks (tomato yellow mite). The pests are not visible to the naked eye (0.20 mm). Females are oval and pearly yellow. Eggs are oval, transparent, and have longitudinal streaks.

— Tetranychidae. Two major species are *Tetranychus urticae* Koch and *T. cinnabarinus* Boisduval (red spider mites). They have an oval and convex body (0.5 mm) and are visible to the naked eye. The mites are very agile and move along networks of silk threads woven by them. Females are greenish-yellow and have two large dark dorsolateral spots. Eggs are a diaphanous white.

Distribution and Host Plants

All four species of mites are cosmopolitan. *A. lycopersici* is only found on Solanaceae, including potato and tomato. The other species are more polyphagous. Preferred hosts of *P. latus* are eggplant, bitter tomato, and bell pepper. The red spider mites are frequently found on tomato, bean, and Cucurbitaceae.

Biology and Damage

A. lycopersici. Eggs are laid on the undersurface of leaves. There are more than 20 generations per year. The mite feeds by piercing the epidermal cells of leaves. The plant takes on a shiny appearance and later turns russet. On the same plant, the lower leaves are often desiccated, the lower side of the middle leaves is russet, and the terminal leaves are shriveled.

P. latus. Eggs are deposited singly in leaf blade cracks. The cycle lasts for about 1 week. This mite attacks young leaves, which curl and harden, inhibiting plant growth. The lower side of the leaves turns shiny and is covered with brown spots. Bell pepper and bitter tomato show filiform leaves with raised, winding veins. Fruit are most susceptible to damage. If infestation occurs as soon as the calyx falls, they show epidermal suberization at harvest, leading to a loss of market value.

T. urticae and *T. cinnabarinus*. Eggs are deposited on leaves and fruit. Under tropical conditions, duration of the life cycle is 10 days and there is no break between generations. Leaves of infested plants are misshapen, with discolored sections; they later decay. Leaves of Cucurbitaceae turn reddish gray, roll and desiccate. Bean or leaf blades are covered with small white dots.

Control Techniques

Specific acaricides should be used, because most insecticides have no effect on mites, and destroy their natural enemies. The first treatment should be carried out as soon as the first symptoms are observed. Insecticides should be alternated to avoid resistance of mites to active ingredients. Recommended acaricides are tetrasul (40 g a.i./ha), dicofol (30-50 g a.i./ha), binapacryl (50 g a.i./hl), or chinomethionate (12.5 g a.i./ha), which is also a fungicide. Outbreaks of *A. lycopersici* can be checked by preventive application of a sulfur-based mixture every 10 days.

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Pests of Inflorescence, Earheads, Pods, and Fruit

Few insects directly damage **flowers of tropical food crops**. However, coleopteran adults (blister beetles, chrysomelid beetles) feed on millet and sorghum inflorescence. The voracious polyphagous caterpillars of *Spodoptera* spp. and the pyralid *Maruca testulalis*, and several thrips species also destroy flowers of several legume crops.

Cereal earheads are attacked by several species of pyralids and noctuids. Some of them only feed on the earhead, such as the earhead caterpillars *Raghuva* spp. and *Masalia* spp.; others are mainly stem borers (e.g. *Sesamia* spp., *Eldana saccharina*) or foliage feeders (e.g. *Spodoptera*) of Gramineae. Some are polyphagous, but on cereals, they preferably attack the earhead (e.g. *Heliothis armigera*, *Cryptophlebia leucotreta*). As they feed on grains, all the caterpillars have a quantitative and qualitative effect on the produce. Cereal bugs (Miridae, Coreidae, Pentatomidae) mainly attack maturing earheads; they puncture grains that are then emptied, shriveled, or spotted. Two midges, *Contarinia sorghicola* and *Geromyia penniseti* destroy grain of sorghum and millet, respectively.

Legume pods are mainly attacked by Lepidoptera and Heteroptera. The pyralids *M. testulalis* and *Etiella zinckenella* and the noctuid *H. armigera* are the most common caterpillars. They perforate pods and feed on grain. Most bugs of cereal grain also puncture young legume pods and grain. Moreover, damage by these pests encourages the development of fungi on the host.

Fruits of Solanaceae and Cucurbitaceae are attacked by several pests. The polyphagous caterpillars mentioned earlier feed on tomato (*H. armigera*) or eggplant (*Spodoptera* spp.). Many species of fruit flies (e.g. *Ceratitis capitata*, *Pseudalaspis cyanescens*, *Didacus* spp.) are responsible for deterioration of the fruit. Punctures by *Thrips palmi* lead to epidermal suberization of cucumber and eggplant. Polyphagous Coleoptera (ladybirds, chrysomelid beetles) and bugs also attack fruits of certain Solanaceae and Cucurbitaceae.

Among the other harmful arthropods, mites are also economically important pests that damage fruit of vegetable crops.

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Table IV. Host plants of certain pests of inflorescence, earheads, pods, and fruit.

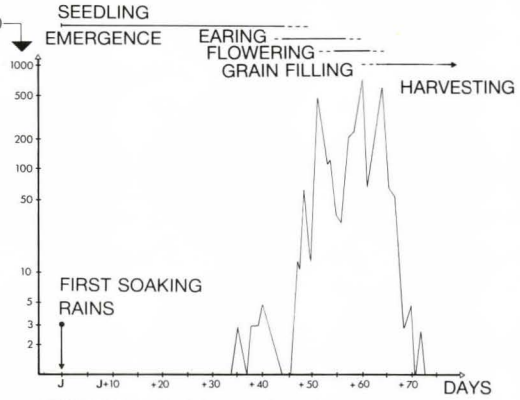
Pest	Host plants: Family: Gramineae	Host plants: Family: Leguminosae	Host plants: Family: Solanaceae	Host plants: Family: Cucurbitaceae	Host plants: Affected plant part: Flowers	Host plants: Affected plant part: Earheads	Host plants: Affected plant part: Pods	Host plants: Affected plant part: Fruit	Remarks
Coleoptera									
Mylabris holosericea	•	•		•	•				Several other Meloidae
Asbecesta spp.	•	•		•	•			•	Mainly on Cucurbitaceae
Henosepilachna elaterii				•	•			•	
Lepidoptera									
Eldana saccharina	•					•			Mainly on maize
Etiella zinckenella		•			•		•		
Maruca testulalis		•			•		•		
Busseola fusca	•					•			Mainly on maize and sorghum
Eublemma gayneri	•				•	•			
Heliothis armigera	•	•	•	•	•	•	•	•	
Masalia spp.	•					•			On millet
Mythimna loreyi	•					•			
Raghuva spp.	•					•			On millet
Sesamia spp.	•					•			
Spodoptera spp.	•	•	•	•		•		•	
Cryptophlebia leucotreta	•		•			•		•	Mainly on cotton
Thysanoptera									
Thrips palmi			•	•				•	
Frankliniella schulzei		•			•				
Taeniothrips sjöstedti		•			•				
Heteroptera									
Creontiades spp.	•	•				•			
Eurystilus marginatus	•					•			On millet and sorghum
Taylorilygus vosseleri	•	•				•			
Acanthomia horrida		•					•		
Leptocorisa apicalis	•					•			Mainly on rice and millet
Mirperus jaculus	•	•				•	•		
Riptortus dentipes	•	•				•	•		
Dysdercus völkeri	•					•			Mainly on millet and sorghum
Acrosternum spp.	•	•				•	•		
Agonoscelis spp.	•	•				•	•		Mainly on millet and sorghum
Aspavia spp.	•	•				•	•		
Calidea dregii	•					•			On sorghum
Diploxys spp.	•					•			
Nezara spp.	•	•	•	•		•	•	•	
Diptera									
Contarinia sorghicola	•					•			On sorghum
Geromyia penniseti	•					•			On millet
Dacus spp.				•				•	
Didacus spp.				•				•	
Pardalaspis cyanescens			•					•	

RAGHUVA SPP. MASALIA SPP.

Noctuidae

EARHEAD CATERPILLARS OF PEARL MILLET

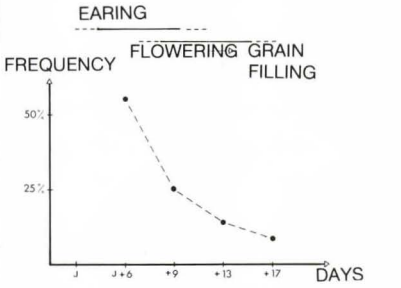
RAGHUVA SP. — 1 mm



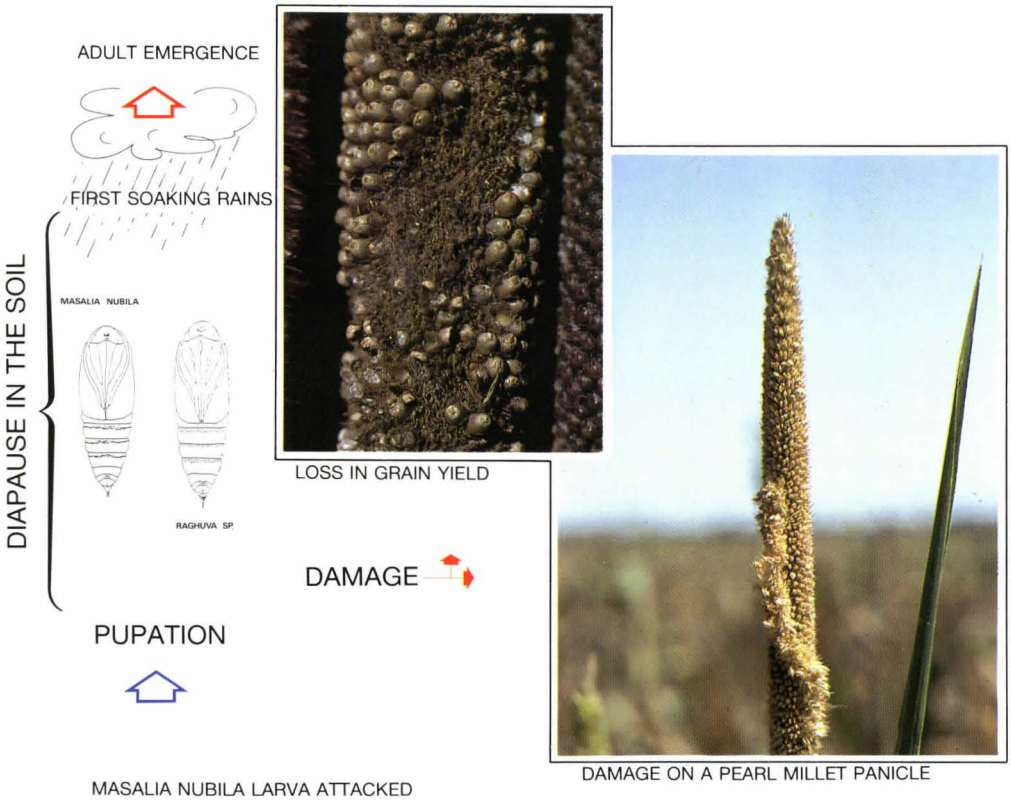
EXAMPLE OF FLUCTUATIONS OF ADULT POPULATIONS OF RAGHUVA SP. IN A PEARL MILLET CROP

EGGS IN A PEARL MILLET FLOWER

— 1 mm



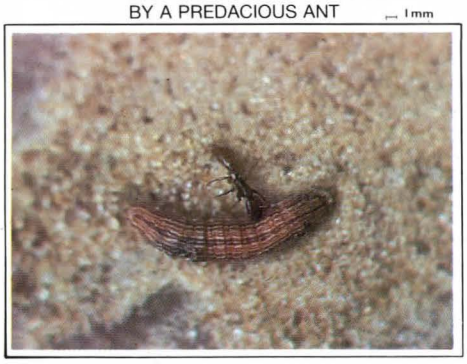
FLUCTUATIONS OF EGG POPULATIONS OF RAGHUVA SP., FROM EARING TO GRAIN FILLING OF PEARL MILLET



DAMAGE ON A PEARL MILLET PANICLE

FIRST DAMAGE (WHITE "GRANULES")

MASALIA NUBILA LARVA ATTACKED BY A PREDACIOUS ANT — 1 mm



LIFE CYCLE

INCUBATION PERIOD	4-5	DAYS	
LARVAL	–	20-35	–
PUPAL	–	11-24	–

DIAPAUSE : 11 MONTHS

— 1 mm RAGHUVA SP. CATERPILLAR

IRAT/CIRAD - B.P. 5035 - 34 032 MONTPELLIER CEDEX - Maquette : T. ERWIN - Photos : B. VERCAMBRE

Raghuva spp. and Masalia nubila Earhead Caterpillars of Pearl Millet

Description

The name "earhead caterpillar" only applies to the genera *Raghuva* and *Masalia* (Lepidoptera: Noctuidae), although many other genera (e.g. *Eublemma*, *Heliothis*, *Pyroderces*) also infest pearl millet heads. The adult *Masalia nubila* Hampson has upper wings that are golden yellow with brown-red mottling. Larvae (20-25 mm) are red with brown-red and white longitudinal lines. Pupae have rounded crests on the first three visible abdominal segments. The genus *Raghuva* comprises a complex of species and subspecies, one of the most important of which is *R. albipunctella* De Joannis. Adults are brown-red to russet. The fore wings have a row of white points. Larvae (20-25 mm) have a yellow to green body with large white longitudinal bands. They take on a red shade before pupation. Pupae have small dots. Eggs of both species are almost spherical, with a diameter of about 0.75 mm.

Distribution

Earhead caterpillars cause serious damage in Africa, from Senegal to Sudan, in the Sahelo-Sudanian zone between the latitudes 11°N and 16°N. Host plants are cultivated and wild millets of the genus *Pennisetum*.

Biology and Damage

Females can lay 400-500 eggs, most of which are deposited singly or in groups of 2-4 on the inflorescence bristles and pedicels during heading. The first sign of an attack is the appearance of whitish, granular excrement. Young larvae feed on glumes and ovaries; they then cut through the pedicels along a more or less spiral passage on the inflorescence. Larvae from eggs deposited at a later stage may also feed on developing grains. The ovolarval stage lasts for 20-35 days, depending on food availability. The insect passes the pupal phase in the soil. At an early stage the pupae enter into diapause that is only broken several weeks before the first rains of the following rainy season (June-July). Development is resumed with the onset of the rainy season and the adults emerge 1 month later. The emergence period lasts for 45-60 days. Only one generation is completed per year.

Economic incidence of the pests depends on a combination of abiotic factors (light soils, rainfall deficit) and the percentage of plants at heading stage when the adults emerge. Grain weight loss may attain 60% of the harvest, but varies considerably according to the year, region, and heading date.

Control Techniques

Infestation spreads very rapidly. It is therefore useful to set up a forecasting system, based on pest models, insect trapping, and inspections at early heading stage.

Certain preventive measures can be taken:

— Tillage at the beginning or end of the growing season destroys 50-90% of the diapausing pupae.

— Heading can be delayed by using long-duration varieties or late planting. However, this will expose the crop to other pests such as midges and borers.

— Certain cultural techniques (varieties, fertilization) can ensure the production of heavy, compact heads.

— Management of useful fauna (e.g. *Trichogramma*) should be encouraged.

Insecticide treatments are justified if crop production is sufficiently high to make them cost-effective. One or two applications could be carried out at the start of heading, at an interval of 5-7 days. Endosulfan (500-700 g a.i./ha, head application only), synthetic pyrethroids, and *Bacillus thuringiensis* are recommended.

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MARUCA TESTULALIS *Geyer*

Pyralidae

BEAN POD BORER

1 mm

ADULT

1 mm

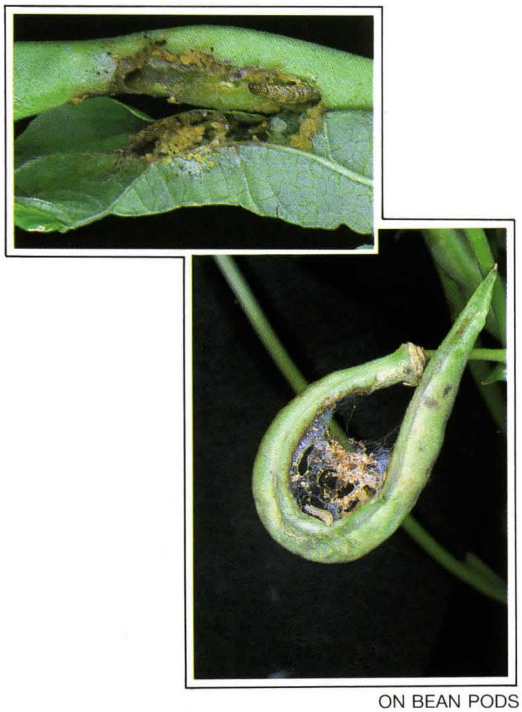
LARVA

LIFE CYCLE
25 °C

INCUBATION PERIOD		2-3	DAYS
LARVAL	–	15	–
PUPAL	–	7	–
ADULT	–	7	–

1 mm

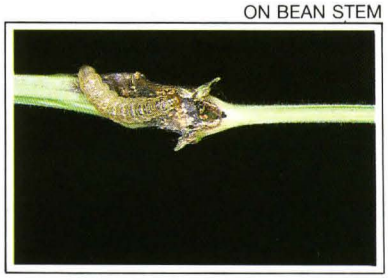
PUPAE



ON BEAN PODS

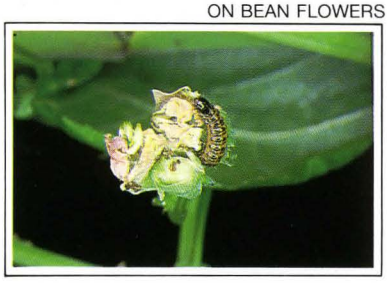
DAMAGE

ON BEAN STEM



ON BEAN LEAVES

ON BEAN FLOWERS



IRAT/CIRAD – B.P 5035 – 34032 MONTPELLIER CEDEX – Maquette : T.ERWIN – Photos : B.VERCAMBRE

Maruca testulalis

Description

The adult *Maruca testulalis* (Lepidoptera: Pyralidae) is a moth with a wingspan of 20-27 mm. The fore wings are deep beige with three white spots; the hind wings are white and transparent, with a dark brown edge. Eggs are almost spherical (0.6 mm x 0.4 mm) with thin streaks. Larvae are white to green with rows of black spots (4 on the dorsal side and 4 on the lateral sides of each segment). They may become reddish shortly before pupation. Pupae are greenish-yellow and 8-11 mm long. They are enclosed in a loose, not very thick, but solid cocoon of silk threads, that is open at the front end.

