# Post-harvest Insect Pests of Groundnut and their Management

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***Abstract***

Groundnuts after harvest are attacked by a plethora of insect pests in storage across the world. This publication discusses the importance of post-harvest processing in the management of insect pests. Emphasis is given to crop husbandry, monitoring, sampling, prevention of insect damage, management of established infestation, and eco-friendly management in commercial and farm-household situations. This bulletin also discusses various practices suitable for commercial and household storage.

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Cover: *Post-harvest processing of groundnut in farmers' fields.*

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**International Crops Research Institute for the Semi-Arid Tropics**
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# Contents

## Introduction

Groundnuts are stored both as unshelled pods and as kernels for different uses. Both forms are vulnerable to attack by a plethora of insect pests after harvest. However, groundnut kernels are more susceptible to insect attack than pods in storage. The amount of damage inflicted by insect pests during post-harvest processing and storage depends on several factors such as moisture content in the product, the form in which it is stored, level of maturity at harvest, sanitation of storage space and the quality of the material itself. In addition, the storage structure also influences the rate of deterioration through its physical environment. Post-harvest processing of groundnuts (threshing, drying and cleaning) has significant influence on insect behavior and establishment in the store. Mature pods are less susceptible to insect pests than immature pods. Damage to pod shells also increases susceptibility to insect pests. Pre-storage processing of groundnut varies from country to country and region to region. In developing countries, pods are often removed from haulms by hand, when the pod-moisture content can be about 15%. However, this procedure is labor intensive. In some situations, beating the haulms against wooden poles until the nuts fall off, or stripping the haulms by using simple strippers, is a common practice. In most cases, manual hand picking is safe and avoids damage to the shells. Excessive drying in the sun or from an artificial heat source can affect the viability of the nuts; therefore, care should be taken to ensure that seed nuts are dried either under shade or at the appropriate temperature. Undamaged unshelled groundnuts can be stored for long periods without insect pest damage provided the moisture content is below 7%.

More than 100 insect species are known to live and feed on stored groundnuts, some of which are of economic importance. The most commonly reported stored pests of groundnut worldwide are listed in Table 1. Though most of the insect pests attack kernels, *Caryedon serratus* (Olivier) is the only major pest of groundnut that infests unshelled nuts. Insect infestation in groundnut is well known for causing direct loss, but indirect loss in terms of quality of the produce also impacts its trade and use. The heat and moisture generated by a large insect population in storage also increases the risk of mold growth, which indirectly spoils the quality through mycotoxin contamination, rendering the stock unfit for human and animal consumption.

Post-harvest losses in groundnut range between 10 to 25% of the production in Asia, and severe damage under long-term storage situations is not uncommon (Azeemoddin 1993). In India, farmers, seed agencies and other oil extraction units store about 65% of the groundnut produce for 6-9 months before final use.

| Table 1: Economically important insect pests of groundnut in storage. | |
|---|---|
| Latin name | Common name |
| *Abasverus advena* (Waltl.) | Foreign grain beetle |
| *Alphitobius diaperinus* (Panzer) | Lesser mealworm |
| *Araecerus fasciculatus* (De Geer) | Coffee bean beetle |
| *Attagenus megatoma* (L.) | Black carpet beetle |
| *Carpophilus dimidiatus* (F.) | Corn sap beetle |
| *Caryedon serratus* (Olivier) | Groundnut bruchid |
| *Corcyra cephalonica* (Stainton) | Rice moth |
| *Cryptolestes pusillus* (Schoenherr) | Flat grain beetle |
| *Dermestes lardarius* (Linnaeus) | Carpet beetle |
| *Elasmolomus sordidus* (F.) | Pod sucking bug |
| *Ephestia cautella* (Walker) | Almond moth |
| *Lasioderma serricorne* (F.) | Cigarette beetle |
| *Latheticus oryzae* Waterhouse | Longheaded flour beetle |
| *Liposcelis* sp. | Booklouse – several species |
| *Necrobia rufipes* (De Geer) | Checkered beetle |
| *Oryzaephilus mercator* (Fauvel) | Merchant grain beetle |
| *Oryzaephilus surinamensis* (L.) | Saw-toothed grain beetle |
| *Plodia interpunctella* (Hubner) | Indian meal moth |
| *Sitophilus oryzae* (L.) | Rice weevil |
| *Stegobium paniceum* (L.) | Drugstore beetle |
| *Tenebrio molitor* L. | Yellow mealworm |
| *Tenebroides mauritanicus* (L.) | Cadelle |
| *Tribolium castaneum* (Herbst) | Red flour beetle |
| *Tribolium confusum* Jacquelin du Val | Confused flour beetle |
| *Trogoderma* sp. | Khapra beetle |
| *Trogoderma granarium* Everts | Khapra beetle |
| *Trogoderma inclusum* LeConte | Larger cabinet beetle |
| *Typhea stercorea* (L.) | Hairy fungus beetle |

