



# POLYPHAGOUS PESTS

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PESTS OF FIELD CROPS AND STORED GRAIN  
AND THEIR MANAGEMENT  
ASEN 3103 (2-1-0)

## **POLYPHAGOUS PESTS**

List of some important Polyphagous pests are

- White grub
- Locust
- Termite
- American bollworm
- Hairy caterpillar
- Tobacco caterpillar
- Mealybugs
- Cutworm
- Whitefly
- Aphids

### **1. Locusts:**



**Fig: Locust swarm in Africa**

S. No.	Common Name	Scientific Name	Distribution
1	Italian locust	<i>Calliptamus italicus</i>	North Africa, Iran, Italy, France, Southern Russia
2	Moroccan locust	<i>Dociostaurus moroccanus</i>	Southern Europe, North Africa, Iraq, Afghanistan, Iran
3	Red locust	<i>Nomadacris septemfasciata</i>	Tanganyika, South Africa
4	Brown locust	<i>Locusta pardalina</i>	Southern Africa
5	South American locust	<i>Scistocerca paranensis</i>	Argentina to Mexico
6	Australian locust	<i>Chortoicetes terminifera</i>	Australia
7	Bombay locust	<i>Patanga succinata</i>	Srilanka, India, Malaysia
8	Migratory locust	<i>Locusta migratoria</i>	India, Europe, Africa, Pakistan, East & south Asia, Australia
9	Desert locust	<i>Schistocerca gregaria</i>	India, Pakistan, Arabia, Northern Africa
10	Tree locust	<i>Anacridium rubispinum</i>	

**1. Desert Locust *Schistocerca gregaria*; Migratory Locust *Locusta migratoria*; Bombay Locust *Patanga succincta***

**Host range:** Aak, neem, datura, jamun, Dalbergia, anjeer, several crop plants etc.

The term Locust is applied to short horned grasshopper species which multiplies in large numbers under favourable conditions, forms swarms and migrates in millions from country to country or from place to place destroying the vegetation. Three species of locusts out of 9 listed above are known to invade India. The desert locust *Schistocerca gregaria* is the most destructive of them. Swarm spread over 10 sq.km & a kilometer of swarm may contain as many as 300 tonnes of locust.

The summer-breeding regions of locusts receive monsoon rains and extend from the south of Sahara, Libya and Egypt in Africa through southern Arabia and Pakistan to north-west India; the breeding regions, on the other hand, receive winter rainfall and extend from the northern belt of Africa and Arabia through Iran up to Baluchistan.

Breeding depends on rains. According to the Biotic theory the periodicity of locust cycles, the periodic locust outbreaks have been following periods of climatic extremes which annihilate the enemies particularly, the vertebrate predators, of the locust in desert and Semi-desert regions where this species lives in its solitary phase during periods of recession.

Locust- breeding takes place in more or less transitional areas between the desert and semi desert regions. The full life history of an individual locust consists of the egg-stage, the hopper stage and the adult stage. A single female lays 500 eggs in 5 egg pods deposited in soil at depths of 8 to 15 cm. The female locust is able to deposit its eggs so deep in the soil by thrusting and extending the hind end of its abdomen which allows much elongation for this purpose. Hence loose sandy soil is suitable for egg-laying. An individual egg looks like a grain of rice which is yellowish in colour, 7 - 8 mm in length and about 1 mm in girth. This egg stage lasts, subject to the prevailing temperature, for periods of about 1½ weeks. At this stage a suitable amount of soil moisture is most essential for the proper developments of eggs. If this prerequisite is provided by timely rainfall, the eggs hatch into what are called vermiform larvae which wriggle their way out of the soil and, after casting off a kind of membranous covering in which they are enveloped, they enter the hopper stage of their life.

From this stage onwards the colour, the structure and the behaviour depend on whether the locust is in its solitary phase, breeding in a scattered manner and in low population density or in its gregarious phase, and breeding in a concentrated manner and in high population density.

However, the hopper stage lasts for about 3 - 10 weeks depending on the prevailing temperature and during this stage the individuals moult. i.e. cast off their skin several times. After the final moult as a hopper, the individual enters the adult stage and about 10 - 15-days thereafter reproduction starts.

In the solitary phase, the hoppers are either green or acquire the colour of the vegetation they are in; they behave like ordinary grasshoppers and remain scattered and as adults they stay grey and fly mainly during the night and as individuals.