Distribution and Host Plants

M. testulalis is widespread throughout the tropics and subtropics on all continents except Europe. It infests about 30 cultivated or wild plants, including *Vigna* spp., *Phaseolus* spp., *Cajanus cajan*, *Crotalaria* spp., it occurs less frequently on *Vicia* sp., *Dolichos* sp., groundnut, tobacco, rice, sesame, castor, hibiscus, etc.

Biology and Damage

Females prefer high humidity and moderate temperatures (20-24°C), and mate only once between the second and fifth night after emergence. Within 3-7 days, they lay 120-200 eggs on various plant organs, including leaves, pods, branch tips, but particularly on flowers and flower buds. The eggs hatch after 3-5 days. Depending on the oviposition site the following symptoms and damage are observed: leaves bound together so that photosynthetic activity is inhibited, bored stems and pods, damaged flower clusters, and destroyed grain. The larvae are lodged in nests that they produce with frass, excrement, and plant debris bound by silk threads. Larvae develop through five stages, with the last two usually occurring in developing pods. Pupation takes place in pods or in the soil, and lasts for 6-12 days. The complete life cycle is 25-50 days, depending on food and climatic conditions. Grain losses may exceed 50%. But in Leguminosae, destruction of 50% of the flowers does not necessarily cause high yield loss because flowers and young pods are produced abundantly and even fall before they mature.

Control Techniques

Appropriate preventive measures involve adoption of an adequate plant density (e.g. at least 200 000 plants/ha for cowpea and bean), planting during periods when pest populations are low, use of tolerant or resistant varieties, and destruction of secondary host plants. Intercropping systems (e.g. cowpea with maize, cassava, sorghum) do not normally decrease pest pressure. Entomophagous insects often have limited effect, but diseases may reduce borer populations during the wet season.

Synthetic pyrethroids (deltamethrin, 12.5 g a.i./ha; cypermethrin, 20-30 g/ha; permethrin, 10-20 g/ha) and endosulfan (400-600 g/ha) are the most reliable insecticides. Treatment should begin at early flowering stage and should be repeated 2-4 times at intervals of 7-10 days, depending on the infestation level and the crop involved.

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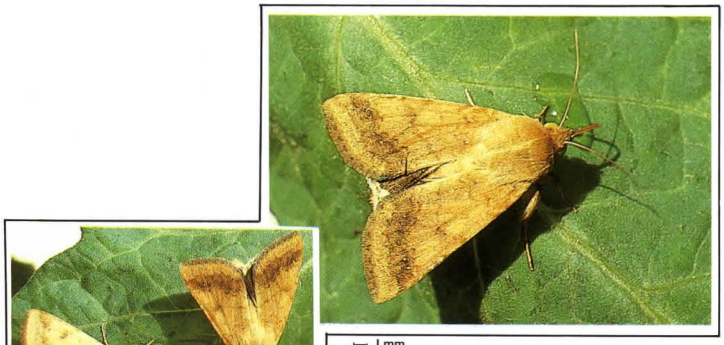
HELIOTHIS ARMIGERA *Hübner*

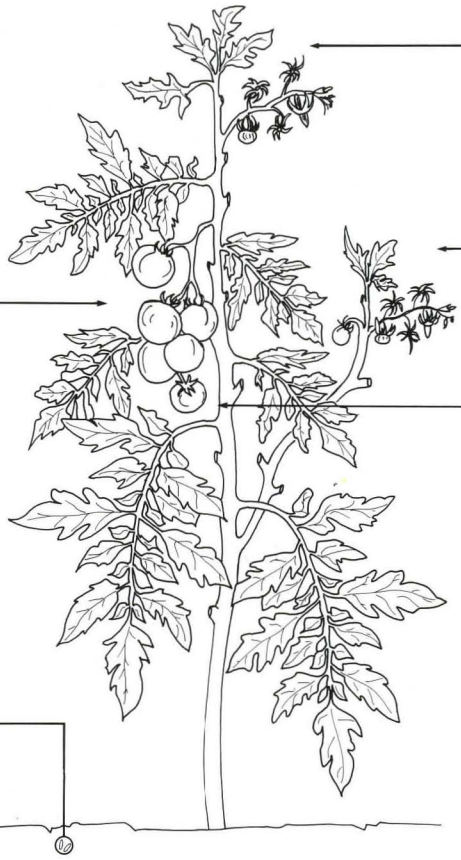
Noctuidae

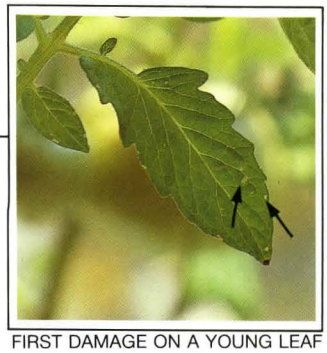
"AMERICAN" BOLLWORM ON TOMATO



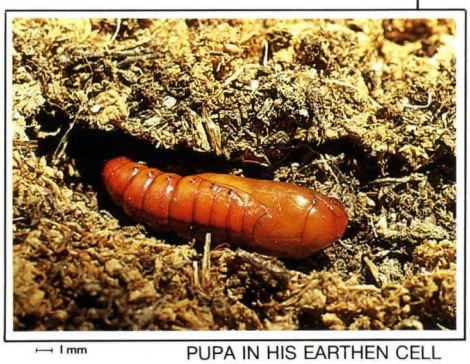
♂ ADULTS ♀

EGGS ON A YOUNG LEAF





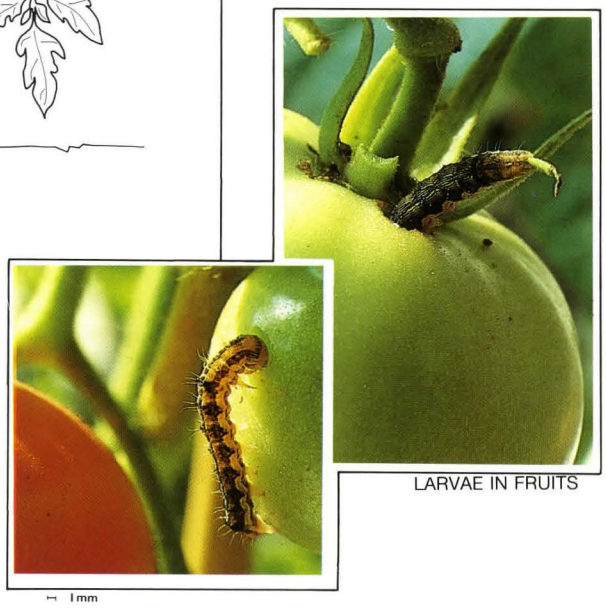
FIRST DAMAGE ON A YOUNG LEAF



PUPA IN HIS EARTHEN CELL

LIFE CYCLE AT 25 °C

INCUBATION PERIOD	2-4	DAYS
LARVAL	–	15	–
PUPAL	–	10-14	–



LARVAE IN FRUITS

IRAT / CIRAD – B.P 5035 – 34032 MONTPELLIER CEDEX – Maquette et photos : T.ERWIN

Heliothis (= Helicoverpa) armigera on Tomatoe

Description

Heliothis armigera (Lepidoptera: Noctuidae) is a moth with a wingspan of 3-4 cm. Its color varies considerably; the male is usually gray-green and the female orange-brown. The hind wings are light colored, with a darker area at the tips. Eggs are white, then brown, hemispherical with a diameter of 0.4-0.5 mm. Larvae may reach 40 mm in length. Fully grown larvae vary from yellow to green, giving the impression that they belong to different species. They are covered with rigid hairs and often have alternating light and dark longitudinal bands. Pupae are brown and about 16 mm long.

Distribution and Host Plants

This species is found in Europe up to 55°N. It also occurs throughout Africa, and in central and Southeast Asia. *H. armigera* is a polyphagous insect, that is found on pea, eggplant, bean, potatoe, and maize; it is responsible for major economic losses in tomato, tobacco, and cotton crops.

Biology and Damage

The female lays up to 3000 eggs that are deposited singly on young tomato leaves and hatch 2-4 days later. Initially, larvae feed on leaf blades, which are soon covered with small holes. They then attack flowering organs and fruit, by often penetrating them at a point close to the peduncle. The larvae tunnel into growing fruit, which continue to develop, and feed on the pulp in a characteristic position-the anterior portion of the body is buried in the fruit and the posterior portion remains outside. The larvae thus attack a number of fruit, usually in the same bunch, before completing development at the fifth or sixth stage. The larval period lasts for 15 days at 25°C. The larvae subsequently burrow 4-5 cm into the soil to pupate. Adults emerge after 10-14 days.

The pest is mainly responsible for destruction of flowers, falling of young infested fruit, and loss of market value of the fruit. Fruit may rot due to infections by pathogens that penetrate through holes made by the larvae. Proximity of or rotation with susceptible crops creates favorable conditions for pest multiplication and increased damage.

Control Techniques

Tomato crops should be sprayed with insecticides at flowering or when *H. armigera* eggs begin to appear. Synthetic pyrethroids (deltamethrin, 25 g/ha per week; cypermethrin, 50 g/ha per week; fenvalerate, 75-100 g/ha per week), endosulfan (1 kg/ha), and acephate (750 g/ha) are recommended. However, active ingredients should be alternated to avoid pest resistance to the insecticide. Only pyrethroids should be used 15 days before the first harvest.

The baculovirus "Heliothis" is an effective pathogen. It can be sprayed on the crops and is inoffensive to other natural enemies of *H. armigera*.

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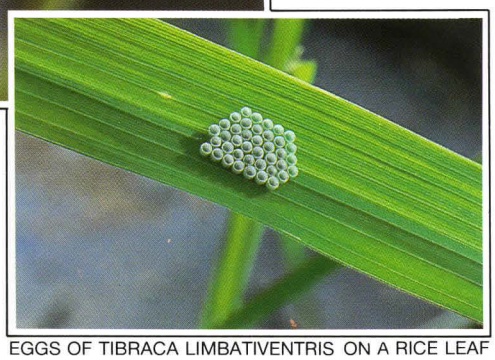
BUGS

OF TROPICAL CEREALS

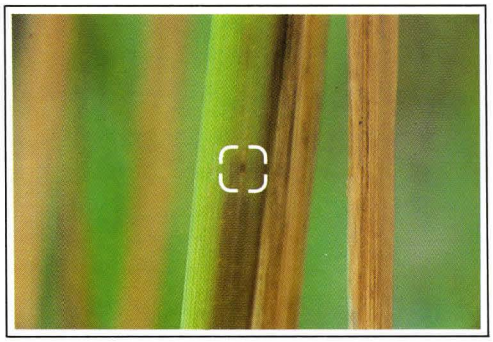
NEW-HATCHED LARVAE OF
ASPAVIA ARMIGERA ON A MAIZE LEAF



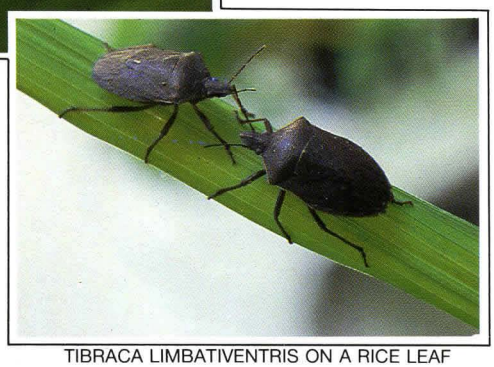
EGGS OF TIBRACA LIMBATIVENTRIS ON A RICE LEAF

LARVA OF DYSDERCUS SP.
ON A PEARL MILLET HEAD

FEEDING PUNCTURE OF
TIBRACA LIMBATIVENTRIS
ON A YOUNG STEM OF RICE



NEZARA VIRIDULA ON A MAIZE LEAF



TIBRACA LIMBATIVENTRIS ON A RICE LEAF

DIPLOXYS SP. ON SORGHUM GRAINS

ASPAVIA ARMIGERA
ON A MAIZE LEAF

IRAT / CIRAD - B.P. 5035 - 34032 MONTPELLIER CEDEX - Maquette : T. ERWIN Photos : IRAT

Tropical Cereal Bugs

Heteroptera of Millet, Sorghum, Rice, and Maize

A large number of phytophagous bug species attack tropical cereals as well as other host plants. They mainly belong to the families Miridae (e.g. *Creontiades* sp. in Africa, *Calocoris angustatus* in India), Pyrrhocoridae (e.g. *Dysdercus völkeri* in Africa), Coreidae (e.g. *Anoplocnemis curvipes*, *Mirperus jaculus*, and *Riptortus dentipes* in Africa; or *Leptocorisa* sp. in Asia and Oceania), Pentatomidae (e.g. *Oebalus pugnax* and *Tibraca limbativentris* in the West Indies; *Diploxys* sp., *Acrosternum* sp., and *Aspavia albidomaculata* in Africa; *Scotinophora* sp. in Asia; *Nezara viridula* throughout the five continents).

Biology and Damage

Each bug has a specific biology and behavior. The female may lay up to several hundred eggs during its life cycle of several months. The eggs are deposited on plant parts or inserted in the tissue, and sometimes on the ground. The incubation period may last less than 1 week. The larval period lasts 2-8 weeks, depending on the species and climatic conditions. The larva grows and acquires the appearance of an adult over generally five development stages. As it grows, the larva pierces stems, leaves, and spikelets, sucks sap and contents of milk-stage grains, and sometimes injects toxic saliva in the tissues. There are several generations per year, some of which develop on wild hosts between the cropping seasons. Certain species are also capable of migrating.

Several types of damage are observed. If sap loss is high, growth of young cereal plants is slow and sometimes inhibited. The toxic saliva may also cause malformation of leaves and stems. Infested plants and tillers are often nonproductive. Heads are particularly susceptible when the grains are at milk stage. Damaged grains carry brown or black spots where they were punctured by the bug; they are wrinkled and sometimes empty. Grains at dough stage are less susceptible although they may sometimes be atrophied. Damaged plant parts, particularly grains, are exposed to pathogens that enter through the punctures made by the bugs.

The percentage of destroyed or seriously damaged grains depends on the population density and phenological stage of the host plant at the time of attack. Risk of heavy reduction of grain yields is low if density does not exceed an average of several individuals per plant.

Control Techniques

Preventive protection of young cereal crops requires seed dressing or in-furrow application of liquid or granular insecticides. Carbofuran and carbosulfan (0.1-0.2 g a.i./m of plant row) are recommended in the second case.

Curative insecticide treatments are often preferred if infestation levels justify such applications. Spraying of lindane (500 g a.i./ha), endosulfan (500 g/ha), carbaryl (2 kg/ha), or chlorpyriphos (300 g/ha) should be effective. Application instructions should be followed scrupulously, especially when the grain is consumed immediately after harvest.

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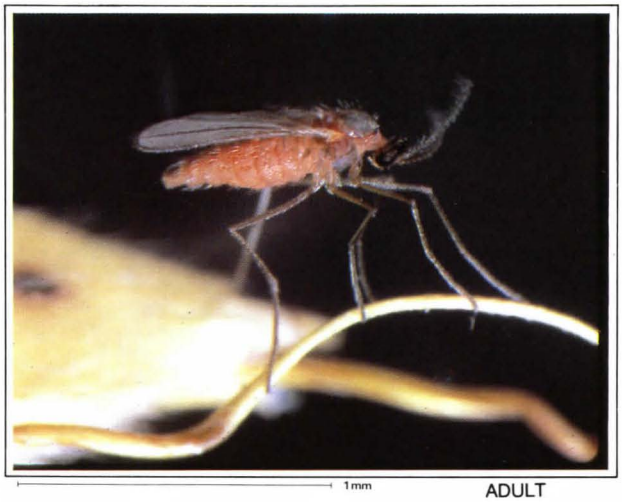
CONTARINIA SORGHICOLA

(COQUILLETT) *Cecidomyiidae*

SORGHUM MIDGE



ADULT

EGGS IN FLOWERING SPIKELETS

DAMAGE

HIGH RATE OF DESTROYED GRAINS

LOSS IN GRAIN YIELD

LIFE CYCLE

INCUBATION PERIOD	2-3	DAYS
LARVAL	–	9-11	–
PUPAL	–	3	–

OLD LARVAE IN A GRAIN

PUPAL SKIN AT THE TIP OF THE SPIKELET

PUPA

PUPATION

DIAPAUSE

PUPATION

DIAPAUSING LARVA WITHIN A SPIKELET

IRAT / CIRAD - B.P. 5035 - 34032 MONTPELLIER CEDEX - Maquette : T.ERWIN - Photos : R. COUTIN (INRA)

Contarinia sorghicola

Description

The adult *Contarinia sorghicola* Coquillet (Diptera: Cecidomyidae) is a midge with an orange body measuring about 1.5 mm in length. The antennae are twice as short in females compared with males. Eggs are elongate (0.3 mm x 0.06 mm), cylindrical, colorless, and with a tapered appendage. The larvae are almost colorless at first, then turn pink and finally dark orange or red when fully grown. The young pupa is 2 mm long and uniformly orange in color.