Sometimes, the damage incurred to the produce in the store is complete, and there is no compensation for damage done by storage pests as is the case for field pests. In temperate countries such as southwestern United States, farmers take up sanitization measures in storage facilities prior to the fall season (before September) to avoid insect infestation later. Though fall conditions (cool temperatures) are not favorable to buildup of insect pests, the spring weather conditions in the temperate countries favor the pests, which necessitate control measures (Dudley et al. 2003).

This bulletin provides information on biology, distribution and host range of the most economically important insect pests of stored groundnuts of the semi-arid tropics such as *C. serratus, T. castaneum, C. cephalonica* and *E. sordidus*. The methods of assessing losses caused by these insects and their management are also discussed.

## Groundnut bruchid, *Caryedon serratus* (Olivier) Coleoptera: Bruchidae

Figure 1. *Caryedon serratus* adult.

Figure 2. *C. serratus* egg.

**Biology and damage:** The adult is a brown beetle, about 4-7 mm long and 5 mm wide with prominent large hind legs (Fig 1). A single gravid female lays 20-30 creamy white eggs (1 mm long), which are glued to the surface of groundnut shell or kernels (Fig 2). The incubation period varies from 4 to 6 days. The newly hatched larva burrows straight through the eggshell and pod wall, and starts eating the kernel. No damage can be seen at this stage unless one searches carefully. The first sign of attack is the appearance of 'windows' (approximately 3 mm in diameter) made on the pod wall by the grub to allow the adult to leave the pod. Each larva feeds solely within a single kernel (Fig 3). Larval development is completed in 40 to 45 days, and the pupal stage lasts for about 15 days (Fig 4). Sometimes, the grown-up larvae leave the pod and pupate at the bottom of the sacks. By this stage, the groundnut seeds are badly damaged and are unfit for human consumption, seed use or oil expulsion. Under optimum conditions (30-33°C and 70-90% relative humidity), the life cycle of *C. serratus* is completed in about 60 days.

Figure 3. *C. serratus* grub.

Figure 4. *C. serratus* pupa and damage.

**Distribution:** *C. serratus* is widely distributed in groundnut growing areas of the world from Myanmar through Hawaii, India, Indonesia, Iran, Israel, Jordan, Mexico, New Zealand, Nigeria, Pakistan, Sri Lanka, Sudan, Thailand and Uganda (Kingsolver 1970). Further, it has also been reported from Zambia, Senegal and West Africa (Feakin 1973), Central Africa (Delobel 1989), and Australia (Cunningham and Walsh 2002). In India, *C. serratus* was first reported to be infesting groundnut round the year in Andhra Pradesh and Tamil Nadu in 1914 (Fletcher 1914). Subsequently, several workers reported its distribution from Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Uttar Pradesh, Punjab, Haryana, Jammu and Kashmir, Himachal Pradesh, Tamil Nadu, Kerala, Andhra Pradesh and Orissa (Mittal and Khanna 1974, Arora and Singal 1978, Ranga Rao and Wightman 1999).

**Host range:** Reports on damage to seeds of legumes by this insect in storage as well as in the field from different parts of the world have been well documented (Cunningham and Walsh 2002, Nandagopal and Prasad 2004). They include *Tamarindus indica* Linn., *Arachis hypogaea* Linn., *Acacia farnesiana* Willd., *Acacia nilotica* (L.), *Acacia tortilis* Hayne., *Albizia lebbek* (Linn.) Benth., *Bauhinia malabarica* Roxb., *Bauhinia monandra* Kurz., *Cassia fistula* Linn., *Cassia brewsteri* (F. Muell.) Benth., *Cassia tomentella* (Benth.) Domin, *Cassia renigera* Benth., *Piliostigma reticulatum* Dc., *Piliostigma thonningii* (Schum), *Pongamia pinnata* (L.) and *Prosopis juliflora* (Sw.).

Extensive pre-season survey of groundnut post-harvest process and storage premises in Zambia suggested that primary infestation from the field was critical in establishment of bruchid in the stores, and that the groundnuts lifted early and dried for longer period than usual in the field (a common practice for confectionery varieties) received consistently higher insect infestation (Conway 1983).