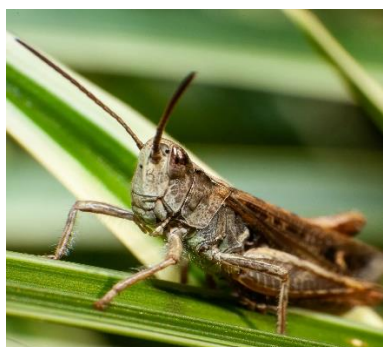
In the gregarious phase, on the other hand. the hoppers exhibit a black colour pattern and march for long distances in definitive bands. When adults, they are pink while immature and yellow in the sexually mature stage; they fly in swarms during day.

The attack of the desert locust used to occur earlier in phases of plague cycles. India witnessed several locust plagues, upsurges and incursions in the past. About 12 locust plagues were observed in India till 1962. Since then no locust plagues occurred. Similarly, 13 locust upsurges were recorded since 1964 till 1997. Small scale localized locust breeding have also been reported and controlled during the period 1998, 2002, 2005, 2007 and 2010.

Since 2010 till now, situation remained calm and no large scale breeding and swarms have been reported. However, solitary phase of Desert locust has been reported from time to time at some locations in the State of Rajasthan and Gujarat.

**Table: Difference between solitaria and gregaria phases.**

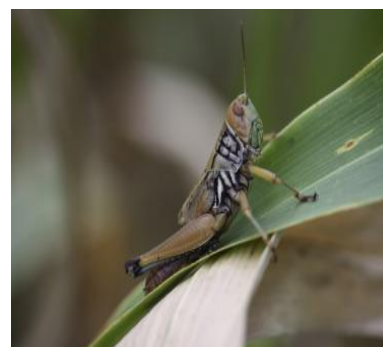
Sl. No.	Solitary Phase	Gregarious Phase
<b>Nymphs</b>		
1	Varies with the surroundings. In general green in colour	pink on emergence which changes to black and finally yellow, when sexually mature.
2	Remain scattered on vegetation	Are in groups or bands and march long distances.
3	No. of moults 5 to 6 sometimes 4 or 7.	5
<b>Adults</b>		
1	Greenish or greyish	Pink when immature Yellow when mature
2	Fly during nights as isolated individuals	Fly during day as swarms
3	Pronotum is short, convex and crested	Pronotum is long, concave (saddle shaped) and Without a crest
4	Antenna is 27-30 jointed	Antennal segments are 26 jointed
5	Eye stripes 6-7	6
6	Femoral spines: Both strong and weak	Femoral spines are weak



**Bombay Locust**



**Desert Locust**



**Migratory Locust**



### **Solitary and Gregarious phase of locust**

**Biology:** The swarms of desert locust that form due to breeding in west Iran and eastern Arabia during winter-spring migrate during May-July to Indo-Pakistan region.

The migratory locust *Locusta migratoria* breeds during spring in Baluchistan and the adults migrate to desert areas of India and breed during the summer.

The mature female drills a hole in moist sandy area, lays the eggs in a cluster and covers them with a frothy secretion which hardens on exposure to air to form egg pod. The ground used for oviposition is recognized by numerous holes of pencil diameter. A female may oviposit thrice at weekly intervals and in a square metre area about 100 egg pods may be noticed [JRF 2011]. The incubation period ranges from 2 to 4 weeks and the nymphs congregate in groups and begin to march from place to place eating up all vegetation along their path. There are five nymphal instars in the gregaria phase and the nymphs become adults in 4 - 6 weeks. The adult swarms at a speed of 12 to 16 kmph [JRF 2011].

Two main phases of development have been recognized in locusts. Studies have shown that the solitary individuals are more juvenile whereas the gregarious individuals are adults in structure, physiology and behaviour. The presence or absence of prosternal tubercle helps in distinction of species.

### **Management**

- Ploughing, digging and harrowing of oviposition sites and destroying the eggs. This is a laborious task and costly.