Distribution and Host Plants

The sorghum midge probably originated in Ethiopia or the neighboring countries; it is now distributed throughout most sorghum-growing regions of the world. It is mainly found in USA, the Caribbean islands, South America, Africa, India, Indonesia, Australia, and Mediterranean Europe.

All host plants are wild or cultivated species of the genus *Sorghum*.

Biology and Damage

The adults appear 1 or 2 hours after dawn and mate immediately. The female seeks flowering panicles of sorghum and deposits between 50 and 100 eggs under the spikelet glumes. The female oviposits and perishes before sunset. The incubation period is about 3 days. Larvae mainly feed on ovaries and complete development in 1 or 2 weeks. They pupate under the glumes. Shortly before adult emergence about 3 days later, the pupa works its way towards the spikelet tip where it can be easily detected. It remains immobile until the molt. The life cycle lasts 2-3 weeks during most of the cropping season. But as the rains grow scarce and the dry season sets in, an increasing number of larvae in the final stage of development form a cocoon and enter into diapause in the spikelets. The diapause is often broken with the onset of the next rainy season, but may sometimes last up to 3 years. A series of 9-12 generations may be completed per year.

C. sorghicola is a major sorghum pest in Africa. Damage includes partial—and sometimes almost total—destruction of the grains. The larvae or orange nymphs can be exposed by pinching the sterile spikelets. The pest multiplies more rapidly when sorghum plantings are phased out and the flowering period is extended. Yield reduction, mainly in late crops, may exceed 50% and sometimes attain 90% in certain regions.

Control Techniques

In order to reduce economic losses, several preventive cultural control measures should be adopted by all the farmers throughout the crop-growing region. These include systematic destruction by burning of nonharvested panicles to eliminate carryover and removal of regrowth or wild sorghums. Planting schedules should be strictly maintained so that flowering occurs simultaneously in all plots.

Insecticide treatments may be cost-effective for high-yielding crops. The insecticide should then be sprayed or dusted when almost half the plants are at flowering stage. Endosulfan, carbamates, organophosphates, or synthetic pyrethroids are recommended, depending on the cropping conditions.

Recent progress in the development of resistant sorghum varieties is encouraging; in the future, such varieties will provide the means for sorghum midge control.

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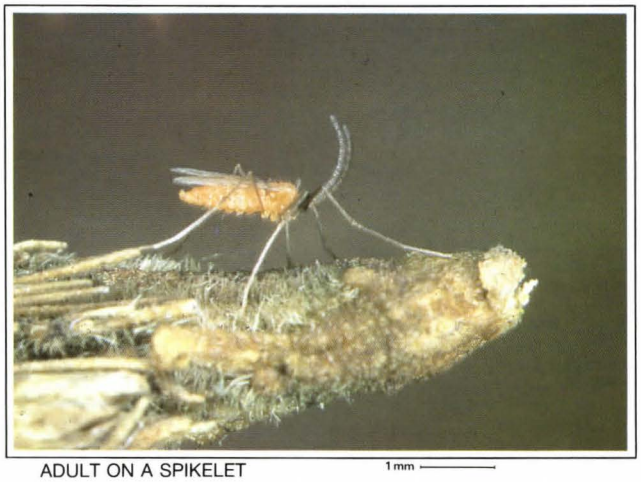
GEROMYIA PENNISETI *(FELT)*

Cecidomyiidae

MILLET GRAIN MIDGE

LIFE CYCLE AT 25 °C			
INCUBATION PERIOD	3	DAYS	
LARVAL	–	7	–
PUPAL	–	2	–

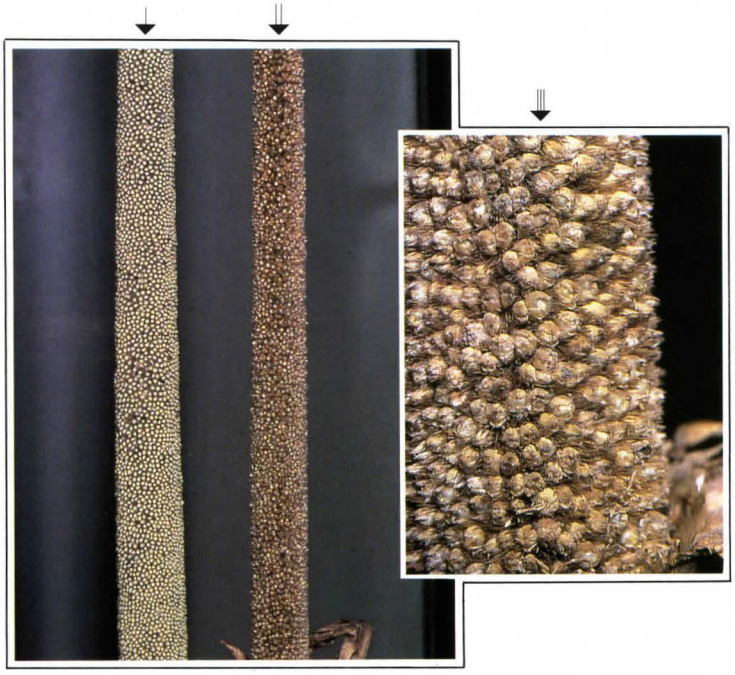


ADULT ON A SPIKELET

1 mm

1 mm

LARVA WITHIN A SPIKELET



DEGATS

- UNDAMAGED HEAD
- HEAD WITH MANY ATTACKED GRAINS
- DESTROYED SPIKELETS

ADULT EMERGENCE

PUPAL SKIN AT THE TIP OF THE SPIKELET

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Geromyia penniseti

Description

The adult *Geromyia penniseti* Felt (Diptera: Cecidomyidae) is a 2.5 mm long, orange-colored midge. Eggs are elongate and slightly curved. The larva is also orange and measures 1.5 mm in length when fully grown.

Distribution and Host Plants

The midge has been present since a very long time in India and Africa. It probably originated in Africa although it was only discovered for the first time in 1936.

Known host plants all belong to the genus *Pennisetum*. The species include *P. typhoides* commonly grown in Africa, *P. polystachyon*, *P. pedicellatum*, *P. alopecuros*, and *P. cenchroides*.

Biology and Damage

The adults begin to appear at sunset and mate immediately. Oviposition starts soon afterwards and extends throughout the night. The female deposits its eggs either singly or in pairs, generally on glumes and glumules between two spikelets or on pedicel bristles. It prefers parts of the head where the female flowers are not open completely and the stigmas have not yet emerged. The incubation period is 3 days. Young larvae penetrate the spikelet between the glume tips, migrate to the ovary and begin to feed on it. Within 1 week, the fully grown larva occupies the entire area between the glumes and pupates there. The final molt occurs 2 days later, after the nymph emerges from the floral cavity and settles on the tip of the destroyed spikelet. A series of 4-5 generations, with an average life cycle of about 13 days, may occur during the wet season. As the dry season approaches, an increasing number of larvae in the final stage of development form a cocoon and enter into diapause between the glumes. They will only pupate at the onset of the next rainy season.

Grain yield loss depends on the number of destroyed spikelets. Early varieties are generally more susceptible. Infestation in late-maturing crops and varieties is lower as natural enemies subsequently reduce pest populations.

Control Techniques

G. penniseti control in millet crops mainly requires burning of nonharvested heads, regrowth, and wild host plants near the fields. Use of varieties with simultaneous flowering checks proliferation and spread of the pest.

Chemical control, by insecticide application on heads, is only justified when planting is phased out on the same production site, for example at a plant breeding or agricultural experiment station.

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PEST IDENTIFICATION AND SURVEYS

Model of Checklist to be Sent with Specimen for Identification

1. Name of operator:

2. Date of specimen collection: / /

3. Place of collection Country: Region:
City: Location:

4. Biological stage of specimen:

Egg ☐ Larva ☐ Pupa ☐ Adult ☐

5. Presence of parasitoids or predators of pest:

6. Name of host plant: **Variety:**

7. Phenological stage of host plant:

Emergence ☐ Stem elongation ☐ Budding ☐ Fruit formation ☐
Tillering ☐ Heading ☐ Flowering ☐ Maturity ☐

8. Damaged plant part(s):

Roots: Internal ☐ External ☐
Tubers: Internal ☐ External ☐
Stems: Internal ☐ External ☐ Base ☐ Middle ☐ Top ☐
Leaves: Upper surface ☐ Under surface ☐ Between epidermises ☐
Flowers: Internal ☐ External ☐ Male ☐ Female ☐
Fruit, pods, grain: Internal ☐ External ☐

9. Type of crops:

Field ☐ Under shelter ☐
Greenhouse ☐ Hydroponic ☐

10. Crop stage:

Planting ☐ Transplanting ☐ Storage ☐
Nursery ☐ Harvest ☐

11. Infestation symptoms on host plant:

12. Damage:

Mild ☐ Heavy ☐ Severe ☐
General ☐ Localized ☐

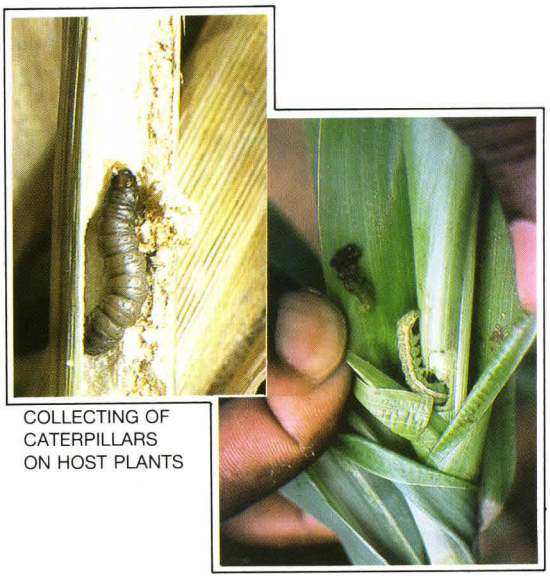
13. Insecticide treatments before pest survey:

SURVEY METHODS

FOR CATERPILLARS IN CROPS

COLLECTING OF DAMAGED HOST PLANTS

COLLECTING OF CATERPILLARS

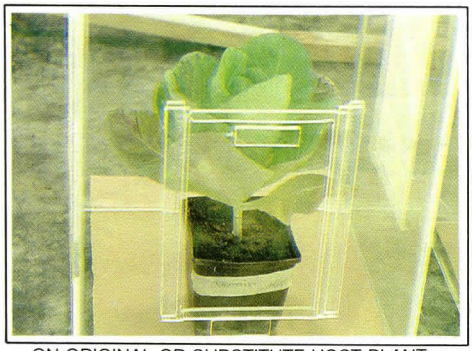


COLLECTING OF CATERPILLARS ON HOST PLANTS

PACKAGE AND DISPATCHING

RECEIPT IN THE REARING LABORATORY

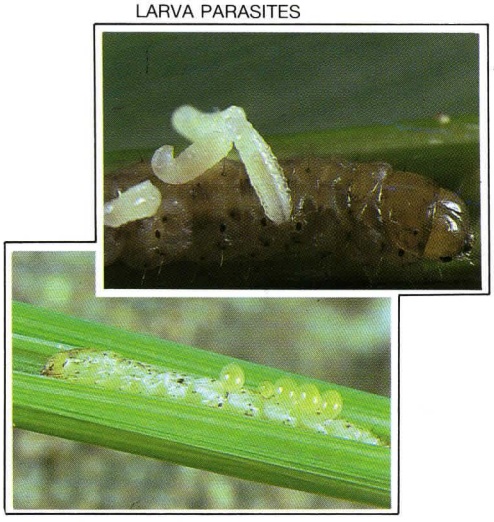
REARING OF THE CATERPILLARS



ON ORIGINAL OR SUBSTITUTE HOST PLANT

ON ARTIFICIAL MEDIUM

LARVA PARASITES



ADULTS OF PARASITES PRESERVED DRY IN TUBES

SELECTION OF SPECIMENS

PUPAE

ADULTS

PRESERVATION OF SPECIMENS

MOTHS IN PAPER ENVELOPES

DISPATCHING OF SPECIMENS TO IDENTFICATION SERVICES

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Identification of Phytophagous Caterpillars

Simple visual observation of a larva is not generally adequate for an accurate and definite identification. Many species, mainly pyralids and noctuids, resemble each other at larval stage. Moreover, the color of larvae of the same species may vary according to age. Species identification requires an examination of the adults obtained from the larvae, except for those that can be recognized easily.

Collection of Caterpillars in the Field

External caterpillars are collected using flexible tweezers, from stems and the upper or lower surface of leaves; they are sometimes found on or below the soil surface. Some species are nocturnal and avoid daylight. Certain infested plant organs are sometimes dissected to extract internal caterpillars (e.g. pyralids and noctuids obtained from grass stems) that are later reared on an artificial diet. The infested plant part or the entire plant is sometimes removed for collecting live samples (e.g. leaf miners).

Preparation and Transport of Specimens

Larvae that need to be transported over long distances to a rearing laboratory are placed either separately (in case of cannibals) or in batches of 10-20 individuals, in ventilated boxes with food (artificial diet or fresh plant parts, such as stems or leaves). Each box should be clearly labelled with the collection date and location, name of collector, host plant, type of damage, and reference number.

When the larvae cannot be reared at the collection site, live specimens should be sent to a specialized laboratory, following the above instructions.

Rearing of Larvae and Pupae in the Laboratory

As soon as the specimens arrive at the laboratory, rearing operations are started, using:

— either the original host plant, or a substitute species. Samples are placed in ventilated cages in full daylight and the plants are watered regularly.

— or an artificial diet when it is available and accepted by the caterpillars. The samples are kept separately in pillboxes, or in batches of 10-20 individuals in transparent plastic sealed boxes.

Developing pupae and parasitized larvae are isolated in sealed tubes.

Selection, Preservation, and Shipment of Specimens for Identification

Parasites (adults) obtained from larvae and moths from pupae are killed on emergence, by freezing or application of cyanide or ethyl acetate. They are preserved in dry state in sealed tubes (adult parasites) or wrapped in paper (moths). Reference data is marked as described earlier and the material is sent to an identification service.

Useful Addresses

- Laboratoire d'élevage et de nutrition des insectes (LENI), CIRAD-GERDAT
- Laboratoire d'entomologie, CIRAD-IRAT
- Laboratoire de faunistique, CIRAD-GERDAT

Address for all three laboratories:
Centre CIRAD de Montpellier
BP 5035, 34032 Montpellier Cedex 1, France

CIRAD-IRAT, Entomologie, BP 5035, 34032 Montpellier Cedex 1, France
Tel: (16) 67 61 58 00 — Telex: 480762 F CIRAD — Fax: (16) 67 61 59 88

SURVEY METHODS

FOR HOMOPTERA

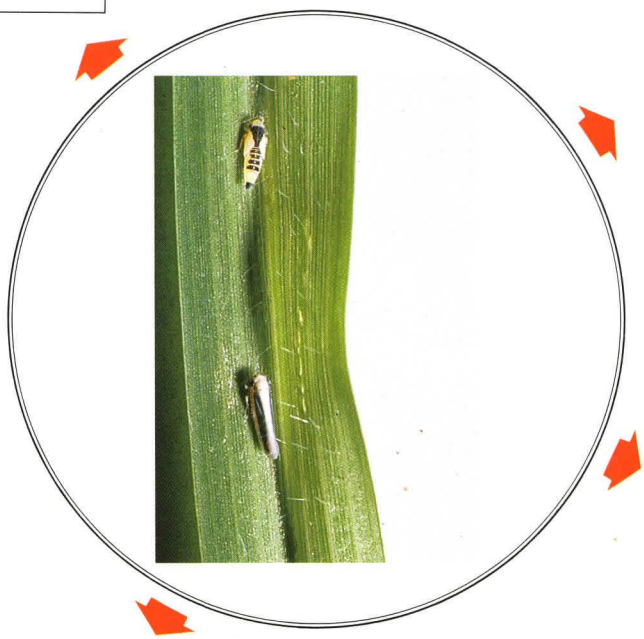
YELLOW PANEL

FISHING-LINE TRAP

STICKY TRAPS

YELLOW PAN

WATER TRAP



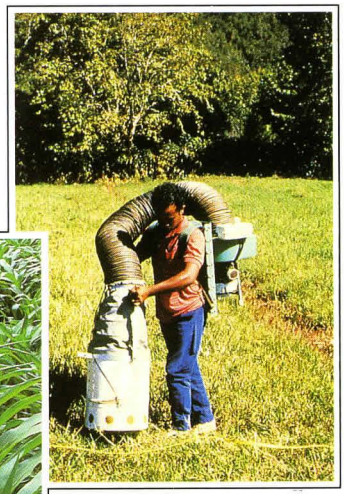
LEAFHOPPERS

VACUUM TRAPPING

SWEEP-NET

SWEEP-NET CATCH

MOUTH SUCTION APPARATUS



MECHANICAL SUCKING NET

I.R.A.T./C.I.R.A.D. – B.P. 5035 – 34032 MONTPELLIER CEDEX – Maquette : T.ERWIN – Photos : T.ERWIN-IRAT

How to Identify Homopteran Pests

Leafhoppers (Cicadellidae, Delphacidae, Cercopidae), whiteflies, aphids, and scale insects are the main homopteran pests of tropical food crops. The insects cause two types of damage through their sucking habit: sap removal (phytophagous insect) or pathogen inoculation (vector).

