

Reference 21 Insects in rice cropping

Summary

Insects can be either harmful or useful to rice cropping. The integrated management of insects, in which the use of insecticides is reduced to the minimum, requires good knowledge of their development cycles. This reference describes the main families of insects that are either harmful or useful to rice cropping, details their development cycles, and presents methods for the integrated control of harmful insects. The dangers of using and manipulating insecticides is also presented.

An ecosystem is a natural environment made up by dynamic interactions between biotic and abiotic elements within well-defined boundaries. The biotic elements include plants, insects (pests, natural enemies, decomposers), microbes and other living organisms. The abiotic elements include the weather, relative humidity, wind, sunlight, rain and soil. Each element has its own specific characteristics and plays its own particular role in the system in space and time, influencing the distribution of living organisms. The term ecosystem also includes the flows of nutrients and energy inside the system.

The rice ecosystem is a grouping of biotic and abiotic elements complex enough to provide a measure of stability. However, pesticide use will generally disturb this balance, because both natural enemies and other non-target organisms may be killed by the treatment.

The concepts underlying the integrated management of insect pests and integrated rice management (IRM) are based on the stability of the agro-ecosystem and on economic efficacy. When the stability of the agro-ecosystem is maintained, the populations of insect pests can be kept to levels that are easy to manage. In order to achieve this, the following points must be taken into account:

- The number, position, role and intensity of all the elements in the ecosystem change, transform or evolve continuously. They build a living system, continually changing, i.e. it is a dynamic ecosystem.
- In all ecosystems there is a hierarchical structure. For instance, plants produce biomass that feeds herbivores (which include insect pests). These are in turn eaten by carnivores (including their own natural enemies) that are in turn eaten by other carnivores. At the end of the process, all organisms feed the decomposers. If, in an agro-ecological system, there are no natural enemies at all, the insect pests will multiply and destroy the crop. This is why natural enemies living in the fields are an important mechanism of protection—maintaining the balance among all the elements in the ecosystem is essential for its sustainability.

Biodiversity

A healthy ecosystem has a high degree of diversity, in terms of the number of species and the genetic diversity of the individuals within the species. In practice, this means that in such an ecosystem there are several different kinds of plants and animals. Among the useful animals, one may include worms

that increase soil fertility and ‘natural enemies’ like spiders, scale insects, frogs and lizards, which help reduce or destroy insect pests. If there are few useful animals in an agro-ecosystem, this may be due a number of problems, e.g.:

- Too much pesticide has been used and these useful animals have been killed.
- There is not enough food for these natural enemies. In their larval stages, most natural enemies eat other animals (e.g. caterpillars, grasshopper nymphs), whereas adults can live from nectar or pollen from the wild plants in the environment. That is why a large variety of plants is necessary in order to maintain the populations of natural enemies. The more diversified the vegetation of an agro-ecosystem, the more diversified the populations of natural enemies, which means that the chances of naturally destroying the populations of insect pests will be greater.
- The structure of the soil does not allow worms and insects to grow. Unfavorable conditions for soil inhabitants include soil not containing enough organic matter or fields being flooded too frequently.

Natural enemies

Large animals usually live longer and have fewer offspring, while smaller animals have shorter life cycles and more offspring. Insects have huge numbers of offspring. One pair of stem borers may have 100 offspring that will all become adults. If, in one month, each female produces 100 surviving and productive offspring, the stem-borer population would reach 30 billion within six months. Fortunately, several mortality factors naturally reduce the increase of insect populations. The growth of all living organisms is regulated by unfavorable environmental conditions and by natural enemies.

What is a natural enemy?

A natural enemy is a living organism that kills, harms and causes disease in other living organisms. There are three types of natural enemies:

- Predators
- Parasites
- Pathogens.

Predators

Predators are animals that hunt and kill other animals, e.g. tigers, snakes, spiders or ladybird (ladybug) beetles. The body of a predator is adapted to hunting, killing and eating its prey. In general, predators have strong teeth and mouths, acute vision and strong legs.