- Trenches of 45 cm deep and 30 cm wide may be dug across the front of marching hoppers and such trenches may be provided with metal sheet barriers, The hoppers are driven to the trenches, collected and destroyed. Poison baits consisting of wheat or rice bran. an insecticide and an attractant like molasses may be used.
- Collection of adults and beating to death or burnt with flame throwers.
- The flying swarms can be controlled by aerial application of an approved insecticide. Neem kernel suspension has been reported to serve as deterrents to locusts. Kites, crows and starlings (*Pastor roseus*) are predaceous on hoppers and adults.
- Monitoring the locust activity with the help of National and International Locust Organizations like Locust Warning Organisation (LWO), Desert Locust Control Organization for Eastern Africa (DLCO- EA), United Nations Special Desert Locust Project of FAO etc.
- Recommended insecticides in India are chlorpyrifos 20 & 50 EC (240 g ai/ha), Diflubenzuron 25 WP (60g ai/ha), Fipronil SSC (6.25 g a.i./ha), Deltamethrin 2.8 EC (12.5g ai/ha), malathion 50 EC etc. Treating the crop with NSK extract @ 0.1 % to 0.5% was found to prevent damage by locust.
- Use of biological agents like *Trox proceras* (beetle) grub feeds on eggs, myna bird, *Beauveria bassiana* etc.

### **Anti-Locust Organization in India**

An effective control of locusts is possible only if there is close collaboration among the affected countries. The Governments of India, Pakistan and Iran regularly exchange information regarding locust situation. A permanent locust warning organization is functioning since 1939 under the control of Plant protection Adviser to the Government of India, New Delhi. Locust Warning-Organization monitors and controls locust activity in 200,000 sq. km. of desert area in western India and has 10 offices and a field investigation lab. It also shares information with FAO and holds regular border meetings with plant protection officials from Pakistan.

## Functions of Central Anti-Locust Organization

- Record locust density in breeding areas & carry out control operations.
- Inform locust movements to various state locust control & warning officers to enable them to get prepared for control.
- Keep watch on extra Indian originating swarms, their size & direction of movement & take appropriate measures.
- Give technical & material assistance to states.
- Co-ordinate the anti-locust work in India by issuing fortnightly bulletins on locust situations both in India & outside.
- **Desert locust is the International pest.** Locust is destructive in both nymphal and adult stage.
- Director of locust control is the Plant Protection Advisor to GOI.
- Each desert locust female lays 11 egg pods, each pod with 100-120 eggs in loose sandy soil 5 -10 cm deep. It takes 1- 4 hr to dig a hole. (JRF 2011)
- One can find 100 egg pods/ m<sup>2</sup> or 5000 eggs. (JRF 2010)
- Speed of locust swarms - 100 to 200 km/day. (JRF 2011)
- Both migratory and gregarious pest is Locust.
- LOCUST IS A MIGRATORY PEST. (JRF 2001)



## **2. Termite: *Odontotermes sp.* (Termitidae: Isoptera)**

First record of noxious insects is termites (Koenig, J.G.).

**Distribution:** Termites or white ants are warmth loving insects and inhabit the entire tropical and subtropical regions of the world except higher altitudes where temperature are too low and the deserts where there is no food. They are polyphagous and have the widest range of host plants. They devour not only the live plant material but also dead wood. This species of termite is common in India found attacking wheat and barley under rainfed conditions in North India and attacks sugarcane, maize, millets and number of tree crops.

**Nature of Damage:** Termites attack wheat and barley from time of sowing onwards and the damage is severe in sandy and sandy-loam soils. It cannot thrive under conditions of bad aeration and poor drainage. The infestation of termites in sugarcane commences with planting of setts. In sugarcane, the termites damage the cut ends and buds of setts affecting their germination to the extent of 28 - 67% resulting in gaps in the field. Setts are completely eaten away leaving only the outer hard rind. In the attacked plants the outer leaves first show signs of drying and attacked canes may come off easily if pulled. The damage may vary from 40 - 50%. The internal part of millable canes are eaten away up to sixth internode and filled with earth. Termites attack results in heavy loss in yield of cane (2.5% in tonnage) and also in sugar production by 4.47 %. The crop raised in light soils suffers to a greater extent, particularly under drought conditions. Two other species *O. bengalensis* and *Trinervitermes biformis* are also known to infest sugarcane in India.

Termites also appear and cause havoc in orchards that have been raised on virgin lands. The insects are heliphobic and either remains underground and feed on roots and then move upwards making the trunks completely hollow or they construct mud galleries on tree trunks. The damage is more severe in nurseries and young newly planted orchards where the entire seedlings or saplings may dry and die away. Formation of earthen galleries on tree trunks decreases with rise in temperature from March onwards and it again increases from September onwards.