Insect Collection

• Direct capture

When the insect is less mobile and easily detected, it can be collected with the plant support (scale insects attached to leaves) or after being separated from the host plant by using flexible tweezers. If the pest is visible but small and quite mobile, it can be captured using a mouth suction apparatus (delphacid vectors in leaf whorls of Gramineae).

If the insect is too small or located very deep in the host plant to be easily detected (leafhopper in a grass prairie), an insect net is used. The plant is shaken vigorously and the contents of the net are removed using the mouth suction apparatus. If the collection or survey covers large areas, the insect net can be replaced by a mechanical suction collector that can be transported and handled by a single person.

• Trapping

Homoptera in the mobile stages can be captured using various types of traps: yellow pans filled with water containing a few drops of a wetting agent, placed at different heights within a crop; yellow vertical panels covered with glue; a wire trap made up of a wooden frame (side, 20-30 cm) and parallel synthetic wires at 2-3 mm intervals and covered with glue; various types of light traps.

Sample Preservation

The insects collected in water are dried on a paper filter, those stuck to glued surfaces are detached using tweezers dipped in a solvent such as petroleum. Mobile species that are collected live in an insect net, light trap, or directly from the plant are killed by asphyxiation in a glass jar containing a piece of cotton soaked in ethyl acetate and closed with a screw cap rubber stopper.

Whiteflies, scale insects, and aphids are preserved in 70° alcohol. Leafhoppers are arranged on layers of cellucotton wrapped in paper.

Each sample should carry a label specifying the date and location where it was collected, name of the collector, host plant and possibly plant part, and reference number given by the collector.

Addresses for Identification of Collected Insects

• Laboratoire de faunistique du GERDAT-CIRAD
Centre CIRAD de Montpellier
BP 5035, 34032 Montpellier Cedex 1, France

• Muséum national d'histoire naturelle
Laboratoire d'entomologie générale et appliquée
45, rue Buffon, 75005 Paris, France

• British Museum
(Natural History)
Cromwell Road, London SW7 5BD, U.K.

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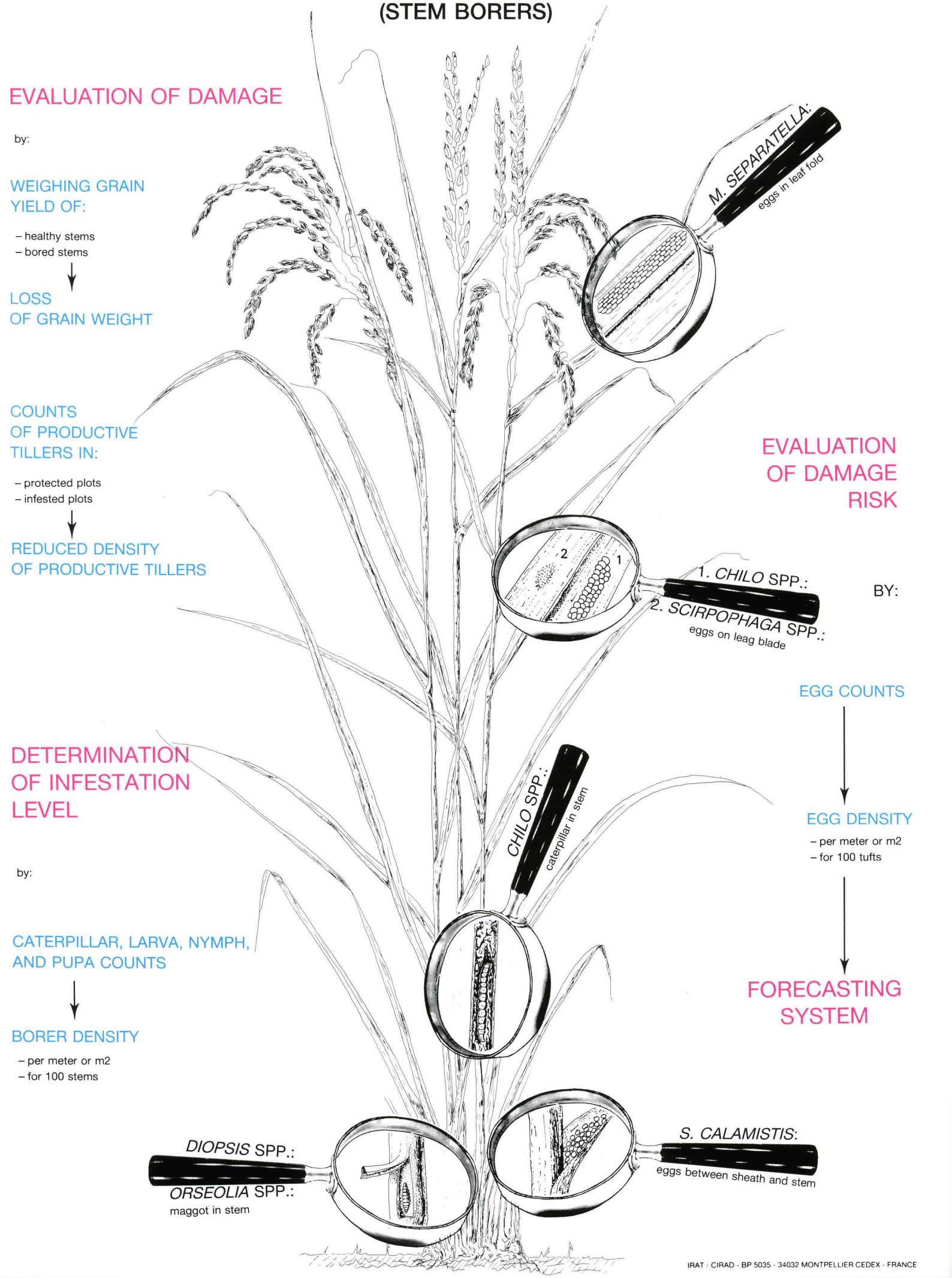
PEST SURVEYS IN RICE CROPS

(STEM BORERS)



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Techniques for Analyzing Pest Status in Rice Crops (Case of Stem Borers)

Pyralids, noctuids, diopsids, and midges pass the larval stage in rice stems. Certain methods are proposed for evaluating infestation risks, attack intensity, and economic incidence.

Evaluation of Damage Risk

Damage risk depends on the phenological stage of the crop at the time of attack and primary infestation level. **At the early tillering stage**, certain early indications are the appearance of diopsid adult swarms near the rice fields, an average density of at least 5 adults/m^2 in early crops or 10 adults/m^2 in late crops, appearance of the onion shoot symptom on stems supporting midge larvae, and pyralid or noctuid eggs. These early signs warrant a preventive insecticide treatment, especially in early crops. **At the late tillering stage**, diopsid or midge infestation has only a minimum effect on yield. However, oviposition by pyralids or noctuids at this stage could cause heavy damage at heading and should be identified as soon as possible.

Determination of Infestation Level

The intensity of stem borer infestation in a rice field can be determined by dissecting stems to detect midge and diopsid maggots as well as pyralid and noctuid caterpillars. The rate is expressed as the average number of individuals per m^2 of the rice crop or meter of transplanted plant rows, and converted into larval density per hectare at different crop phenological stages. It can also be expressed as the percentage of mined tufts or tillers.

Determination of Yield Loss

Yield loss **due to the reduction of the number of productive stems during tillering** can be measured by comparing yields from treated and nontreated crops. Yield loss (Ls) in terms of grain weight/ha, is determined by the following equation:

$$Ls = \frac{w_1}{n_1} \times 10\,000\,(T - NT)$$

where:

n_1 = average number of stems without borers in a sample of stems taken at panicle maturity stage in nontreated plots;

w_1 = grain weight of n_1;
T = average number of productive stems/m^2 in treated plots;
NT = average number of productive stems/m^2 in nontreated plots.

Yield loss **due to a reduction of panicle weight** is determined by collecting and dissecting a sample of 200 productive stems. Yield loss (Lp) in terms of grain weight/ha, is determined by the following equation:

$$Lp = \frac{\frac{200\,w_1}{n_1} - (w_1 + w_2)}{200} \times 10\,000\,N$$

where:

n_1 = number of stems in the sample without stem borer attack signs;

n_2 = 200 - n_1;
w_1 = grain weight of n_1;
w_2 = grain weight of n_2;
N = average number of panicles/m^2 in the rice crop.

The calculation is less accurate when other pests simultaneously cause severe damage in the test plots.

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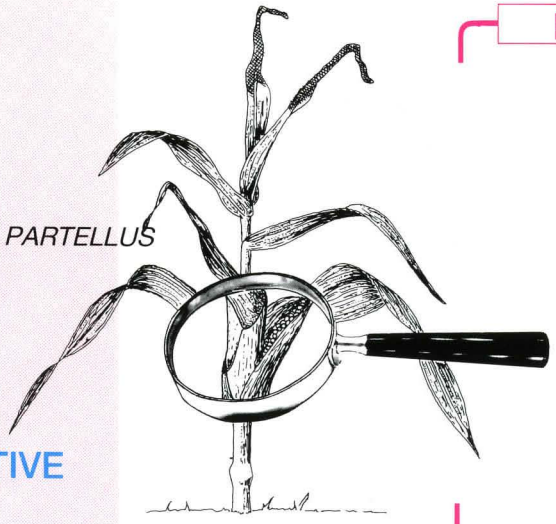
PEST SURVEYS IN MAIZE CROPS

(STEM BORERS)



FORECASTING SYSTEM

COUNTS OF *SESAMIA* SPP.
AND *B. FUSCA* EGGS
BETWEEN SHEATHS AND STEMS

↓

CHANGES IN EGG
DENSITY/HA

↓

CHOICE OF DATES
FOR CURATIVE INSECTICIDE
TREATMENTS ON YOUNG PLANTS

COUNTS
OF DEAD HEARTS
AND BROKEN STEMS
DUE TO *SESAMIA* SPP., *B. FUSCA*. *C. PARTELLUS*

↓

DETERMINATION OF THE PERCENTAGE OF DESTROYED PRODUCTIVE STEMS PER HECTARE

EVALUATION OF DAMAGE

DURING FLOWERING-HEADING

DURING STEM ELONGATION

DETERMINATION OF GRAIN YIELD LOSS

↑

WEIGHING YIELDS OF CROPS:
– PROTECTED BY INSECTICIDES
– EXPOSED TO NATURAL INFESTATION

EVALUATION OF THE PERCENTAGE
OF INFESTED HEADS

↓

DETERMINATION OF INFESTATION LEVEL

PER COMPLEX OF STEM BORERS:
SESAMIA SPP., *C. PARTELLUS,*
B. FUSCA, E. SACCHARINA

↑

EVALUATION ON THE PERCENTAGE OF:
– INFESTED STEMS
– BORED INTERNODES

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Techniques for Analyzing Pest Status in Maize Crops (Case of Stem Borers)

In tropical Africa, maize crops are likely to be attacked by several species of pyralids and noctuids, including *Sesamia calamistis*, *Busseola fusca*, *Chilo partellus*, and *Eldana saccharina*. The attacks may occur from the 4-6 leaf stage until the heads reach maturity. Stem borers cause three types of damage. They feed on the growing point of the young plant causing death. Internodes are bored during elongation and heading. This may lead to a breaking of the stem or a weakening of the plant and subsequent reduction of productivity. Heads are also attacked during development or maturity, leading to partial destruction of the grain.

Evaluation of Damage Risk

For *S. calamistis* and *B. fusca*, evaluation of damage risk is based on early signs of oviposition between the sheaths and stems of young plants because the risk is higher in the case of early infestations. For *C. partellus* and *E. saccharina*, it is based on monitoring of young larvae of the first generation before they penetrate the internodes. The initial infestation rate is measured by the percentage of plants attacked by the borers. Such evaluations are required for decisions concerning preliminary curative insecticide treatments and the optimum date for application according to the degree of crop intensification.

Determination of Infestation Level

On young plants, *S. calamistis* and *B. fusca* infestation intensity is based on the percentage of attacked plants. The percentage corresponds approximately to the rate of plants destroyed before elongation, as very few young stems can resist an early attack by the two borers.

During stem elongation, infestation levels of the four borers are not evaluated individually. The percentage of infested stems and bored internodes is calculated for the entire pyralid and noctuid complex. The two criteria are the most relevant for evaluating damage intensity depending on the cropping zone, farming system, crop duration, varieties, etc.

At heading, the percentage of infested maize heads is calculated for the entire borer complex.

Loss Evaluation

The only losses that can be measured directly are those due to stem breaking during elongation. Yield loss due to this type of damage is approximately the same as the rate of destroyed plants.

On young plants that may produce side tillers after an attack by *S. calamistis* or *B. fusca*, plant density per hectare in treated plots (insecticide treatment of the soil or seed) is compared with that in check plots. Such a comparison is the only means for evaluating actual economic incidence of early attacks by the two borers.

Similarly, the only method for an accurate evaluation of stem borer damage at elongation and heading stages is a comparison of grain yield and 1000-grain weight from plots treated with insecticides (granules in leaf whorls) and check plots exposed to natural infestation.

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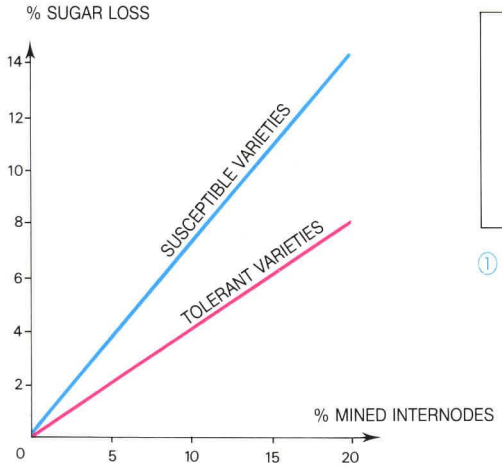
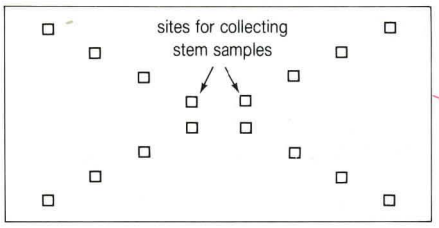
PEST SURVEYS IN SUGARCANE PLANTATIONS

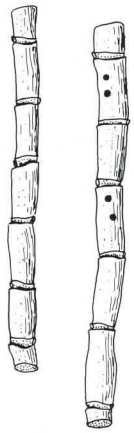
(STEM BORERS AND WHITE GRUBS)



⑥ DETERMINATION OF SUGAR LOSS

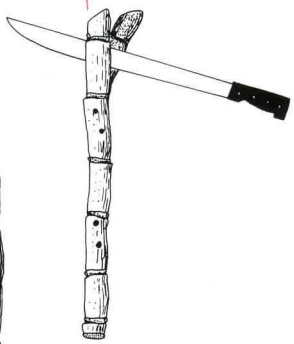


① CROSS-SECTION SURVEY OF A PLOT

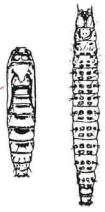


② SEPARATION OF MINED AND HEALTHY STEMS

% INFESTED STEMS

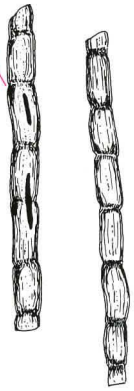


③ SPLITTING OF INFESTED STEMS



NUMBER OF BORERS PER 100 STEMS

④ COUNTING OF BORERS IN STEMS



⑤ TOTAL MINED AND HEALTHY INTERNODES

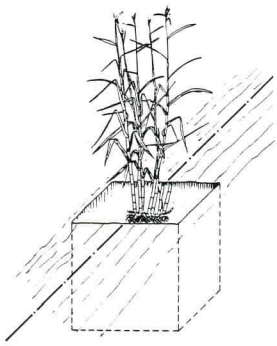
% BORED INTERNODES

EVALUATION OF STEM BORER DAMAGE

DETERMINATION OF WHITE GRUB DENSITY IN THE SOIL

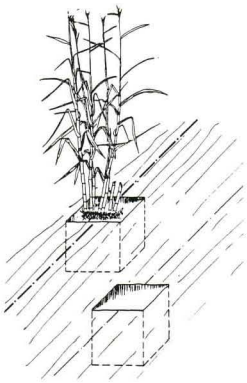
COUNTING OF WHITE GRUBS ONLY IN STOOLS
(1 × 1 × 1 m or 1 × 1 × 0.50 m)

AVERAGE NUMBER OF WHITE GRUBS PER STOOL



COUNTING OF WHITE GRUBS IN STOOLS AND INTERROWS
(0.5 × 0.5 × 0.5 m)

DENSITY OF WHITE GRUBS PER HECTARE



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Techniques for Analyzing Pest Status in a Sugarcane Plantation

Stem Borers (e.g. Eldana saccharina, Chilo sacchariphagus)

Three operations need to be carried out for industrial plantations that are divided into plots for the survey.

Sample plots are selected for carrying out the observations. The sample should represent the percentage area planted to different varieties and, for each of them, the ratio of virgin and ratoon canes, range of harvest dates and, if possible, spatial distribution.

Example: In a sugarcane plantation of 150 plots, half are planted to variety NCO 376 that is harvested in November, December, and January until the fifth regrowth. A representative sample would be made up of 30 plots including 15 plots of NCO 376 (2 plots of plant canes and 13 plots of ratoons), Each of the three harvest periods (November, December, January) is represented by 5 plots of the 15 selected for the sample.