Parasites

Parasites also consume other organisms, but they enter (or attach themselves to) the body of their victims and feed on their tissues and fluids, which weakens and even kills them. Parasites thus live at the expense of another organism that is the victim or ‘host’ on which the parasite feeds.

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Pathogens

Pathogens are micro-organisms that cause diseases. Like many parasites, they enter the body of their host, in which they live and multiply, weakening and finally killing their host. Bacteria, fungi and viruses are pathogens.

Rice predators: useful insects

Rice predators include spiders, ants, some insect families (e.g. Carabidae), plant bugs, amphibians, dragonflies, and other beetles and water bugs; however, the most important ones are the spiders—one spider can consume about 30 white leaf hoppers in a day. Spiders do not belong to the insect group but are arachnids; that is, animals whose head and neck are not separated. One peculiarity of spiders is that they never eat rice, and only feed on insects, whereas insect predators feed both on rice and insects.

The main spider families that can be found in African paddy fields are:

- **Lycosidae:** They are often called ‘wolf’ spiders as they are often found in packs of 3 or 4 like wolves. E.g. *Pardosa* spp., *Lycosa* spp., *Wadicosa* spp.
- **Thomisidae:** They are often called ‘crab’ spiders because they actually look like crabs and can move in all directions without turning around. E.g. *Thomisus* spp.
- **Tetragnatidae:** They are giant spiders, sometimes known as ‘long-jawed’ spiders, and their bodies are long and well developed. E.g. *Tetragnata* spp.
- **Araneidae or Argiopidae:** They are the best weavers and really weave spider webs. E.g. *Argiope* spp., *Gasteracantha* spp.
- **Pholcidae:** They are often called ‘grand-dad long-legs’ as their legs are very long and very thin. E.g. *Pholicus* spp.
- **Salticidae:** They are often called ‘jumping’ spiders as they leap and jump instead of running or walking. E.g. *Salticus* spp.

The most important rice insect pests: harmful insects (Table 21.1)

The insects that harm rice can be classified into five main groups according to the type of damage they cause:

- Stem borers.
- Defoliators.
- Piercing–sucking insects.
- Root cutters.
- Storage pests.

Table 21.1. Insects in rice cropping

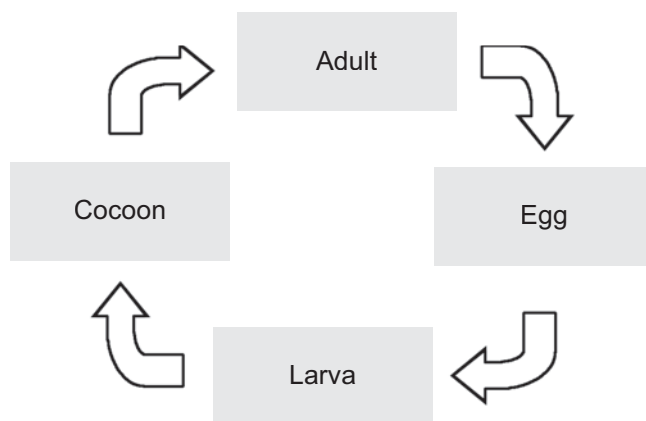
Name of damage	Order/ Family/ Species	Type of damage	Symptom description	Stage of insect causing damage	Susceptible plant stage	Impact on yield
Rice Yellow Mottle Virus (RYMV)	Coleoptera Locusts Leafhoppers	Leaf destruction Cut leaves Perforated spots with minute strips	Early yellowing Stunting	Adult	Vegetative stage, even when transplanted	Sometimes no yield at all
Onion tube	Fly (African Rice Gall Midge)	No leaf destruction	Some leaves change into yellowy-white tubes, looking like onion leaves	Larva (small yellow worm)	Vegetative stage	Sometimes no yield at all
Dead heart	Red flies with black antennae: <i>Dioptis</i> and butterflies: <i>Chilo</i> , <i>Sesamia</i> , <i>Scirpophaga</i>	No leaf destruction	Some leaves change into yellowy-brown tubes called dead heart Plants can be pulled up easily	Larva (small yellow worm)	Early vegetative stage	High yield despite attack
Defoliation	Small white butterflies <i>Nymphula</i>	Many leaf fragments floating on water: they are the sheaths/ covers that protect the larvae	Tips of rice leaves are cut Field whitening	Larva	Early tillering	Rice fields usually recover without losses
Destruction of roots	Termites <i>Microtermes</i> <i>Macrotermes</i>	No tube formed No leaf destruction	Early yellowing and drying of leaves	Adult termite "workers"	Any time in cycle whenever water is lacking	Losses may be high
Grain blackening	Stinking bugs <i>Aspavia leptocorysa</i>	Small black or brown spots on grains	Bad grain quality (color, fragrance, flavor)	Adult	Reproductive stage and maturity	Small-scale indirect losses