## Red flour beetle, *Tribolium castaneum* (Herbst) Coleoptera: Tenebrionidae

**Biology and damage:** Red flour beetles attack stored groundnuts and other grain products such as flour, cereals, meal, crackers, beans, spices, pasta, cake mix, dried pet food, dried flowers, chocolate, nuts, seeds and even dried museum specimens. The adults are 3-4 mm long and brown in color (Fig 5). The adults live for several months and are strong fliers. The female lays eggs in cracks of the testa or on the damaged portions of the kernel to enable the young grub to feed on the kernel directly. A female lays up to 450 individual eggs, distributed among the pods or seed. Eggs hatch in 3-4 days. The grubs are cylindrical in shape with prominent projections on the last abdominal segment. The pupal period lasts for 7-10 days, and the adults can live up to 18 months. The mean developmental period requires about a month under optimal conditions (30°C and 90% RH). Pupation takes place inside the damaged kernel without a cocoon. The grubs are facultative predators of other storage insect eggs and larvae, and are sometimes cannibalistic. The grubs feed on the kernel making them unfit for use as seed and human consumption. The damage results in powdery appearance in the produce (Fig 6). The infestation can be recognized by the presence of creamy white grubs and active adults. This species has been recognized to cause direct and indirect losses affecting both viability and quality of the produce.

Figure 5. *Tribolium castaneum* adult.

**Distribution:** The red flour beetle is of Indo-Australian origin, widely distributed in temperate areas, and can survive the winter in protected places (godowns). In the United States, it is found primarily in the southern states. Thus, it is known to be cosmopolitan in distribution and infests all crop products, which is particularly severe in the tropics.

Figure 6. *T. castaneum* damage.

## Rice moth, *Corcyra cephalonica* (Stainton)
## Lepidoptera: Pyralidae

**Biology and damage:** The rice moth has a wingspan of 12-15 mm, with grayish brown forewings (Fig 7). The female lays up to 150 eggs within a few days of emergence. The adults live for 1-2 weeks and drop their eggs in the produce. The creamy white larvae start feeding on the seed immediately after hatching. At maturity, they construct white silken cocoons for pupation. The larvae are capable of damaging sound kernels, and can feed both on the surface and within the seed. They spin a tough silken fibre, webbing the kernel and frass (Fig 8). This type of damage can easily be distinguished from the fine dust that results from beetle damage. Pupation takes place in the galleries developed by the larvae or in the crevices in storage structures. Development from egg to adult requires 30-35 days under optimum (30°C and 90% RH) storage conditions. The males emerge 1-2 days before females.

**Distribution:** Rice moth is cosmopolitan in distribution and known to infest all crop products, which is particularly severe in unhygienic storage situations.

Figure 7. *Corcyra cephalonica* adult.

Figure 8. *C. cephalonica* damage.

## Pod sucking bug, *Elasmolomus sordidus* (Fabricius) Hemiptera: Lygaeidae

**Biology and damage:** The adult is dark brown, approximately 10 mm long and 2 mm wide (Fig 9). Each female lays about 100 eggs in its lifespan of about 30-40 days. In the field, the females lay their eggs in the soil or on groundnut haulms, but under storage conditions, eggs are laid loosely among the groundnuts or on sacks. The first instar nymphs have a bright red abdomen; later instars become progressively darker. All stages of the pest feed on seeds, perforating the pod with their rostrum. On groundnut, the initial infestation starts when the harvested plants are placed for drying in the field. The infested pods are discolored and show oily spots on the outside. In case of severe infestation, the produce is unfit for seed as well as human consumption. This causes seed shriveling (Fig 10) and increases the free fatty acid content of the oil, producing a rancid flavor.

**Distribution:** This species is widespread in Africa, Asia, Brazil, Mexico and Hawaii. Besides groundnut, it also attacks sesame and cotton.

Figure 9. *Elasmolomus sordidus* adult.

Figure 10. *E. sordidus* damaged (L) and healthy kernels (R).

## Pre- and post-harvest process

It is very important to harvest groundnut at optimum maturity to reduce the post-harvest losses and to maintain the quality of the produce under long-term storage conditions. Both early as well as late harvesting can result in substantial loss. Due to its indeterminate growth habit, pod maturity is not uniform in

groundnut. If one waits for all the pods of a plant to mature, the seeds in early-formed pods, in some cases, start sprouting due to lack of seed dormancy, or pod walls start disintegrating due to attack of fungi and other microbes. The easiest and most practical method to look for pod maturity is internal pericarp color. Darkening of the internal surface of the pericarp is directly related to seed maturity (Fig 11). When 75–80% pods show internal pericarp darkening, it means the crop is at optimum maturity.

Figure 11. Matured groundnut pod with darkening of pericarp.