Pest surveys are carried out in these plots to determine infestation levels. Batches of stems are collected from each plot according to a predetermined design (e.g. cross-section sampling). The operator cuts a series of stems along the line, removes them from the plot, numbers the healthy and infested stems, and splits the infested stems. Larvae and pupae in the internodes are recorded and the number of healthy and infested internodes from the total batch of stems is counted. Once the batches from all the collection sites are examined, the infestation level in the plot is determined by:

- the average number of stem borers collected from 100 stems,
- the percentage of infested stems,
- the percentage of mined internodes.

Data collected from all the sample plots are aggregated to determine the average level of stem borer damage in the plantation.

Economic incidence of pest damage is measured by converting the average damage level into sugar loss.

The ratio between the percentage of mined internodes (% MI) and relative reduction in sucrose content (% R) is calculated by the following equation:

$$\% R = C \times \% MI$$

where C is a coefficient ranging from 0.4 to 0.7 depending on the variety. Average sugar loss/ha is then determined for all the sample plots at harvest; it corresponds approximately with that of the plantation for a given cropping season.

White Grubs (E. baumanni, H. marginalis, etc.)

White grub infestation levels in a sugarcane plantation can be measured by counting the larvae in the soil. The observations are carried out at a time when most of the grubs are at the second or third stage of development. They cause maximum damage and can be easily recognized at these stages.

The observations are carried out:

— **either exclusively on rows** (1 m x 1 m x 1 m around the plant) to determine **average larval density per plant**.

— **or on rows and interrows** (0.5 m x 0.5 m x 0.5 m) to determine **average larval density per hectare**.

The number of observations should not be less than 2/ha in the first case and 4/ha in the second.

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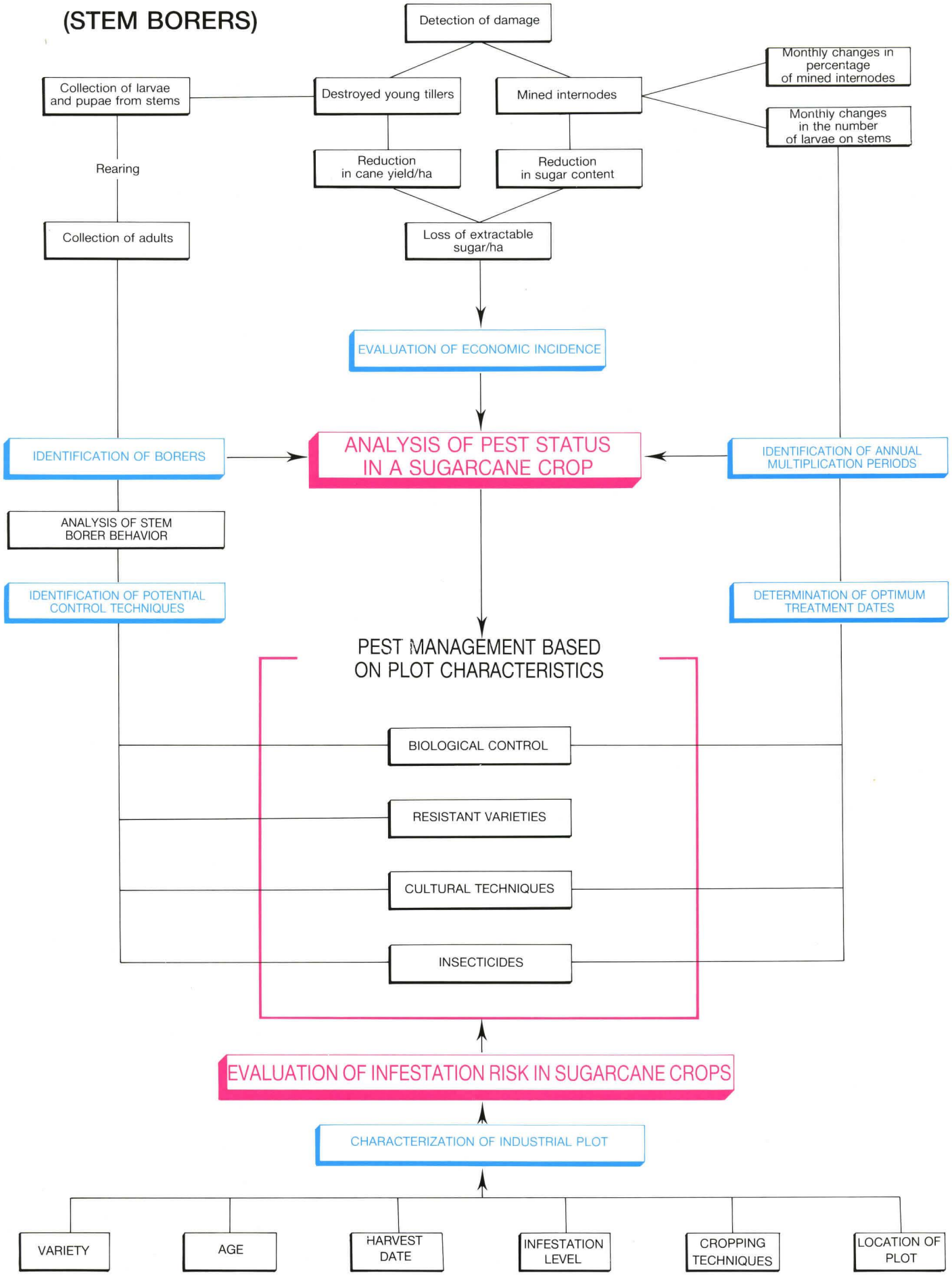
PEST MANAGEMENT IN SUGARCANE PLANTATIONS

(STEM BORERS)



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Pest Management in Sugarcane Plantations (Case of Stem Borers)

Analysis of Pest Status

Stem borers that attack a sugarcane plantation should be identified accurately, based on observations of adults from larvae collected in sugarcane plots. Regular pest surveys should be conducted over several years to study changes in the pest population and damage according to the season and crop stages. The information is required for determining peak activity periods and locations. Data on the biology and behavior of stem borers on the host plant should be collected either through direct observations or other information sources. The economic incidence of stem borer damage, in terms of sugar loss, should also be calculated as accurately as possible. **All these data are required for designing a rational pest control strategy.**

Plot Characterization and Risk Evaluation

Stem borer infestation levels in a plot mainly depend on agronomic characteristics, such as variety, duration of vegetative stage, infestation level during the preceding crop cycle, age (plant canes, ratoons), harvest date, location of the plot in the plantation. Ranking of these factors on the basis of results of earlier long-term surveys in representative plots, identification of the major factors (e.g. crop cycle and varieties for *E. saccharina*), and other data on the plot are useful for evaluating infestation risk in a crop during a given cropping season. High-risk sites should then be identified for concentrating control operations.

Development of a Control Strategy

The control strategy should be defined for both plantation and plot-based operations.

If average infestation rate in a plantation exceeds 5% of bored internodes, preventive measures, based on the use of suitable varieties and cropping systems, should be taken. For example, varieties with resistance or tolerance to stem borers should be selected for high-risk plots.

A plot-based pest management policy should be developed. During each cropping season, plots with agronomic characteristics that may cause infestation levels to exceed 5% of bored internodes should be identified, and appropriate preventive or curative measures should be taken. These include early harvesting, mulching, insecticide treatments of young ratoon crops, mass releases of insect parasites.

Both types of measures require constant monitoring of the plots; the increased workload, however, has high payoffs in terms of efficiency and cost-effectiveness of control techniques.

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PEST MANAGEMENT IN SUGARCANE PLANTATIONS

(WHITE GRUBS)

DETECTION OF SYMPTOMS AND TYPES OF DAMAGE

IDENTIFICATION OF WHITE GRUBS

BIBLIOGRAPHY

BIOECOLOGY OF WHITE GRUBS

BIOLOGICAL CYCLE
POPULATION DYNAMICS
BEHAVIOR ON HOST PLANTS

ECONOMIC INCIDENCE

CANE LOSS/HA
SUGAR LOSS/HA

CHARACTERIZATION OF PLOTS, OF CROP AND CLIMATIC CONDITIONS

SOIL, CLIMATE, VARIETIES
CULTURAL TECHNIQUES
INFESTATION LEVELS
SOCIOECONOMIC CONDITIONS

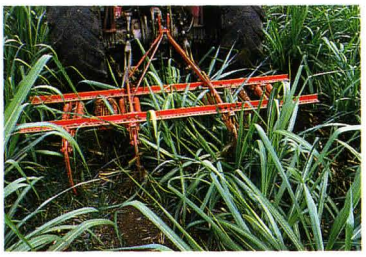
DETERMINATION OF CONTROL TECHNIQUES

RISK ANALYSIS FOR ANALOGOUS REGIONS

DEVELOPMENT OF APPROPRIATE PEST MANAGEMENT TECHNIQUES FOR EACH REGION

⇨ TOLERANT AND RESISTANT VARIETIES ⇒ VARIETAL CHOICE

⇨ CULTURAL TECHNIQUES ⇒



HOEING

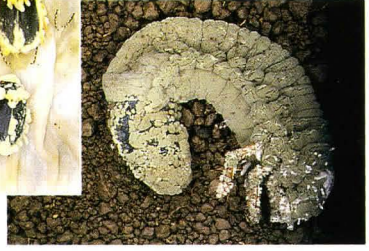
⇨ CHEMICAL CONTROL ⇒

LARVA CONTROL

ADULT CONTROL

⇨ BIOLOGICAL CONTROL ⇒

WITH FUNGI



PEST MANAGEMENT COSTS

ECONOMIC THRESHOLD

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Maquette : T.ERWIN - Photos : B.VERCAMBRE

Pest Management in Sugaracane Plantations (Case of White Grubs)

Detection of Symptoms and Damage

White grubs represent the underground larval stage of Coleoptera of the family Scarabeidae. Damage symptoms are:

— **poor ratooning**: buds, young roots of stools, and collars of young ratoons are gnawed by the adults (e.g. *Heteronychus* spp., Dynastinae);

— **early drying of stems**: roots are cut by the larvae during cane growth (e.g. several species of Melolonthinae and Rutelinae).

Identification of Control Techniques

The pests are first identified by a **specialist** (species identification is based on an examination of the adult). Bioecological studies are undertaken for developing a control strategy after studying all **available information** on the pest.

Risk Analysis

Plot characteristics (soil, cultural techniques, varieties, climatic conditions, etc.) are used to assess **sugar loss** per hectare, which is then converted into **costs**. Cropped areas (large plantations or smalholdings) with similar effects of white grub attack are determined for a rational analysis of risks in each area.

Development of Pest Management Systems Suited to Each Region

Efficient means to reduce pest populations are determined on the basis of tests of control techniques. The cost of control operations is compared with that of sugar loss, to establish an economic damage threshold, generally expressed in terms of the number of white grubs per unit area. The economic risk can thus be determined for each plot according to its characteristics. For example, in sandy soils one white grub per stool causes the same damage as 3-5 white grubs in a deep soil.

Use of **tolerant or resistant varieties** (high root density, high silica content in the roots, etc.) and **cultural techniques** are usually recommended and do not involve extra cost. Irrigation, wherever possible, is very effective as it increases plant vigor.

Insecticide application in the furrow is often effective, especially the slow-release formulations as persistence is prolonged over several years. Surface application within the row with light incorporation of the insecticide (e.g. lindane, diazinon, chlorpyrifos-ethyl) is effective against adults that damage collars. General application before planting is useful for controlling young *Melolonthinae* larvae. The cost of such treatments is quite moderate. But they can lead to biological imbalances, by mainly destroying beneficial fauna.

Biological control consists in encouraging the development of indigenous natural enemies or the introduction of new ones (e.g. scolid wasps that require flowered hedges around fields). Specific pathogens of the pests can also be used. This form of control requires high investments that can only be recovered over several decades. Biopesticides (pathogen germs in granule form) will be available in the future.

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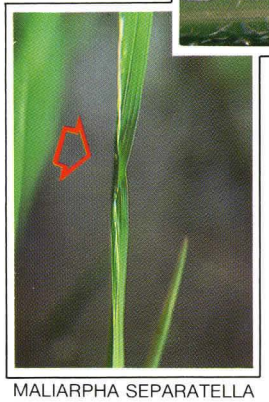
MAIN PESTS

OF RICE IN AFRICA

CHILO ZACCONIUS



MALIARPHA SEPARATELLA

EGGS

DIOPSIS THORACICA

SESAMIA CALAMISTIS

SCIRPOPHAGA SP.

ASPAVIA ARMIGERA

LARVAE IN STEMS

DIOPSIS THORACICA

SESAMIA CALAMISTIS

CHILO ZACCONIUS

MALIARPHA SEPARATELLA

NYMPHULA SP.

SPODOPTERA LITTORALIS

HISPID LEAF BEETLE

LARVAE AND ADULTS ON LEAVES

IRAT CIRAD – BP 5035 – 34 032 MONTPELLIER CEDEX – Maquette : T. ERWIN – Photos : IRAT

Which is this African Rice Pest?

(Only common species found in Africa are listed here)

Serial No.	Description	Species	Cross reference
Eggs			
1.	Laid on leaf blades or sheaths		3-4
2.	Inserted under sheaths or in leaf tissue		19-20
3.	Bare, nonprotected		5-6
4.	Protected		15-16
5.	Clusters		7-8
6.	Laid singly		13-14
7.	Overlapping		9-10
8.	Adjacent		11-12
9.	Flattened	*Chilo zacconius*	
10.	Spherical	*Nymphula* sp.	
11.	Yellow, arranged irregularly	*Chnootriba similis*	
12.	Regularly arranged side by side	Pentatomidae	
13.	Elongate, smooth	*Orseolia oryzivora*	
14.	Elongate, striated	*Diopsis* sp.	
15.	Covered by down		17-18
16.	Protected by leaf fold	*Maliarpha separatella*	
17.	Covered by gray down	*Spodoptera* sp.	
18.	Covered by brown down	*Scirpophaga* sp.	
19.	Inserted under leaf sheaths	*Sesamia* sp.	
20.	Inserted in leaf tissue	Hispinae	
Caterpillars			
1.	Stem borers		3-4
2.	Leaf feeders		9-10-11
3.	With 5 longitudinal pink stripes	*Chilo zacconius*	
4.	Without longitudinal stripes		5-6
5.	Pink color	*Sesamia* sp.	
6.	Without pink pigmentation		7-8
7.	Yellowish brown	*Scirpophaga* sp.	
8.	Pearly white	*Maliarpha separatella*	
9.	Green, lodged in rolled leaf blade tip	*Marasmia trapezalis*	
10.	Yellow, in a case	*Nymphula* sp.	
11.	Greenish-black, heavy feeders of leaf blades	*Spodoptera* sp.	
Other Larvae			
1.	Diptera (maggots), stem miners		4-5
2.	Coleoptera, leaf blade feeders		6-7
3.	Heteroptera, grain suckers	Bugs	
4.	Yellow, with black hooks at anal extremity	*Diopsis* sp.	
5.	White	*Orseolia oryzivora*	
6.	Yellow with spines, leaf blade miners	Hispinae	
7.	Gray turning to white, with white bristles	*Chnootriba similis*	

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MAIN PESTS

OF MAIZE IN AFRICA

ELDANA SACCHARINA

COB

MARASMIA TRAPEZALIS

SPODOPTERA SP.

HELIOTHIS ARMIGERA

LEAVES

FEEDING DAMAGE

LARVA

CHILO PARTELLUS

DAMAGE OF
CHILO PARTELLUS

STEM

SESAMIA CALAMISTIS

ELDANA SACCHARINA

PLANTLET

GONOCEPHALUM SP.

JULUS

HETERONYCHUS SP.

IRAT / CIRAD - B.P. 5035 - 34032 MONTPELLIER CEDEX - Maquette : T. ERWIN - Photos : IRAT

Which is this African Maize Pest?

(Only common species found in Africa are listed here)

Seedlings

• Gnawed roots	
Presence of coleopteran larvae in the soil	Melolonthidae Elateridae
• Gnawed collar	Tenebrionidae
Withered and broken seedlings	
Myriapoda in the soil	Millipedes
Termite mounds in the vicinity	Termites
Crickets	*Gryllotalpa africana*
Coleopteran adults	
Dynastidae	*Heteronychus sp.*
Tenebrionidae	*Gonocephalum sp.*
Brown-gray caterpillar, often curled	*Agrotis ipsilon*

Stems

• Deadhearts or bored internodes that could cause stems to break, due to pyralid or noctuid caterpillars	
Pinkish-white caterpillar with two dark longitudinal bands	*Busseola fusca*
Pink, shining caterpillar	*Sesamia sp.*
White-cream caterpillar with two rows of brown spots	*Chilo partellus*
Gray-black caterpillar	*Eldana saccharina*

Leaves

• Portions of the leaf blade gnawed, perforated, consumed	
Grayish caterpillar with gray-yellow bands	*Mythimna loreyi*
Dark green or brown caterpillar, heavy feeder	*Spodoptera sp.*
Small green-yellow caterpillar causing curling of leaf tips	*Marasmia trapezalis*
Acrididae	Several species of grasshoppers
Ladybird adults and larvae	*Chnootriba similis*
• Leaf blade covered with sooty mold	
Green aphids with black appendages	*Rhopalosiphum maidis*

Earheads

• Mined earheads, consumed grain	
Gray-black caterpillar	*Eldana saccharina*
Grayish caterpillar with brown spots	*Cryptophlebia leucotreta*
Pinkish-gray caterpillar	*Mussidia nigrivenella*
According to the stage, brown, green or yellow caterpillar	*Heliothis armigera*
• Punctured, shriveled, or empty grains at milk stage, due to heteropteran larvae and adults	Several species of bugs

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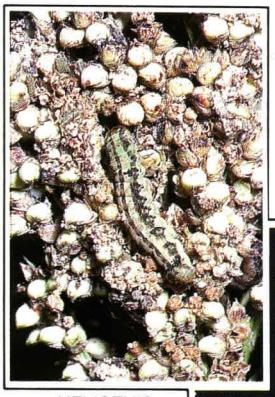
MAIN PESTS

OF SORGHUM IN AFRICA

CONTARINIA SORGHICOLA

◀ DAMAGE
LARVA ▼

SPODOPTERA SP.