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There are about 50 different species from two families: Lepidoptera and Diptera. The most frequent Lepidoptera are: *Chilo* spp., *Maliarpha separatella*, *Sesamia calamistis*, *Nymphula depunctalis*, *Eldana saccharina*, *Scirpophaga* spp. The most frequent Diptera are *Diopsis* spp. and *Orseolla oryzivora*, the ‘African rice gall midge’ (Reference 22).

The development cycle of most insects follows four stages: adult, egg, larva, and pupa or cocoon.



Stem borers

Stem borers cause the worst damage, as they infest rice plants from the seedling stage to maturity, including:

1. Damage on young plants during early and later tillering. Caterpillars enter the leaf sheath and the young stem from the bottom, causing the death of the stem: such damage is often called ‘dead heart’ (see Reference 23).
2. Damage to the panicle, causing ‘white panicles’ (see also Reference 23). The young caterpillars (mostly from the second generation) gather a few centimeters below the panicle inside the flower stalk, which then dries up entirely. According to the timing of the attack, it becomes either a completely white or a dried panicle, which may eventually break.

Apart from these two visible cases, any attack on the stem is just as harmful. If the insect attacks when the plant has already reached an advanced stage of development, the older caterpillar embeds itself in the lower parts of the stem and reduces or even stops the nourishment of the panicle. Damage then shows through the drying of some of the spikelets, leading to a decrease in the number of grains at harvest. This effect, which is far less visible, reduces the weight of the harvest and can only be measured by weighing the harvest.

Defoliators

The damage caused by leaf defoliators usually concerns fragments on leaf edges and tips, but in some cases, the leaves can be cut off. When the plant is already grown, such damage is usually without great

economic importance. However, when such infestations take place in the early development of the plant (until mid-tillering), they may harm a great part of the plant and lead to irretrievable losses.

One of the most widespread species is *Nymphula depunctalis*. It is a small (10–12 mm) pearly-white butterfly that lays its eggs in tight rows along the leaves. The larva crawls on a leaf and cuts it crosswise a few millimeters from its end, leaving only a tiny part connected to the remainder of the leaf. Because of the lack of turgidity, the leaf fragment wraps itself around the caterpillar, which then closes the part of the leaf that is almost cut off with a few silk threads, cuts the part that is still attached to the remainder of the leaf, and falls into the water. It is then well protected and can move on the water, with only the upper part of its body out of the leaf. It can then easily swim from rice stem to rice stem, climb up and feed. During the larva stage, it will change its protecting leaf many times. Drying the field for at least 3 days is an efficient method of control.

Other species of defoliators are: *Cnaphalocrosis medinalis*, *Marasmia trapezalis*, *Diacrisia scortilla*, *Parnara* spp., *Hispides* spp.

Piercing–sucking insects

Piercing and sucking insects can attack the leaves, stems and grains. They may be numerous and cause significant damage. This category includes bugs, whiteflies and acarids (i.e. micro-mites, parasitic micro-worms); they mostly cause damage during maturation, at the milky and dough grain-filling stages.

Root cutters

Root cutters are insects that partially or totally develop in the soil. Some can be found only in inland valleys, while others live only in the upland areas.

Rice mole cricket (Gryllotalpa africana)

These belong to the locust/grasshopper family. They mostly live in the upland areas, but can live in all kinds of ecosystems. They mostly damage field borders.