**Life history:** The organization of the termite colonies in general is based on such a rigid system of division of labour. These different functionaries constitute well-defined castes like the soldier caste, the worker caste, the reproductive caste and the royalty. The royalty exclusively retains to itself the sole of reproduction and the queen is the mother of the whole colony. The queen is the largest individual, the size of which at times exceeds five centimeters in length and one

centimeter in thickness due to the enlargement of the abdomen which is full of eggs. The rest of the colony consists of the king, the functional consort of the queen, three sub-castes of fertile reproductives and two sterile castes of workers and soldiers. There are generally three types of reproductives (a) the macropterous ones which have fully developed membranous wings, comparatively larger brains and eyes and the full complement of normal reproductive organs, (b) brachypterous ones with rudimentary wing pads, and (c) apterous ones with no trace of wings at all. The sterile castes the workers, which constitute the main labour force of the colony, have undergone reduction in brain and eye development. Their mouth-parts, which are used as the working tools for all types of odd jobs, are fairly strong although much less developed than in the soldier caste. The mouthparts of the soldier caste are used for very active defence and offence, for giving a tough fight to the enemy. The mandibles are very large, projecting and shaped for a variety of uses. In some species of termites, there is a special rostrum projecting out from the head region and an offensive secretion from a special gland is ejected out from the top of the rostrum; this represent the evolution of chemical warfare even in such structurally primitive insects; soldiers possessing this organ are called Nasute soldiers. Winged sexual forms appear with the first shower of monsoon. The mating takes place either up in the air or on the ground and soon after mating the insects lose their wings, re-enter the soil and start a new colony. To start with the couple takes all the care of tending and feeding the young ones but once a sufficient number of workers are thus reared up they relieve the founder couple of all kinds of labour and begin in turn to tend their parents as royal dignitaries. They grow and maintain almost pure crops of certain varieties of fungus which are called fungus gardens. The Queen lays one egg every 2 -3 seconds continuously during her entire life span of 7 - 10 years. There are two major termite castes. They are reproductive and non reproductive.

## **Reproductives**

**Primary reproductives (king and queen):** They are highly developed individuals sexually. They have fully developed wings and compound eyes and are usually heavily pigmented; wings are meant for nuptial flight only. Male is often small and follow the female after mating and shedding of wings to start a new colony. Queen is the prefect female and egg laying machine. Termite queen lives for 5 - 10 years or up to 20 years and lays 70 - 80 thousand eggs/day or 1 egg/ sec. A colony has only one queen. The place where queen reside is Royal chamber, which is in the centre of the nest 0.5m below the ground surface. King develops from unfertilized egg

after consuming the superior diet. King lives in royal chamber along with queen and mates with queen time to time. King's life is shorter than queen and after death, he is replaced by new one.

**Supplementary reproductives:** They have short wings and are less heavily pigmented and are of both sexes. They sometimes carry on extensive reproduction in the colony and may supplement the queen in building the colony. In case of death of queen or king, they undergo sexual development induced by workers.

**Non reproductives: (sterile castes)**

**Workers:** They are sterile wingless adults developed from fertilized eggs but reared on ordinary food. They are pale in colour, lack compound eyes. Smaller than soldiers. Mandibles are relatively small but well developed for chewing the food. They collect food and feed queen, soldiers and newly hatched young ones, build nests, tunnels and galleries. Cultivate fungal garden. Fungal garden is present in the centre of the nest near to royal chamber. They form the bulk of the colony. Only Workers are destructive to the crops.

**Soldiers:** Developed from unfertilized eggs. They are sterile wingless adults with greatly enlarged head and mandibles. They protect the colony. They constitute 10% of the population. Two types of soldiers are seen: **Mandibulate soldiers** with powerful mandibles with no frontal rostrum. They fight with the intruders. **Nasute soldiers:** Mandibles vestigial but there is long median frontal rostrum at the end of which the frontal gland opens. They repel the intruders through the secretions of the frontal gland. (Termite taxonomy is based on soldiers). Other type of soldiers are **Nasutoid soldiers:** head prolonged anteriorly into a narrow stout through which a sticky secretion is exuded. **Phragmotic soldiers:** Head is strongly sclerotized, In termites. the taxa without soldiers are **Anoplotermes, Apeculitermes.**

**Kalotermitidae** Eg: *Kalotermes sp.* (Dry wood termites), have no connection with soil. Potential pests of tea, coffee, rubber, cocoa, cashew and teak. *Glyptotermes dilatatus* feed the wood in honey comb fashion without making a central hollow. House infesting termite *Cryptotermes sp.* In Kalotermitidae, Macrotermitidae, undifferentiated nymphs act as workers called "pseudergates" or **pseudoworkers** (reversal of metamorphosis). True workers are absent.