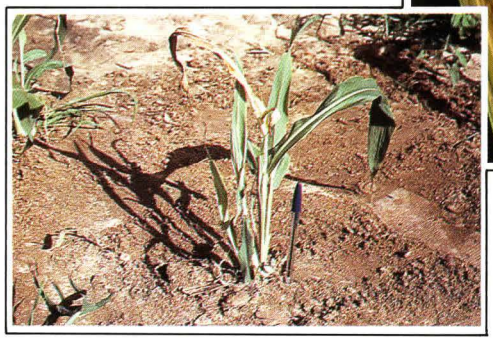
COB

HELIOTHIS
ARMIGERA

DIPLOXYS SP.

ATHERIGONA SOCCATA

LARVA ▶
DAMAGE ▼



PLANTLET

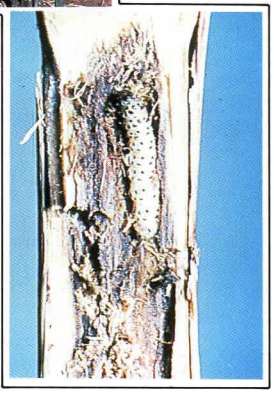
STEM

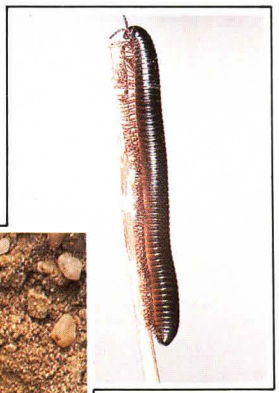
ELDANA
SACCHARINA

SESAMIA SP.

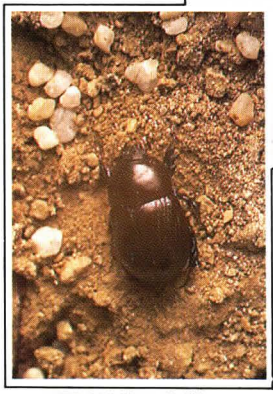
ACIGONA IGNEFUSALIS

◀ DAMAGE
LARVA ▼





JULUS



HETERONYCHUS SP.

IRAT / CIRAD - B.P. 5035 - 34032 MONTPELLIER CEDEX - Maquette : T.ERWIN - Photos : IRAT

Which is this African Sorghum Pest?

(Only common species found in Africa are listed here)

Seedlings

• Gnawed roots	
Presence of coleopteran larvae in the soil	Melolonthidae Elateridae
• Gnawed collar	Tenebrionidae
Withered and broken seedlings	
Myriapoda in the soil	Millipedes
Termite mounds in the vicinity	Termites
Crickets	*Gryllotalpa africana*
Coleopteran adults	
Dynastidae	*Heteronychus sp.*
Tenebrionidae	*Gonocephalum sp.*
Brown-gray caterpillar, often curled	*Agrotis ipsilon*

Stems

• Deadhearts due to tunnels made by dipteran larvae	*Atherigona soccata*
• Deadhearts or bored internodes that could cause stems to break, due to pyralid or noctuid caterpillars	
Pinkish-white caterpillar with two dark longitudinal bands	*Busseola fusca*
Pink, shining caterpillar	*Sesamia sp.*
White-cream caterpillar with two rows of brown spots	*Chilo partellus*
Gray-black caterpillar	*Eldana saccharina*
Yellowish-gray caterpillar with oval black spots	*Acigona ignefusalis*

Leaves

• Portions of the leaf blade gnawed, perforated, consumed	
Grayish caterpillar with gray-yellow bands	*Mythimna loreyi*
Dark green or brown caterpillar, heavy feeder	*Spodoptera sp.*
Small green-yellow caterpillar causing curling of leaf tip	*Marasmia trapezalis*
According to age, brown, green, or yellow caterpillar	*Heliothis armigera*
Acrididae	Several species of grasshoppers
• Leaf blade covered with sooty mold	
Green aphids with black appendages	*Rhopalosiphum maidis*
Bright yellow aphids	*Melanaphis sacchari*

Panicles

• Flowers destroyed by Coleoptera	Several Meloidae species
• Inflorescence and grain consumed by caterpillars	*Mythimna loreyi* *Spodoptera sp.* *Heliothis armigera*
• Grains containing orange dipteran larvae	*Contarinia sorghicola*
• Punctured, shriveled, or empty grains at milk stage, due to heteropteran larvae and adults	Several species of bugs

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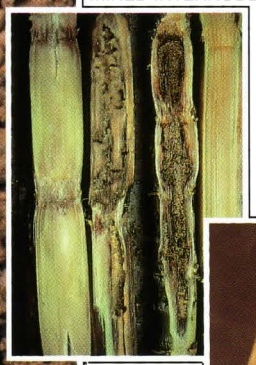
MAIN PESTS

OF SUGAR CANE IN AFRICA AND/OR INDIAN OCEAN

SESAMIA CALAMISTIS

"DEAD HEART"

ELDANA SACCHARINA



MINED INTERNODES

CHILO SACCHARIPHAGUS

STEM BORERS

PULVINARIA ICERYI

SACCHARICOCCUS SACCHARI

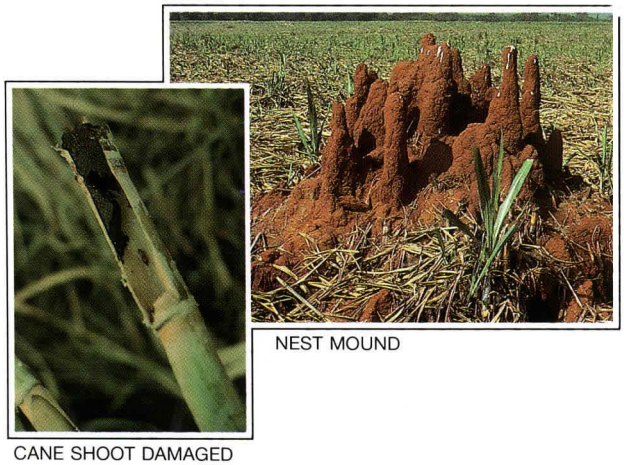
SCALE INSECTS AND MEALYBUGS

EULEPIDA BAUMANNI

COUNT OF WHITE GRUBS

WHITE GRUBS

TERMITES



NEST MOUND

CANE SHOOT DAMAGED

HETERONYCHUS SP.

IRAT/CIRAD – B.P. 5035 – 34032 MONTPELLIER CEDEX – Maquette : T.ERWIN – Photos : IRAT

Which is this Sugarcane Pest? (Africa and/or Indian Ocean)

(Only common species are listed here)

Cuttings and Roots

• Gnawed internodes and eyes of cuttings	Termites
• Roots gnawed and cut by white grubs	*Clemora smithi* (Mr) *Eulepida baumanni* (Af) *Hoplochelus rhizotrogoides* (Md) *Hoplochelus marginalis* (R, Md)
• Root sap removed by sucking insects	
Cicada larvae	*Yanga guttulata* (Md)
Scale cysts ("ground pearls")	Margarodidae

Collars and Young Shoots

• Collar gnawed and shoot destroyed by brown-black scarabids	*Heteronychus* spp. (Af, Md)
• Young shoot bored by caterpillars, desiccated leaf whorl (deadheart)	
Shiny, pink caterpillar	*Sesamia* spp.
White caterpillar	*Argyroploce schistaceana* (R, Md, Mr)

Stems at Elongation Stage

• Stems bored and internodes mined by caterpillars	
White-cream caterpillar having segments with brown spots	*Chilo sacchariphagus* (Md, R, Mr)
Anthracite gray caterpillar, sometimes temporarily cream-colored	*Eldana saccharina* (Af)
• Stems supporting scale insect colonies	
Scale with circular white cover	*Aulacaspis tegalensis*
Pink mealybugs with soft integument, attached to nodes	*Saccharicoccus sacchari*

Leaves

• Large patches consumed by locusts and grasshoppers	Acridoidea
• Portions of leaves gnawed or consumed by caterpillars	
Small green-yellow caterpillar that gnaws leaf tips	*Marasmia trapezalis*
Blackish larva, heavy feeder of leaves except the large veins	*Spodoptera* spp.
Grayish larva feeding voraciously on leaf blade	*Mythimna loreyi* (Af, Mr)
• Sheaths and leaf blades covered by scale	
Scale insect with oblong white ovisac	*Pulvinaria iceryi* (Af, R, Mr)
Scale with circular white cover	*Aulacaspis tegalensis*
• Leaves covered with aphids	
Pale green aphid with black cornicles	*Rhopalosiphum maidis*
Bright yellow aphid	*Melanaphis sacchari*

Legend: Occurrence in Africa (Af), Mauritius (Mr), Madagascar (Md), Réunion (R).

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MAIN PESTS

OF LEGUMES IN AFRICA

MARUCA TESTULALIS
IN A BEAN POD

ACANTHOMIA LEONTJEVI
ON A COWPEA POD

HELIOTHIS ARMIGERA ON A COWPEA POD

PODS

FLOWERS

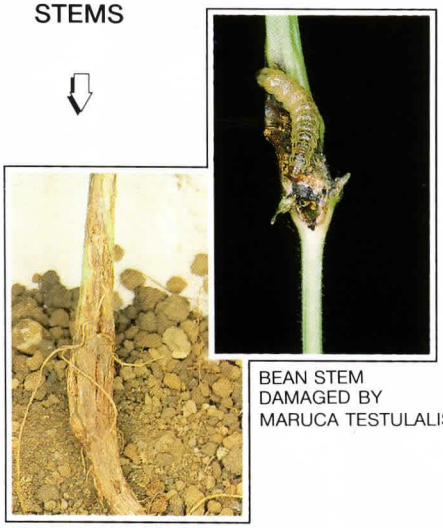
COWPEA FLOWERS
DAMAGED BY THRIPS

PSEUDOCOCCUS LILACINUS ON GROUNDNUTS

ROOTS

LEAVES

STEMS



BEAN STEM
DAMAGED BY
MARUCA TESTULALIS

BEAN STEM DAMAGED
BY OPHIOMYIA PHASEOLI

BEAN LEAVES DESTROYED
BY LARVAE OF SPODOPTERA SP.

BEAN LEAF ATTACKED
BY MARUCA TESTULALIS

LARVAE OF AMSACTA SP.
FEEDING ON COWPEA LEAVES

IRAT/CIRAD – B.P. 5035 – 34032 MONTPELLIER CEDEX – Maquette : T.ERWIN – Photos : IRAT

Which is this African Legume Pest?

(Only common species found in Africa are listed here)

Roots, Collars

• Roots gnawed and cut by coleopteran larvae	
White grub larvae (several species)	Melolonthidae Elateridae Tenebrionidae
Weevil larvae on groundnut	*Graphognathus* spp. *Anaemerus fuscus*
• Groundnut roots infested by mealybugs	
Pink mealybug covered in white waxy meal	*Dysmicoccus brevipes*
White mealybug	*Pseudococcus lilacinus*
• Groundnut roots punctured by brown-green leafhopper	*Hilda patruelis*
• Gnawed or cut collar	
Myriapoda in the soil	Millipedes
Termite mounds in the vicinity	Termites
Crickets	*Gryllotalpa africana*
Coleopteran adults	
Dynastidae	*Heteronychus* sp.
Tenebrionidae	*Gonocephalum* sp.
Brown-gray caterpillar, often curled	*Agrotis ipsilon*

Leaves

• Portions of leaves gnawed, consumed	
Very hairy yellow caterpillar with brown specks	*Amsacta moloneyi*
Dark green or brown caterpillar, heavy feeder	*Spodoptera* spp.
Green caterpillar with three white bands	*Trichoplusia ni*
Coleopteran larvae and adults	Coccinellidae Chrysomelidae Curculionidae
• Acridoidea (large number of species)	Grasshoppers
• Leaf blades mined by small (2-3 mm) maggots	*Ophiomyia phaseoli* (St) *Liriomyza* spp.
• Distorted leaves that turn yellow and chlorotic, and desiccate	
Pale yellow to brown thrips	*Thrips tabaci*
Green leafhoppers	*Empoasca* spp.
Whitefly	*Bemisia tabaci*
Aphids (several species)	Aphididae
Mites	Tetranychidae Tarsonemidae

Flowers

• Punctured by thrips (several species)	Thripidae (Le)
• Consumed by adult blister beetles	Meloidae (Le)

Pods and Grain

• Perforated pods, consumed grain	
Bright green-yellow caterpillar with black spots	*Maruca testulalis* (St, Fl, Le)
Green or brown caterpillar with black and white bands	*Heliothis armigera* (St, Fl, Le)
Greenish caterpillar with a brown band	*Etiella zinckenella*
Blue to metallic green chrysomelid beetle	*Asbecesta cyanipennis* (Fl)
• Punctured pods and grain	
Bugs (large number of species)	Miridae (St, Le) Coreidae (St, Le) Pentatomidae (St, Le)

Legend: Pest also occurs on stems (St), flowers (Fl), or leaves (Le).

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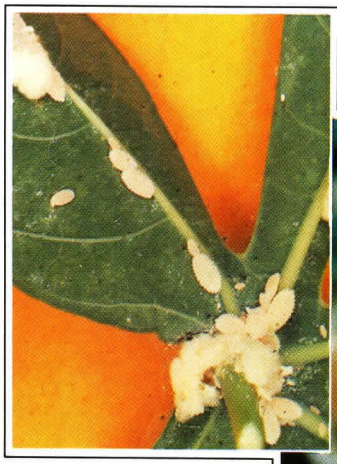
MAIN PESTS

OF ROOT CROPS IN AFRICA

A



MEALYBUG COLONIES
ON A LEAF

THE CASSAVA MEALYBUG,
PHENACOCCUS MANIHOTI

C

A

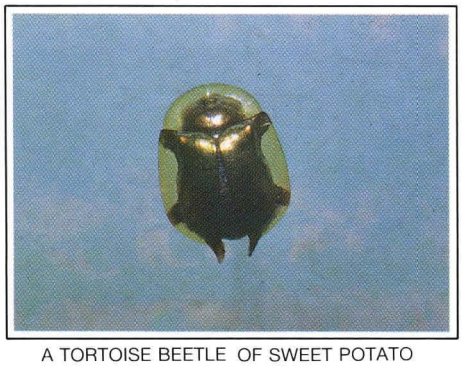
GROWING TIP COVERED WITH
MEALYBUG COLONIES

C

A FEMALE WASP, EPIDINOCARSIS LOPEZI,
PARASITOID OF P. MANIHOTI

B

CASSAVA LEAVES ATTACKED BY THE MITE, MONONYCHELLUS PROGRESIVUS



A TORTOISE BEETLE OF SWEET POTATO

Photos : A – BOHER
B – J.GUTTIEREZ
C – NENON

IRAT/CIRAD – B.P 5035 – 34032 MONTPELLIER CEDEX – Maquette : T.ERWIN

Pests of Root Crops

Major Pest Species

• Cassava

Cassava is grown in most tropical African countries as a staple food crop. It is mainly attacked by two main classes of arthropods: insects and mites.

— Insects

Scale insects are the most common pests and the most harmful. *Phenacoccus manihoti* (Pseudococcidae) originated in South America and was accidentally introduced into Africa some years ago. It is now present in most of the cassava-growing areas of the continent. The females are pinkish in color and measure 1-3 mm in length. They are covered in white waxy meal and have short lateral and caudal filaments. Reproduction occurs throughout the year, but the pest generally proliferates during the dry season. It colonizes the stems, leaves, and buds of cassava plants and inhibits growth. Damage usually includes distortion and stunting of the terminal leaves, shortening of the stem internodes, occasional general withering followed by destruction of the plant. Tuber yield loss in heavily infested crops sometimes exceeds 50%.

Among other scale insects that attack cassava, three species are fairly common: *Coccus viridis* (Coccidae), green in color; *Ferrisia virgata* (Pseudococcidae), whitish with two dark longitudinal lines; and *Aonidomytilus albus* (Diaspididae), with an elongated silver white scale.

Other insects recorded on cassava are generally not very harmful. Damage caused by soil pests (termites, white grubs) on recently planted setts; other sucking insects (thrips, bugs, whiteflies) on branches, leaves, and buds; and foliage feeders (Acrididae, caterpillars) is usually not economically significant. The whitefly *Bemisia tabaci* can, however, be dangerous as a vector of the cassava mosaic disease.

— Mites

Several mites, mainly belonging to the genera *Mononychellus* and *Tetranychus*, multiply on cassava. Leaves are infested by the green cassava mites *M. progresivus* and *M. tanajoa* or the spider mites *T. telarius* and *T. neocaledonicus*. Chlorotic dots appear on the upper surface, followed by distortion and stunting in case of a severe attack. Terminal leaves may desiccate and fall. During the dry season such damage can seriously reduce yields.