Termites

These can be found in both inland valleys and upland areas, especially when water is lacking, which explains why flooding the fields is the easiest way to control them. They feed on roots and underground elements of the plant, leading to yellowing and drying of the leaves. The most widespread species found in rice fields are *Microtermes*, *Macrotermes* and *Trinervitermes* spp.

Water weevils (Afroryzophilus djibai)

This insect lives exclusively in the muddy waters of inland valleys. The harmful stage is the larva which feeds exclusively on rice roots.

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Storage pests

Stored rice can be attacked by a wide range of insects whose identities and cycles differ from those found in the fields. Most feed on rice and any other stored grain. They can be classified into two groups according to the infestation mode: some begin attacking the crops in the field and are brought into the granary or store with the harvest, as is the case for weevils and moths; others attack only stored grains, and can come from either inside or outside of the store.

Insect control

Crop management practices

These practices both hinder the multiplication of harmful insects and favor rice growth. The most efficient practices are the following:

- Destruction of rice stubble and crop residues, i.e. the places where larvae and nymphs can survive between seasons.
- Respect and synchronization of cropping calendars to avoid insect proliferation.
- Use of good-quality or treated seeds.
- Careful monitoring of crops and destruction of primary infection sources, including host weeds.
- Where possible, avoid mono-cropping and use crop rotations to disrupt insect cycles and prevent proliferation.
- Associated or row intercropping cultures to limit insect propagation among plants.

To be efficient, crop management practices aimed at insect control must be implemented over large areas. As most farmers manage surface areas of one hectare or less, such practices require agreements and organization over the whole inland valley.

Biological control

Biological control aims at limiting the density of insect pests by using natural enemies as predators, parasites or pathogens. Two strategies may be used, namely preserving the density of natural enemies or increasing their density. Preservation simply means that one avoids destroying natural enemies through crop management practices or some interventions like the use of pesticides. Increasing natural enemies means that the number of natural enemies will be artificially increased in the environment: this implies that natural enemies will have to be bred and released, and this is difficult to implement in Africa. Therefore, natural preservation will be chosen to increase the population naturally. The most well-known example is that of two parasites of African rice gall midge: farmers should be told to keep *Paspalum scrobulatum* (Reference 22) around their fields, as it is the favorite dwelling of these two parasites. The more this plant grows, the denser the natural enemies, which naturally leads to a decrease in gall-midge populations.

Furthermore, it has been shown that after weeding, putting the weed residues in heaps around the rice straw leads to an increase in spider populations which hide there during the day, and at night hunt the nocturnal stem borers. These methods are called preservation and increase methods, which show that some crop management practices are also biological control practices.

Some other biological control methods can also be used, including in particular the promising use of very specific sexual attracters (pheromones), which, once synthesized, may help destroy insect pests by simply trapping them or can be used in combination with insecticides. This method is beginning to be used for some Lepidoptera that attack fruit. The pheromones of *Chilo suppressalis* and *Chilo zacconius* are known and some synthesized components are being tested. Such 'products' are very interesting as they may also help 'predict' infestations and help choose which kind of control to use, as pheromones allow the detection of very small populations of insects, especially before they begin multiplying. However, stem-borer pheromones are not yet available in Africa.

Biological control has the great advantage of being harmless to health and the environment. Nevertheless, it often demands relatively complex management, and requires rather high investments and a certain level of technological expertise.

Genetic control

This type of control requires the use of tolerant varieties; it is usually not very expensive for farmers and imposes few constraints on the environment. Varieties can be differentiated according to the degree of resistance and classified as: low, medium and highly resistant. There are two types of genetic resistance: vertical resistance, to some insects, and horizontal resistance, to most insects.

Chemical control

Chemical control is usually quite affective, as insecticides kill the insects in a short time. Furthermore, insecticides are usually widely available in stores. Nevertheless, insecticides are expensive and impose technical constraints. Spraying liquids is not very precise and is less efficient than using granules, which can be applied by hand or with cheap equipment. Some farmers use Furadan to prevent stem borers from multiplying. However, the danger of frequently using insecticides is that some insects adapt to insecticides and become resistant. Furthermore, most insecticides are not specific and kill both harmful and useful insects. Using insecticides can therefore be dangerous to the ecosystem and the environment, and such an option should be used only as a last resort, after considering all other possibilities.