At harvesting, groundnut pods generally contain about 35% moisture, which must be brought below 7% to provide optimal conditions in storage. The harvested plants are well shaken to dislodge the soil from pods and are left in the field for 2–3 days for initial drying before stripping. In the postrainy season, when higher temperatures (40-45°C) prevail at the time of harvesting, the pods must be stripped immediately and dried under shade. Both mechanical and manual threshing is common in Asia. In case of small holdings, the harvested plants are taken home for pod stripping and drying. It is important to remove all damaged [physical, insect (Fig. 12) and nematode (Fig. 13)], rotted and sprouted pods from the harvested produce as they reduce the quality and serve as a source of inoculum for diseases and insect pests in the storage area.

Figure 12. Termite scarification on groundnut pods.

Figure 13. Nematode injury on groundnut pods.

## Monitoring insect pests

It is very important to monitor regularly (once in a fortnight), insect populations in harvested produce and stores so that remedial measures can be taken as soon as infestation is noticed. The crop husbandry also has a bearing on pre-disposing factor to insect pest attack during storage. It is important to manage soil inhabiting insect pests and nematodes during the pod development stage in the field effectively. While harvesting the crop, damage to the pods should be avoided. Although insect traps (sticky traps, light traps, pitfall traps, pheromones) are effective in detecting insects, it is difficult to estimate insect populations from a trap catch as in some cases the damaging stages of the insect do not move from the feeding sites and hence cannot be trapped. In such situations, it is important to know the symptoms of damage in the produce. A simple rule of thumb is to remember that for storage pests, the presence of webbing represents the damage caused by lepidopteran (larvae), while absence of webbing and the presence of powdery remnants represent damage by coleopteran insects (beetles).

## Loss assessment

For estimation of losses caused by insect pests in a consignment, it is not practical to examine every bag or pod, and therefore, it is suggested that the damage is recorded from representative samples of the lot. Since insect infestations are not uniform or even randomly distributed within a store, the sample that gives true indication of infestation or loss must be used to ensure appropriate evaluation.

## Sampling in stored sacks

In large consignments, the condition of storage may vary markedly among the sacks, for example, the temperature at the centre of the stack may be different from that of the surface. These differences should be taken into account by following a stratified sampling procedure. To make it easy and effective, the division of a single stack into a number of layers, each containing the same number of sacks will help in drawing representative samples. In a given number of sacks in each layer, samples must be drawn at random without bias as shown in Figure 14 in

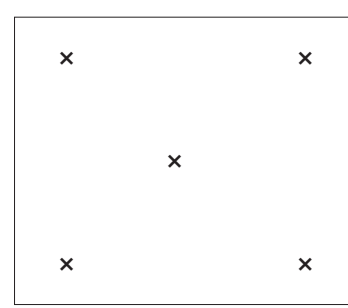

Figure 14. Sampling procedure in each layer of stack.

a stack. If there are ten sacks or less, sample each sack, if there are between 11 and 100 sacks, sample 10 sacks at random. To obtain the representative samples, the stack must be dismantled, which will involve disturbance of normal insect movement in the store. When stacks are broken down while sampling, the sacks must be replaced in their original position, so that the disturbance within the stack is minimum. If the samples are taken only from the most accessible sacks, the measurement of loss represents only that part, and not the whole stock. Thus, each stack must be selected without bias to have an equal representation of the consignment. Specialized tools are available for removing representative samples from sacks, such as sack spears or probes. If no suitable equipment is available, representative samples can be obtained by coning and quartering method following random procedures (Dick 1987).

## Bulk storage

In case of bulk storage, the simplest sampling method is double tube sampling sphere. This can be up to 4 meter long with the collecting tube divided into a number of compartments, which also records the depth from which the sample is drawn. However, in some cases, it may not be possible to reach the bottom of the large heap or container where the insect tends to live.

## Determination of loss

There are several acceptable methods of estimating the loss to stored products. To estimate the damage (%), each sample is divided into damaged and undamaged pods or kernels and the per cent damage is calculated by using the following formula:

$$\text{Damage (\%)} = \frac{\text{Number of damaged pods} \times 100}{\text{Total number of pods}}$$

$$\text{Weight loss (\%)} = \frac{(UNd) - (DNu) \times 100}{U(Nd + Nu)}$$

where Nu = No. of undamaged pods; Nd = No. of damaged pods; U = Dry mass of undamaged pods; D = Dry mass of damaged pods.

## Management of storage pests

In the developing world, the high cost of chemical pesticides, and non-availability of effective formulations and efficient storage structures necessitate the need for

low cost effective post-harvest insect management practices. While making the decisions on chemical control, one should be aware of the economic threshold to justify the investment, level of contamination, and the operational hazards. This will further be determined based on the purpose of the product such as for oil extraction, food, seed or export.