• Yam

Yam is also infested by several scale insects including *F. virgata* (also on cassava) and *Aspidiotus destructor*. The most frequent species is *Aspidiella hartii* (Diaspididae) which is cosmopolitan, cream in color, and attacks yam tubers in the field and in storage. Coleoptera can weaken plants or make tubers unfit for sale. *Heteronychus licas* and *Heteroligus* spp. (Dynastidae) are shiny brown-black beetles that make holes in tubers. *Lema* spp. and *Lilioceris livida* (Chrysomelidae) are beetles whose adults and larvae feed on leaves and buds.

• Sweet potato

Leaves of sweet potato are perforated or eaten by several insects, such as the weevils *Alcidodes* spp. (brown-black, 12-15 mm long) and *Cylas* spp. (blue-black, 6-8 mm long), the tortoise beetle *Aspidomorpha apicalis* (bright yellow, with green elytra), or the polyphagous caterpillars *Spodoptera* spp. and *Trichoplusia ni*. Scale insects (*F. virgata*), aphids (*Aphis* spp.), and whiteflies (*B. tabaci*) invade leaf organs and transmit virus diseases.

Larvae of the weevils *Alcidodes* spp. and *Cylas* spp. bore stems but mainly make tunnels in tubers, causing them to rot or lose their market value.

Control Techniques

Chemical control of *P. manihoti* is difficult because cassava is generally grown as an extensive crop. It is cost-effective, however, to spray diazinon or methidathion on heavily attacked plots to prevent infestation from spreading. No insecticide should be applied within 15 days before leaf or tuber harvest. In its center of origin, *P. manihoti* is destroyed by a large range of parasites and predators. Certain species, such as *Epidinocarsis lopezi* (Hymenoptera: Encyrtidae), were released and are now established in West and central Africa. Chemical control of mites is rarely warranted or practiced.

Insecticide treatments on yam or sweet potato are also not very common. Dipping of tubers in an insecticide solution before planting, soil treatment with endosulfan or carbofuran, foliar application of fenitrothion or fenthion can be carried out, if necessary, to protect the two crops against soil and leaf pests. Earthing up of young sweet potato plants is the best cultural technique to reduce risk of weevil infestation.

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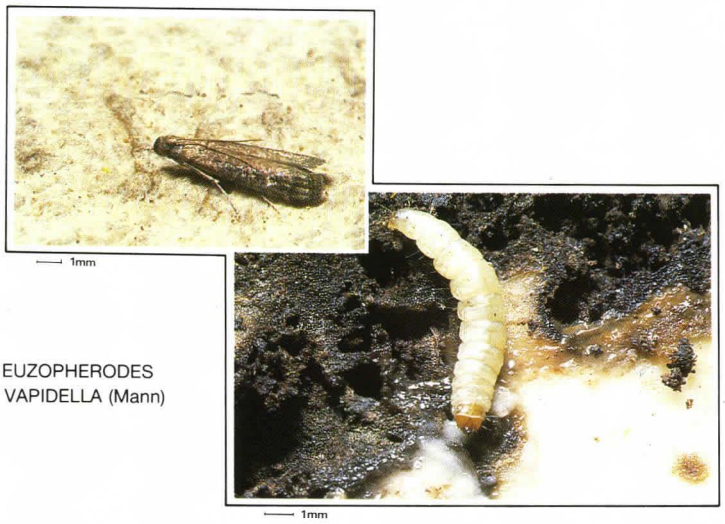
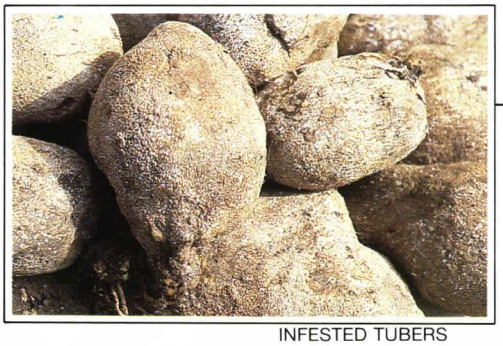
STORAGE PESTS

OF YAMS IN WEST AFRICA



EUZOPHERODES
VAPIDELLA (Mann)

TINEIDAE N.G.



INFESTED TUBERS

DAMAGE

SCALE INSECTS

LEPIDOPTERA

SERIOUS DAMAGE

SYMPTOMS

SOME STORAGE SYSTEMS

VERTICAL CRIBS

"BAOULE" BIN

IN VILLAGES

IN A BIG FARM

PITS

IRAT / CIRAD - B.P 5035 - 34032 MONTPELLIER CEDEX Maquette : T. ERWIN Photos : B. SAUPHANOR

Insect Pests of Stored Yam in West Africa

Storage of fresh yams leads to higher losses, due to metabolic changes (dehydration, respiration, germination), and pests and diseases (rodents, insects, pathogens), than if they were stored in the dried form.

Major Insect Pests

Stored yam is exposed to a large complex of insect pests. More than 50 species were recorded in Côte d'Ivoire. The main pests are:

- Two Lepidoptera that cause the same type of damage:
  - — *Euzopherodes vapidella*, a pyralid moth of yam;
  - — Tineidae n.g. is a moth pest of yams, that has not yet been described.

Eggs are deposited on the tuber surface, often where there is an injury in the epidermis due to earlier attacks by rodents or insects, degermination, or other causes. The larvae bore tunnels in the tuber that they fill with excrement, causing the stocked yams to deteriorate. *E. vapidella* develops on tubers with a higher water content than those infested by Tineidae n.g.; infestation also occurs earlier.

- Scale insects, including *Aspidiella hartii*, develop on tubers both in the field and in storage. Although weight loss is low, the market value of the yams diminishes. Germination of seed yams is also reduced and retarded.

Secondary infestation by other pests, particularly Coleoptera, on infested tubers accelerate destruction.

Protection of Yam Stocks

Insecticide treatments are recommended for stocks with high infestation risks. These include stocks for long-term storage or those made up of susceptible varieties of the species *Dioscorea alata*, particularly the "Bete Bete" group. The tubers are dipped in a solution of 10 g of deltamethrin and 25 g of pirimiphos-methyl in 100 liters of water. The solution can also be sprayed until the tubers are completely drenched. The treatment should be carried out directly after harvest, repeated 3 weeks later and possibly once more at degermination. However, complete protection cannot be guaranteed if the epidermis is broken after harvest or due to rodent attacks.

Although several Hymenoptera parasites can reduce pest populations, parasitism occurs too late to be effective.

The yam species *D. esculenta*, *D. dumetorum*, and *D. cayennensis*, do not require insecticide treatment as they are not suited for extended storage due to rapid dehydration, and are not very susceptible to insect pests.

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STORAGE PESTS

OF CEREALS (WEST AFRICA)

ADULT OF SITOPHILUS ZEAMAIS ON RICE GRAINS

MAIZE GRAINS DAMAGED BY PROSTEPHANUS TRUNCATUS

DAMAGE OF SITOPHILUS ZEAMAIS ON A MAIZE COB

ADULT OF PROSTEPHANUS TRUNCATUS
ON MAIZE GRAINS

DAMAGE OF PROSTEPHANUS
TRUNCATUS ON A MAIZE COB

PRIMARY INFESTATION

BY

BEETLES

DAMAGE OF RHYZOPERTHA DOMINICA
ON RICE GRAINS

ADULT OF RHYZOPERTHA A DOMINICA
ON RICE GRAINS

DURATION OF TOTAL LIFE CYCLE AT 30 °C

30 DAYS

ADULT PERIOD

PROSTEPHANUS TRUNCATUS	*45-60*	*DAYS*
RHYZOPERTHA DOMINICA	*8*	*MONTHS*
SITOPHILUS ZEAMAIS	*4-5*	*MONTHS*

I.R.A.T./C.I.R.A.D. – B.P. 5035 – 34032 MONTPELLIER CEDEX – Maquette : T.ERWIN Photos : B.SAUPHANOR

Coleopteran Storage Pests of Tropical Cereals

Main Pest Species in Africa

• Weevils (Curculionidae)

The two most common species are *Sitophilus oryzae* and *Sitophilus zeamais*. They are polyphagous (grain, pasta, flour, etc.) but prefer rice and maize, respectively. The adults are 3-5 mm long, and are recognized by their bent antennae and sometimes very long rostrum. The females have a life span of several months. They lay their eggs in grain (in the field or in storage). The larvae are short, thick, and legless. They mature and pupate in the grain. At 30°C, duration of the life cycle is 1 month.

• Beetles (Bostrychidae)

The most common species is *Rhyzopertha dominica*. *Prostephanus truncatus* was accidentally introduced into Tanzania some years ago and is now spreading towards the western part of Africa. The two species are polyphagous but are mainly pests of rice and maize, respectively. The adult *P. truncatus* (3-5 mm) is bigger than that of *R. dominica* (2-3 mm) and its elytra slant backwards more abruptly. The female *P. truncatus* lays its eggs in maize heads and grain in the field or in storage, whereas that of *R. dominica* lays them on the surface of stored grain. Larvae of the two species are arched with thin legs. They mature and pupate in the grain. The life cycle of the two beetles lasts 3-6 weeks, depending on the temperature.

• Dermestidae, Silvanidae, Tenebrionidae

Other common Coleoptera pests of stored grain in Africa are: *Trogoderma granarium* (Dermestidae) larvae with tufts of barbed hairs; *Oryzaephilus surinamensis* (Silvanidae) with elongate and slightly hard-bodied larvae; and *Tribolium castaneum* (Tenebrionidae) with hard-bodied larvae.

Damage

These pests cause considerable damage to grain—threshed or on heads—either in the field or in storage. Their presence can be detected from oviposition or emergence holes on grain envelopes. Damage due to larval feeding ranges from quality degradation to total destruction of the grain content. The pests often attack simultaneously and encourage the development of secondary fungus infections in stored grain. Grain weight losses are high and quality degenerates.

Control Techniques

Cereal stocks can be protected against the pests by:

• **Disinfestation of storage areas**, either by spraying insecticides on the walls or by fumigation;

• **Insecticide treatment of food stocks**:

— by dusting or spraying contact insecticides. Organophosphates (pirimiphos-methyl, chlorpyrifos-methyl, etrimfos, at doses of 10 g a.i./t grain; malathion, bromophos, etc.) and synthetic pyrethroids (deltamethrin, 1 g a.i./t grain; bioresmethrin, 1.5 cm^3 a.i./t grain) are effective as single insecticides or mixes;

— by fumigating with active ingredients such as methyl bromide (gas), carbon tetrachloride (liquid), aluminum (or magnesium) phosphide in the form of tablets, pellets, or strips.

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STORAGE PESTS

OF CEREALS (WEST AFRICA)

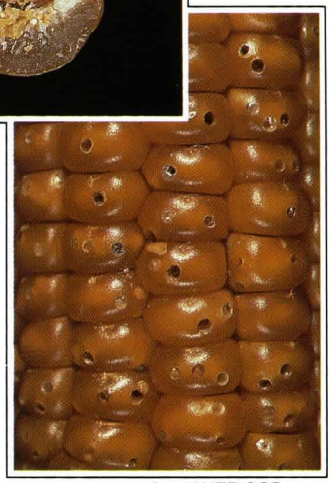
ADULT

PLODIA INTERPUNCTELLA

ADULT

SITOTROGA CEREALELLA
ON MAIZE GRAINS

LARVA

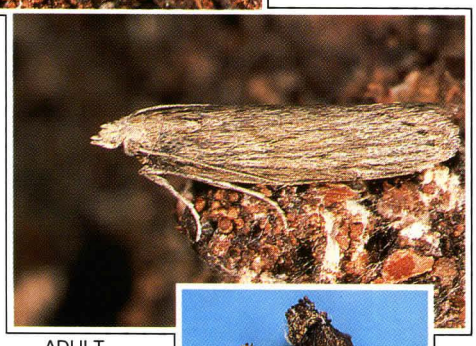


DAMAGE ON MAIZE COB

PRIMARY INFESTATION
BY
MOTHS

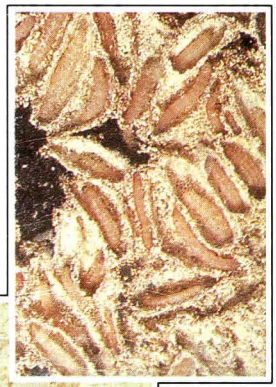
LARVA

CORCYRA CEPHALONICA



ADULT

PUPAL COCOONS

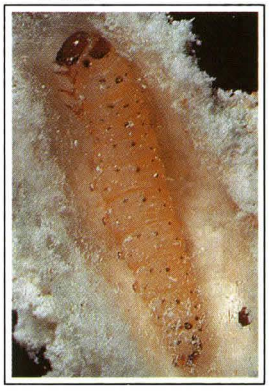


PUPAL
COCOONS

EPHESTIA KUEHNIELLA

ADULT

LARVA



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Lepidopteran Storage Pests of Tropical Cereals

Main Pest Species in Africa

• *Sitotroga cerealella* (Gelechiidae), Angoumois grain moth

The adult is a pale yellow moth, with a wingspan of 10-15 mm. The female lays 100-200 eggs on grain — in the field or in storage — of various cereals (maize, millet, rice, etc.).

The larva penetrates the grain to develop. A month later when it is fully grown, the pinkish-white larva measures 6-8 mm in length. Pupation occurs in the grain and lasts about 1 week.

• *Corcyra cephalonica* (Pyralidae), rice moth

In spite of its name this Lepidoptera is polyphagous. Stored grain and flour of milled rice, maize, and various legumes are infested by this pest. The adult is a yellowish-gray moth, with a wingspan of 15-25 mm. The female lays 100-150 eggs. The larva is ivory-colored and can reach 13 mm in length. After 4-5 weeks of development, it pupates in an opaque white cocoon.

• *Plodia interpunctella* (Pyralidae), meal worm moth

This species attacks almonds, nuts, and dried fruit as well as rice, maize, groundnut, and flour products. The adult has a wingspan that can exceed 30 mm. Its fore wings are copper brown on the external side. The female lays several hundreds of eggs on stored produce. The larva, ivory in color, feeds on the produce during the 20-40 days of its development. It pupates in a fairly loose cocoon outside the stored material.

• *Ephestia* spp. (Pyralidae)

Ephestia cautella is the most common species in Africa. It is highly polyphagous and attacks a wide range of stored produce including cereals, legumes, dried fruit, coffee, and cocoa. The adult has brownish fore wings with a span of 15 mm. The female can lay more than 200 eggs. The pinkish-gray larva can grow to 20 mm in length and feeds mainly on grain germ. It pupates in a thin silky cocoon outside the stock.

Anagasta (syn. *Ephestia*) *kuehniella* and *Ephestia elutella* are moth species that are found more frequently in the temperate regions.

Damage

The type of damage varies according to the pest. *S. cerealella* partially empties the grain and prepares an emergence outlet for the adult. Damage is comparable to that by weevils, but *S. cerealella* rarely penetrates deeper than 30 cm in bulk stored grain. *C. cephalonica*, *P. interpunctella*, and *E. cautella* mainly feed on grain germ. Aggregations are formed by grains adhering to silk tubes that also hold larval waste. The stored grain is thus unfit for sale or consumption, it is also incapable of germination in the case of seed.

Control Techniques

Stored cereals can be protected against the pests by:

— disinfestation of storage areas either by spraying insecticides on the walls or by fumigation;

— insecticide treatment of stored grain.

Treatment of stored grain is carried out:

— either with contact insecticides that are dusted or sprayed. Organophosphates (pirimiphos-methyl, chlorpyrifos-methyl, etrimphos, at doses of 10 g a.i./t grain; malathion, bromophos, etc.) and synthetic pyrethroids (deltamethrin, 1 g a.i./t grain; bioresmethrin, 1.5 cm^3 a.i./t grain), applied separately or mixed, are efficient;

— or with fumigants, such as methyl bromide (gas), carbon tetrachloride (liquid), or aluminum (or magnesium) phosphide (tablets, pellets, or strips).

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CONTROL STRATEGIES

Chemical Protection of Crops

Chemical control of food crop pests is only warranted when it is effective and economical. Authorized insecticides should be used and the treatments should be carried out according to phytosanitary regulations and manufacturers' recommendations.

Table V gives some characteristics of active ingredients mentioned in this publication. It is not, however, a complete list of insecticides or acaricides that can be used against the different pests.

Table V. Some characteristics of active ingredients mentioned in this publication.