Integrated insect control

Integrated insect control means that the populations of harmful insects will be kept as low as possible so that the ecosystem stability is not disturbed and rice cropping can be economically efficient. Integrated control means that one is led to think and to combine judiciously the different control techniques.

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Pesticides and natural enemies

What is a pesticide?

In most local languages, the word used for ‘cure’ or ‘medicine’ is also often used for pesticides. However, pesticides are neither cures nor medicines, but rather poisons that kill. This becomes clearer when one studies their names and meanings:

- Insecticide = kills insects.
- Raticide = kills rats.
- Fungicide = kills fungi.
- Bactericide = kills bacteria.
- Herbicide = kills weeds.
- Nematicide = kills nematodes (nematodes are microscopic worms).

Some pesticides have an effect on respiration or on digestion. Others kill indirectly by their effects on development or reproduction. Whatever the mechanism of action, the result is identical: the harmful insect is killed. However, it is not only the harmful insect that is affected! Other insects, including natural enemies, and even animals or humans may fall ill or die because they came into contact with pesticides.

We should avoid calling pesticides ‘cures’ or ‘medicine’ and call them what they are: *poisons*. By doing so, we remind ourselves and others that pesticides are dangerous and that their use ought to be as limited as possible. If it becomes essential to use them, they must be used with great care, as they are dangerous for human health and for the environment.

Insecticides can be divided into two groups according to the way they work. Some are immediately absorbed by the insects when they come into contact with the insecticide: these are contact insecticides. These insecticides are sprayed over plants and the insects come into contact with them while moving over the plant. The other insecticides are systemic, as they enter the insect body through their food, and the insecticide will kill the insect when it goes through its intestines. Systemic insecticides are applied as granules sprinkled on the ground, which are absorbed by the plants. When the insects eat the plants, they also swallow the pesticide. Both insecticides are toxic to natural enemies.

Pesticides, natural enemies and harmful insects

Most farmers have noticed that the problems with insect pests like aphids and other small insects appeared after they began using insecticides. Two reasons can explain this phenomenon:

- Insecticides never kill all the insect pests in a field. The insects that survive are more resistant to the pesticide than those that died. The surviving insects are those which will reproduce and transmit

their resistance characteristics to the next generation. If the insecticide is applied often and at high doses, the selection for resistant insects occurs very quickly. Insects with a short life cycle like aphids can rapidly develop resistance to insecticides.

- Pesticides kill natural enemies, which are more susceptible to pesticides than the insect pests are. Furthermore, the life-cycle of natural enemies is generally longer than that of harmful insects, which means that natural enemies need a longer period to recover and thus for their population to reach its previous size. Without their natural enemies to limit their numbers, the harmful insects can multiply very rapidly.

Pesticides and human health

Pesticides can have acute or chronic effects on human health. The acute symptoms of poisoning are nausea, vomiting, disturbed vision and trembling. When pesticides are frequently used over a long time, the effects can become chronic and the symptoms may be blood-pressure changes, heart problems, skin (dermatological) problems, neurological problems and cancers. Pesticides can kill human beings. The United Nations World Health Organization (WHO) has published that, each year, about 1 million people are poisoned by pesticides, and that 20,000 die from their effects.

Some safety rules

To prevent dangers linked to pesticide use, it is important to follow some basic safety rules:

- Always wear protection equipment (mask, glasses, gloves and boots) while treating.
- Respect recommendations about doses and associations with other products.
- Avoid, as much as possible, applying products when it is very hot or very sunny (between 11:00 and 16:00), and walking into the wind.
- Never smoke while treating, or before washing thoroughly.
- Ask people standing close, especially those placed down-wind, to move away while treating.
- Thoroughly clean treatment and protection equipment after use and store far from food and out of the reach of children.
- Take care not to clean the equipment or to throw away any solution remaining in an area close to a source of water used for home or cooking purposes.
- If, by accident, the product comes into contact with the eyes, nose or mouth, rinse with abundant water and go to the closest health center, if possible, with the references of the product (packaging or label).

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Bibliography

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