**Hodotermitidae** True harvester termite attacks grasses, stored wheat etc. In India it attacks eucalyptus seedlings. Living and breeding wholly underground, Builds conical mounds.

**Rhinotermitidae:** Subterranean in habit and some invade wood works in buildings. Milk exuding termite is *Coptotermes spp.* Highly destructive to wood work also able to penetrate the sheathing of electric wires causing short circuiting.

**Termitidae:** Eg. *Termes sp.* *Odontotermes sp.* Higher termites grow fungal gardens. Largest family one half of the known species.

- *Eremotermes dehraduni* attacks the camphor bush *Ocimum kilimandscharicum*.
- *Microcerotermes* minor pest of eucalyptus saplings in nurseries in India.
- *Odontotermes assamuthi*- pest of sugarcane
- *Odontotermes formosanus* pest of sugarcane and young camphor trees.
- *O. microdentatus* large, dome shaped mounds; pest of eucalyptus seedlings.
- *O. obesus* builds tall, sub cylindrical mounds. Most common species.
- *O. parvidens*- attack bark and cause girdling the trunk; underground nest
- *O. redemanni*- build tall, sub conical earthen mounds
- *O. wallonensis*- irregular shaped mounds with a number of rounded open mouthed chimneys.
- *Hypotermes obsuriceps*- sub conical mounds. Attacks live coconut palm.
- *Nasutitermes Sp.* mounds ball like lodged on the branches of trees.

#### **Management strategies:**

- Destroy termitaria (termite mounds) in the vicinity of fields and treat the spot with sprays. This should be practiced on community basis in villages/farms.
- Use only well rotten manure, otherwise termite incidence is aggravated.
- Treat the seeds of wheat or barley with chlorpyrifos or endosulfan or imidacloprid using, respectively, 90 and 240 ml and 10 g a.i. with 5 litres of water and spraying over one quintal seed spread on floor and periodically turned over to ensure proper treatment. This should be done 1-2 days before sowing. For sowings in fields having previous history of termite incidence, this operation should invariably be undertaken.
- In case preventive seed treatment for termites has not been undertaken before sowing and termite incidence is noticed in standing crop of wheat or barley, mix 0.8 litre chlorpyrifos with 50 kg sand and broadcast in one hectare field. This treatment is not as effective as seed treatment but appreciable reduction in termite damage could be achieved.
- Subterranean termites can be controlled by destroying queen either by digging it out or dropping aluminium phosphide tablets inside the termitarium @ 2 tabs/termitarium of 1 m diameter or pouring chlorpyrifos 20 EC diluted @60 ml/18 litre of water.
- Stubble of the previous crop and other dead decaying matter should be removed.
- Application of entomo-pathogenic fungus *Metarhizium anisopliae* at the time of planting.
- Use of *Calotropis procera* leaves and seed kernels of *Azadirachta indica*.

- Use of chlorpyrifos 10G as a soil treatment.
- Application of phorate 10G @1 kg a.i./ha in the furrow at the time of sowing.
- Seed treatment with chlorpyrifos 20 EC @ 12.5ml/ kg seed.
- To protect the wood paint with solignum.

✓ Other insects and arthropods living in the termitorium are collectively called as *Termitophiles* (ARS 2015).

✓ **Kleptoparasitism:** Sometimes, very minute termites like *Microtermus* build their nest within the nest of bigger species.

✓ **Inquilines (guests)** are other animals living in nests of social insects like termites and ants.

✓ Termite workers cultivate fungus food (ambrosia) inside the **Termitorium**.

✓ In some ponerine ants and *Leucotermus*, there is an intermediate form between queen and worker whose ovaries are well developed called 'ergatoids'. Soldiers are called 'Dinergates'.

✓ Application of the entomo-pathogenic fungus *Metarrhizium anisopliae* at the time of planting is done for the management of termites.