Active ingredients	Modes of action	Toxicity (WHO classification)	Formulations marketed in Africa
Organochlorine compounds			
Endosulfan	C, St, Re	Moderately hazardous	EC, GP, UL, SC, WP
BHC	C, St, Re	Moderately hazardous	WP, DP
Lindane	C, St, Re	Moderately hazardous	EC, MG, WP, UL, DP, GR, SL, SC, KN, DS, EO
Organophosphorus compounds			
Acephate	C, St, Re	Slightly hazardous	WP
Bromophos	C, St, Sys	Highly hazardous	EC, WP
Chlorfenvinphos	C, St	Extremely hazardous	EC, GR, WP, DP
Chlormephos	C, St	Extremely hazardous	GR
Chlorpyrifos-ethyl	C, St, Re	Moderately hazardous	EC, MG, UL, GB
Chlorpyrifos-methyl	C, St, Re	Slightly hazardous	EC, UL
Diazinon	C, St	Moderately hazardous	GR, DP, EC, FG, CG, WP, CS
Dichlorvos	C, St	Highly hazardous	SL, EC, SC, AE, KN
Diethion	C, St	Moderately hazardous	EC, WP
Dimethoate	C, St, Sys	Moderately hazardous	EC, UL
Disulfoton	C, St, Sys	Extremely hazardous	GR, DS
Etrimfos	C, St	Moderately hazardous	EC, DP, WP
Fenitrothion	C, St	Moderately hazardous	DP, WP, EC, UL, SL, GR
Fenthion	C, St, Re	Highly hazardous	EC, WP, GR, DP, UL, EW
Fonofos	C, St	Extremely hazardous	MG, CS
Formothion	C, Sys	Moderately hazardous	EC
Isofenphos	C, St	Highly hazardous	EC, GR
Malathion	C, St, Re	Slightly hazardous	EC, DS, UL, WP, DP
Methidathion	C, St, Sys	Highly hazardous	EC
Monocrotophos	C, St, Sys	Highly hazardous	SL
Phosalone	C, St, Sys	Moderately hazardous	SC, WP, DP
Pirimiphos-methyl	C, St	Slightly hazardous	WP, DP, EC, UL, LF
Quinalphos	C, St	Moderately hazardous	EC
Terbuphos	C, St, Sys	Extremely hazardous	MG
Trichlorfon	C, St	Slightly hazardous	GR, SP, WP, UL
Carbamates			
Bendiocarb	C, St	Moderately hazardous	WP, SP
Carbaryl	C, St	Slightly hazardous	WP, GB, DP
Carbofuran	C, St, Sys	Highly hazardous	GR, CB
Carbosulfan	C, St, Sys	Moderately hazardous	MG
Methomyl	C, St, Sys	Highly hazardous	WP, SL
Pyrethroids			
Bioresmethrin	C, St, Re		EC
Cypermethrin	C, St	Moderately hazardous	EC, UL, SL
Deltamethrin	C, St	Moderately hazardous	EC, UL, WP, DP, SC
Fenvalerate	C, St	Slightly hazardous	EC, UL
Permethrin	C, St	Slightly hazardous	EC, CS, WP
Fumigants			
Methyl bromide	Re	Extremely hazardous	
Carbon tetrachloride	Re	Extremely hazardous	
Aluminum phosphide	Re	Extremely hazardous	TB
Magnesium phosphide	Re	Extremely hazardous	FT
Sulfotep	C, Re	Extremely hazardous	
Acaricides			
Binapacryl	C	Moderately hazardous	WP
Chinomethionate	C	Slightly hazardous	WP, SC
Dicofol	C	Slightly hazardous	WP, EC, SL
Tetrasul	C	Slightly hazardous	WP

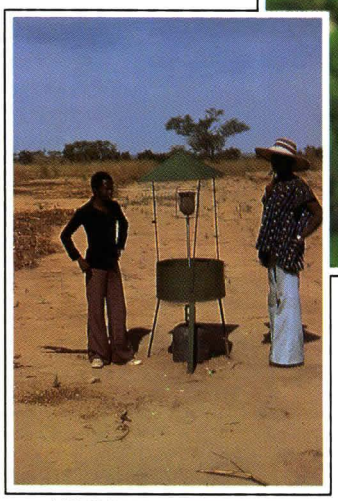
Pesticide formulation types (GIFAP)

AE : Aerosol dispenser
CB : Bait concentratre
CG : Encapsulated granule
CS : Capsule suspension
DP : Dustable powder
DS : Powder for dry seed treatment
EC : Emulsifiable concentrate
EO : Emulsion, water in oil
EW : Emulsion, oil in water
FG : Fine granule
FT : Smoke tablet
GB : Granular bait
GP : Flo-dust
GR : Granule
KN : Cold fogging concentrate
MG : Microgranule
SC : Suspension concentrate
SL : Soluble concentrate
SP : Soluble powder
TB : Tablet
UL : Ultra low volume liquid
WP : Wettable powder

Modes of action

C : Contact action
St : Stomach action
Re : Respiratory action
Sys : Systemic action

CHEMICAL CONTROL OF RICE PESTS



LIGHT TRAP

PHEROMONE TRAP

EGGS WITH PINCHING OF THE LEAF

TRAPPING AND PEST SURVEYS

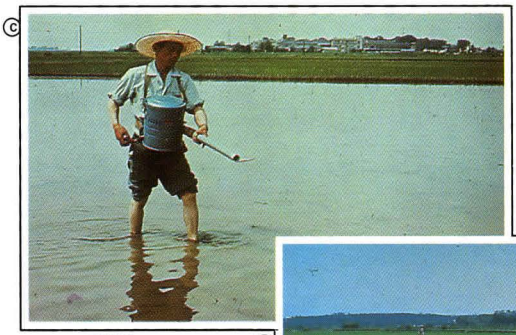
INSECTICIDE EXPERIMENT
AGAINST NYMPHULA DEPUNCTALIS

CHOICE OF THE BEST TIMING OF TREATMENTS

CHOICE OF ACTIVE INGREDIENTS

Ⓑ GRANULAR APPLICATION IN THE WATER

GRANULAR SPREADER Ⓐ



Ⓒ DUSTING

Ⓓ FOLIAR SPRAYING

SOIL TREATMENTS

FOLIAR APPLICATIONS

CHEMICAL CONTROL METHODS IN RICE FIELDS

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Chemical Control of Rice Pests

In rice crops, chemical control of pests is directed against soil species in upland crops, and stem borers (Lepidoptera and Diptera), foliage feeders, and sucking insects (leaves, stems, and grain).

Control of Soil Pests in Upland Rice Crops

• Seed treatment

The insecticide is often combined with a fungicide. Lindane (100 g/q seed), carbofuran (500-800 g/q), and carbosulfan (150 g/q) are recommended.

• Soil treatment

For generalized soil treatment, lindane (1.5 kg a.i./ha), carbofuran (1 kg/ha), or isofenphos (1 kg/ha) can be applied. For localized treatment in the plant furrow, recommended insecticides include carbofuran granules (500 g/ha), carbosulfan (500 g/ha), diazinon (5 kg/ha), and chlorpyrifos-ethyl (500 g/ha).

However, such soil treatments are rarely cost-effective under current upland rice cultivation conditions in Africa.

Control of Stem Borers in Irrigated Rice Crops

• Treatment in nurseries

An effective early treatment is the application of an insecticide, such as carbofuran (2 kg/ha), 5 days before transplanting.

• Treatment in rice fields

If the plants were treated in the nursery, field crops could be protected against diopsids, midges, and stem-boring pyralids and noctuids by one or two applications (4 and 6 weeks after transplanting) of insecticide granules in the rice field water. In the absence of a nursery treatment, the first application should be carried out 1 week after transplanting.

Some of the effective active ingredients against stem borers are: carbofuran (500-800 g a.i./ha) against a fairly wide range of species, diazinon (2 kg/ha) or isofenphos (1 kg/ha) for specific control of diopsids, chlorfenvinphos (1 kg/ha) against pyralids of the genus *Chilo*.

Control of Foliage Feeders

These pests can attack suddenly and rapidly damage crops. If early treatments against borers are ineffective against leaf pests, a foliar application is recommended using endosulfan (500 g/ha), carbofuran (600 g/ha), carbaryl (1 kg/ha), fenitrothion (0.6 kg/ha), fenthion (0.6 kg/ha), or diazinon (1 kg/ha).

Control of Sucking Insects and Disease Vectors

Application of systemic insecticide granules in the rice field water for controlling stem borers, also protects rice plants against most leaf sucking pests, including leafhoppers that transmit diseases. Alternatively, leaves are sprayed with carbaryl (1 kg/ha), endosulfan (700 g/ha), or fenitrothion (1 kg/ha), if necessary.

Note: For further information on major African rice pests against which these chemical control measures are recommended, readers should refer to the following factsheets: "*Sesamia calamistis*," "*Chilo zacconius*," "*Maliarpha separatella*," "*Diopsis macrophthalma* (= *D. thoracica*)," "*Orseolia oryzivora*," "*Nymphula depunctatis*," "Main Pests of Rice in Africa," "Pest Surveys in Rice Crops."

Chemical control methods against storage pests are described in the following factsheets: "Coleopteran Storage Pests of Tropical Cereals," "Lepidopteran Storage Pests of Tropical Cereals."

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CHEMICAL CONTROL OF MAIZE PESTS

PHEROMONE TRAP FOR STEM BORERS

FISHING-LINE TRAP FOR LEAFHOPPER VECTORS OF VIRUS DISEASES

SESAMIA CALAMISTIS

CHILO PARTELLUS

TRAPPING

PEST SURVEYS

CHOICE OF THE BEST TIMING OF TREATMENTS

GRANULAR SPREADER Ⓐ

Ⓑ DUSTING

Ⓒ GRANULAR APPLICATION

SOIL TREATMENTS

FOLIAR APPLICATIONS

WITH A TRACTOR

SPRAYINGS

WITH AN HELICOPTER

Ⓓ

CHEMICAL CONTROL METHODS IN MAIZE FIELDS

IRAT / CIRAD – B.P. 5035 – 34032 MONTPELLIER CEDEX – Maquette : T.ERWIN – Photos : IRAT – RHONE POULENC (A.B.C.D)

Chemical Control of Maize Pests

In maize crops, chemical control of pests is directed against soil species which are particularly harmful to seedlings and young plants, leaf pests, and stem borers.

Control of Soil Pests

• Seed treatment

The insecticide is often applied in combination with a fungicide or bird repellent. Lindane and endosulfan (alone or mixed) as well as carbofuran are recommended. They are dusted at a dose of 200-300 g of the formulation per quintal of seed.

• Soil treatment

For general disinfestation of the field before planting, lindane is first applied over the entire surface and then incorporated in the soil at a dose of 1.5 kg a.i./ha. Insecticides recommended for localized treatment in plant furrows are carbofuran granules (600 g/ha), carbosulfan (500 g/ha), bendiocarb (300 g/ha), chlormephos (300 g/ha), terbuphos (200 g/ha), or chlorpyrifos-ethyl (500 g/ha).

• Insecticide baits

Baits are used against black cutworms (including *Agrotis ipsilon*). Those that contain endosulfan, carbaryl, or chlorpyrifos-ethyl are recommended.

Control of Leaf Pests

Leaf feeders (caterpillars of pyralids and noctuids, Coleoptera, etc.) can be controlled by spraying insecticides such as endosulfan (800 g/ha), chlorpyrifos-methyl (400 g/ha), trichlorphon (1.2 kg/ha), cypermethrin (50 g/ha), and deltamethrin (20 g/ha), or *Bacillus thuringiensis* (serotypes H1, 3a, or 3b against noctuids).

Young maize plants are protected against leaf-sucking insects, particularly vectors of virus diseases, by applying granules of systemic insecticides, such as carbofuran, in the plant furrow (see Soil treatment).

Control of Stem Borers

Under tropical conditions, application of granules in the leaf axis and whorl is more effective than spraying. Diazinon (150 g/ha), carbofuran (1 kg/ha), chlorpyrifos-ethyl (400 g/ha), fenitrothion (800 g/ha), and synthetic pyrethroids (20-150 g/ha, depending on the active ingredient) are some of the recommended active ingredients. The treatment should be carried out on detection of an oviposition peak and a large number of newly hatched larvae in a maize crop. The treatment may be repeated, depending on the climatic conditions and population build-up of the pest in the maize-growing region.

Note: For further information on major African maize pests against which these chemical control measures are recommended, readers should refer to the following factsheets: "*Chilo partellus*," "*Eldana saccharina*," "*Sesamia calamistis*," "*Busseola fusca*," "Vectors of Some Virus Diseases of Maize," "Main Pests of Maize in Africa," "Pest Surveys of Maize Crops."

Chemical control methods against storage pests are described in the following factsheets: "Coleopteran Storage Pests of Tropical Cereals," "Lepidopteran Storage Pests of Tropical Cereals".

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CHEMICAL CONTROL OF LEGUME PESTS

Before planting, bury the insecticide in the soil or in the furrow

AMSACTA SP. ON A COWPEA LEAF ▶

◀ JULUS ON GROUNDNUTS

Apply the inecticide when the first new-hatched larvae appear

SOIL PESTS

LEAF-FEEDING INSECTS

THRIPS ON FLOWERS

POD BORERS

BUGS

DAMAGE OF THRIPS ON COWPEAS ▼

Apply the insecticide when the first flowers open, then every ten days

◀ ACANTHOMIA SP.

Apply the insecticide as soon as the first bugs are seen on the leaves, then up to the maturation of pods if necessary

◀ DAMAGE OF MARUCA TESTULALIS ON BEANS

Apply the insecticide when the first young pods appear, then every week

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Chemical Control of Legume Pests

Control of Soil Pests

• Seed treatment

The insecticide is often combined with a fungicide. Lindane and endosulfan (alone or mixed) are recommended at a dose of 200-300 g of the formulation per quintal of seed.

• Soil treatment

For generalized soil treatment before planting, lindane is applied over the entire soil surface and incorporated at a dose of 1.5 kg a.i./ha.

For localized application in the plant furrow, chlorpyrifos-ethyl granules (500 g/ha), diazinon granules (2 kg/ha), or carbofuran granules (500 g/ha) are used. The insecticide should not come into contact with the seed.

• Poisoned baits

Poisoned baits can be very effective on small plots, particularly for controlling black cutworms (*Agrotis ipsilon*). Recommended insecticides are those with chlorpyrifos-ethyl, trichlorphon, or endosulfan base.

Control of Leaf Feeders

Leaf-feeding caterpillars can be effectively controlled by leaf application of active ingredients with minimum toxicity in order to protect beneficial insects. Such insecticides include endosulfan (600 g/ha), carbaryl (100 g/hl), methomyl (300 g/ha), and synthetic pyrethroids (20-50 g/ha, according to the active ingredient). Leaf-feeding Coleoptera can be eradicated with diazinon (300 g/ha), malathion (500 g/ha), or carbaryl (75 g/hl); Acrididae with fenitrothion (400 g/ha). If damage levels warrant treatment against leaf miners, a preventive soil treatment is recommended using a systemic insecticide such as carbofuran, or a leaf application of fenthion (75 g/hl, against *Liriomyza* spp.) or fenitrothion (500 g/ha, against *Ophiomyia phaseoli*).

Control of Pod Borers

Pod borers and seed feeders are controlled by spraying endosulfan (400-600 g/ha), diazinon (400 g/ha), or synthetic pyrethroids such as deltamethrin (12 g/ha), cypermethrin (20-30 g/ha), or permethrin (10-20 g/ha).

Control of Sucking Insects

Seed or soil treatments in young crops using systemic insecticides are effective against sucking insects such as thrips, leafhoppers, and whiteflies. During flowering, the legume crop can be protected against thrips by applying endosulfan (400 g/ha), monocrotophos (200 g/ha), dimethoate (75 g/hl), or deltamethrin (25 g/ha). Bugs are exterminated by application of trichlorphon (600 g/ha), fenitrothion (500 g/ha), monocrotophos (300 g/ha), or endosulfan (500 g/ha). Aphids are controlled by spraying malathion (1 kg/ha), diazinon (300 g/ha), or endosulfan (500 g/ha). Mites are controlled by dicofol (400 g/ha) or pirimiphos-ethyl (500 g/ha).

Recommendations

Constant surveillance is required for decisions on insecticide treatments, including the selection of treatment date and frequency, depending on the phenological stage of the crop and pest population dynamics. Treatments should be carried out only when they are indispensable and cost-effective and should conform to manufacturer's recommendations.

Note: For further information on the legume pests against which these chemical treatments are recommended, readers should refer to the following factsheets: "*Liriomyza* spp.," "*Spodoptera* spp. Pests of Leguminosae," "*Maruca testulalis*," "*Thrips* spp.," "*Ophiomyia phaseoli*," "Soil Pests of Tropical Food Crops," "Polyphagous Leaf-feeding Caterpillars of Tropical Food Crops," "Leaf-feeding Coleoptera of Tropical Food Crops."

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Integration of Other Control Measures

Insecticide control has its dangers and limits. Excessive or irrational use can lead to pollution of the environment, appearance of insecticide resistance phenomena in insects, presence of toxic residue in food consumed by man or animals. Insecticides should therefore be used judiciously and combined with other means to enhance efficiency.

Potential of Biological Control

Biological control using entomophagous insects has often been unsuccessful. But failure was often due to inadequate financial and logistic resources that were sometimes too meager for attaining the objective. The results of the Africa-wide *Phenacoccus manihoti* project with considerable international input will therefore be particularly enlightening. The objective of the effort is to reduce *P. manihoti* (cassava mealybug) populations in Africa by using introduced parasites and predators. In the future, it would be useful to preserve indigenous beneficial fauna. Other possibilities for the middle term include selection of parasites and predators with resistance to insecticides and the use of plant allomones and animal pheromones for attracting natural enemies to the pest.

Biological control by propagating entomopathogens (viruses, bacteria, fungi) should also be developed, especially when such pathogens can be usefully combined with insecticides.

Progress in the Development of Resistant Varieties

Where yield levels of food crops are low there is generally no economic justification for using insecticides. In most regions where cultivation is being intensified, the choice of varieties and cultural practices is dictated by the need to obtain stable yields that are not affected by unfavorable physical and biological factors (climate, soil, pests, diseases, etc). Research on insect-host plant relations, particularly work on the identification of chemical mediators that help pests to detect their host, and considerable progress in plant genetics should soon lead to the development of breeding programs that integrate crop resistance, or tolerance, to major pests.

Impact of Cultural Practices

Security measures are particularly important for low-input food crops. Certain traditional practices minimize risks of inadequate yields to ensure sufficient food for on-farm consumption. But they are generally designed to protect crops against climatic hazards and rarely against overexposure to infestations. They can therefore be disadvantageous for preventing pest attacks; for example, staggering of sorghum plantings can be favorable to grain midge development. In such situations, the most satisfactory compromise should be adopted.

Cultural techniques should be selected in relation to a global strategy for protecting crops against physical and biological stress. This requires a proper understanding of climatic and soil conditions, crop behavior, and pest population dynamics.

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