## Prevention of infestation

**Commercial storage:** Good warehouse management and hygiene are key to prevention of insect infestation in stored products. Groundnuts must be processed properly after harvest and dried to bring the seed moisture below 7%. Before shifting groundnut to the store, it should be thoroughly cleaned and free from all crop residues. If old gunny bags are used, they should be checked for any infestation before filling with new produce. If necessary, they should be disinfested either by soaking in dichlorvas solution (0.05%) or by fumigation with celphos. The filled sacks must be placed on wooden platforms away from walls to protect them from moisture from the ground and to provide proper ventilation around stacks (Fig 15). To facilitate spraying, there must be some space between stacks.

Figure 15. Stacking groundnut bags on wooden platform.

**Pod storage:** Insect pests that attack groundnuts after harvest prefer kernels as they are unable to infest intact pods. Keeping the produce as pods for as long as possible is an effective strategy in limiting the damage, except for *C. serratus* attack. However, storage in the form of pods is bulky and requires more space. Usually the infestation in any stock starts from the outer layers of the stock, hence application of chemical protectants on the surface can provide effective control. On the other hand, dust formulations such as malathion (5%), fenvalerate (5%) can be applied to the surface of the bags or mixed directly with pods where pods are meant for seed purpose.

**Kernel storage:** Groundnut is sometimes stored as kernel to economize the space in storage, to save transportation costs and for export purposes. Groundnuts meant for confectionary use are often shelled soon after the harvest so that the damaged and shriveled kernel can be discarded. The direct

application of insecticide to the kernel is discouraged because of possible residues in the kernel if not used for seed. However, kernel in sacks can be protected by the application of either liquid formulations or dusts on the outside as recommended in pod storage. Dusting with an inert substance such as attapulgite-based clay dust (ABCD) can also help to minimize storage insect problems.

## Management of established infestation

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

## Storage for seed purpose

Under unfavorable conditions, groundnut seed (shelled groundnut) loses viability quickly. If seeds are to be stored, they should be stored under low temperature conditions. In general, the lower the temperature, the longer is the expected storage life of the seeds. The seed quality of groundnuts having ≤7% moisture content can be maintained for at least one year at 1 to 5°C and 65 to 70% relative humidity.

In case of pest outbreak in storage, the bags should be covered with a polythene sheet and fumigated as explained earlier. The fumigator should use protective clothing (hand gloves, nose mask and goggles). After fumigation is over, put

on the exhaust fan for 6-8 hours to keep the room free from chemical fumes. Fresh air should be allowed in for some time (couple of hours) by keeping the windows and doors open before handling the produce provided they have insect proofing. At household level, fumigation should be done outside, away from the living quarters.

**Eco-friendly management of storage pests at farm and household level:** At farm level, groundnut is often stored as pods, and it may not be possible for the smallholder farmers to provide high quality storage conditions. The pods should be stored in polythene lined gunny bags or in some other safe storage structures (small seed bins, earthen pots or metal drums) in a well-ventilated and rodent free room. Only undamaged, well-dried clean pods should be stored to avoid fungal and insect pests' attack in the storage.

- After 2–3 days of drying in the field, when high temperatures (40-45°C) prevail at the time of harvest, the pods must be stripped immediately and dried under shade to maintain seed viability for a longer period.
- Maintenance of optimum moisture content (below 7%) of seed, sanitation of seed as well as storage space, and appropriate storage methods are always critical in preventing the development and damage caused by storage pests. In rural household situations where measuring moisture content is difficult,

Figure 16. Ceramic pot used for groundnut storage in Vietnam.

see that the testa of the seed comes away with gentle pressure applied to the seed between thumb and forefinger after thorough drying.

- Clean the storage containers thoroughly and expose them to sunlight for a couple of days before storing groundnuts.
- In case of *C. serratus,* to prevent primary infestation from alternate hosts (Tamarind, Acacia and Pongamia) avoid drying groundnuts near these host trees.
- In Vietnam, well dried pods are stored in earthen pots of 20-25 kg capacity lined with dried banana leaves. The top of the container is filled with a thin layer (one cm depth) of rice and then sealed with mud. This facilitates effective storage against insect pests without affecting the viability.
- Storing groundnut kernel with dried neem leaves (about 500 g of leaves for 10 kg kernel) in any sealed container can be effective.
- At household level, groundnut kernel should be kept in sealed packets in a refrigerator to keep them insect free and fresh for family consumption.

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# About ICRISAT


The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT is supported by the Consultative Group on International Agricultural Research (CGIAR).

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