### 3. Aphids

**Host range:** Wide host range- cereals, pulses, vegetables, oilseeds, fruits, flower crops etc.

Some important species are

- Wheat aphid: *Macrosiphum granarium*
- Potato aphid/ green peach aphid: *Myzus persicae*
- Pea aphid: *Acyrthosiphum pisum*
- Mustard aphid: *Lipahis erysimi*
- Cotton aphid: *Aphis gossypii*
- Sugarcane woolly aphid: *Ceratovacuna lanigera*
- Apple woolly aphid: *Eriosoma lanigera*
- Tea aphid: *Ceylonia theaeicola*.
- Corn aphid: *Rhopalosiphum maidis*
- Sugarcane aphid: *Tetraneura javensis*
- Okra aphid: *Aphis malvae*
- Radish aphid: *A. brassicae*
- Pigeon aphid: *A. cardeui*
- Ground nut aphid: *A. craccivora*
- Cabbage aphid: *Brevicoryne brassicae*
- Orange aphid: *Toxoptera aurantia*
- Ber aphid: *Rhizobius jujube*
- Banana aphid: *Pentalonia nigronervosa*
- Peach aphid: *Brachycaudus helichrysi*
- Coconut aphid: *Cerataphis variabilis*
- Rose aphid: *Microsiphum rosae*

Being sucking pest, the aphids draw the cell sap from the plants. Both nymphs and adults cause damage to the plants by their sap sucking habit. Four main kinds of symptoms are produced by them Sap sucking leads to devitalization and reduced/ stunted plant growth. Injection of toxic saliva during sap sucking leads to gall formation on leaves. Honey dew extraction by aphids attracts growth of black sooty mould which interfere with photosynthetic efficiency of plants. Aphids causes brightening of buds, curling of leaves, and appearance of discoloured spots on leaves. Severe infestation cause wilting and yellowing of plants and finally leads to death.

Excellent transmitter of virus of plant diseases. Of the 300 known plant viruses 90% of them are transmitted by aphids.

- *Myzus persicae*- potato leaf roll
- *Aphis maidis*- sugarcane mosaic virus
- *Pentalonia nigronervosa*- Banana bunchy top/ cardamom katte disease [CSB 2017].
- *Toxoptera citricidus*- Citrus triesteza.

### **Biology:**

In non-migratory aphids, the wingless, parthenogenetic and viviparous females continue to breed throughout the year. Obligatory migratory aphid consists of the following stages: Eggs, fundatrices, fundatrigeniae, migrants, alienicolae, sexuparae and sexuales. Eggs are laid in the primary host by sexuales. **Fundatrices** are the first wingless female aphids produced from eggs on the primary host. **Fundatrigeniae** are the parthenogenetic female offsprings of the fundatrices. Fundatrigeniae after 2-3 generations change to migrants which are winged, parthenogenetic, viviparous females which fly to secondary host. **Alienicolae** are the apterous and winged parthenogenetic viviparous females produced by migrants. Alienicolae after some generation produce **sexuparae** which are also apterous and winged parthenogenetic viviparous females. Sexuparae migrate to primary host to produce **sexuales** which are apterous and winged oviparous females.

#### 4. Hairy caterpillars

*Amsacta moorei*, Red hairy ctp., [JRF 2000]. Pupal diapause.

Bihar hairy ctp., *Spilosoma oblique* [IARI PhD 2002]. Sporadic pest. Pupal diapause.

#### 5. Cut worms

The majority of cutworms found in India fall under the genera *Agrotis* and *Euxoa*.

Greasy cutworm, *Agrotis ipsilon*- [ARS NET/ PRE, 2010]. common in India. older stages of larva are cannibalistic.

Gram cut worm, *Ochropleura flammata*- destructive in north; adult aestivate; Migration of moths to and from mountains. Bivoltine. *A. segetum* and *A. biconica*- common in south.

#### Management:

- Hand picking and destruction of caterpillars
- Digging of holes all over the fields so that the caterpillar fall into the holes and being cannibalistic kill each other.
- Heavy irrigation or flooding kills the caterpillars by asphyxiation.
- Provision of heaps of grasses so that the caterpillars congregate under heaps. Burning of heaps along with caterpillars.
- Setting of light traps to capture and killing of adults.
- Drenching the soil around the plant and ridges with chlorpyrifos 20EC@2.5 lit/ ha.



## 6. Mealybugs

Mealybugs are cottony in appearance, small oval, soft-bodied sucking insects. Adult mealybugs are found on leaves, stems and roots and are covered with white mealy wax, which makes them difficult to eradicate. They form colonies on stems and leaves developing into dense, waxy, white masses. They suck a large amount of sap from leaves and stems depriving plants of essential nutrients. The excess sap is excreted as honeydew which attracts ants and develops sooty mould inhibiting the plant's photosynthetic ability.

The host range of the mealybugs includes grape, fig, date palm, apple, avocado, banana, citrus, okra, tomato, brinjal, cotton and a few ornamentals. *Hibiscus rosa-sinensis* is a typical host which is frequently attacked by *Maconellicoccus hirsutus*. Host records of *M. hirsutus* extend to 76 families and over 200 genera, including beans, Chrysanthemum, citrus, coconut, coffee, cotton, corn, Croton, cucumber, grape, guava, Hibiscus, peanuts, pumpkin, rose, and mulberry. Reason for its recent outbreak is due to climate change and vast host range.

Mealybugs are white to pink in colour. In case of *M. hirsutus*, eggs as well as crawlers are pink in colour. Immature females and newly matured females are greyish-pink which are dusted with mealy white wax. Adult females are soft-bodied, elongate oval and slightly flattened. Females are provided with 9-segmented antennae, anal lobe bars, numerous dorsal oral rim ducts on all parts of the body except the limbs and long, flagellate dorsal setae. Males have one pair of very simple wings, long antennae and white wax filaments projecting posteriorly with no mouthparts.

### Some important species

Striped mealybug (*Ferrisia virgata*)

Longtail mealybug (*Pseudococcus longispinus*)

Citrus mealybug (*Planococcus citri*)

Solanum mealybug (*Phenacoccus solani*)

Pink sugarcane mealybug (*Saccharicoccus sacchari*)

Pineapple mealybug (*Dysmicoccus brevipes*)

Pink mealybug (*Maconellicoccus hirsutus*; synonyms - *Phenacoccus hirsutus*)

Solenopsis mealybug (*Phenacoccus solenopsis*)

Mango Mealybug (*Drosicha mangiferae*)

## **BIOLOGY**

Reproduction is mostly parthenogenetic but some species such as *M. hirsutus* are biparental. The mature female lays eggs in an egg sac of white wax, usually in clusters on the twigs, branches, or bark of the host plant but sometimes on the plant's leaves and terminal ends. Each egg sac may contain as many as 600 eggs, majority of which are female resulting in explosive outbreak. Some species such as *D. brevipes* are ovoviviparous i.e. the eggs hatch within the female and give birth to live larvae. Egg development takes between 3 and 9 days. Eggs hatch into nymphs called crawlers and are very mobile. In appearance, nymphs of both sexes resemble female adults. There are three nymphal instars in female and four in males which lasts for 22-25 days. The last instar of the male is an inactive stage with wing buds within a cocoon of mealy wax. Individual mealybugs may take as long as 30 days to grow through all the nymphal stages under normal conditions. There may be as many as 15 generations per year. The species survives cold conditions as eggs or other stages, both on the host plant and in the soil. In warm climates, the insects stay active and reproduce round the year.

Non-infected plants can be infected from infected plants as juvenile mealybugs can crawl from an infected plant to another plant. Small 'crawlers' are readily transported by wind, rain, birds, ants, clothing and vehicle and may settle in cracks and crevices, usually on new plants. The wax, which sticks to each egg, also facilitates passive transport by equipment, animals or people. The female mealybug is not active and unable to fly. In fact, humans are great friends helping in transport of mealybugs. As the infested plant back the colonies of mealybugs migrate from shoot tips to twigs, branches and finally down the trunk. Long distance movement is most probable through carrying infested planting material and fresh fruit and vegetables across the country or even from one end of a farm to the other. Ants, attracted by the honeydew, have been seen carrying mealybugs from plant to plant.

## **NATURE OF DAMAGE**

- Infested growing points become stunted and swollen which may vary depending upon the susceptibility of each host species.
- Heavy clustering of mealybugs can be seen under leaf surface giving the appearance of a thick mat with waxy secretion. Severe infestations resemble patches of cotton all over the plant.
- They excrete copious amount of honey dew that attracts ants and help in development of black sooty mould which inhibits the plants ability to manufacture food.

- Both nymphs and adults suck the sap from leaves causing withering and yellowing of leaves.
- Fruit may drop prematurely on crop plants. Heavy infestation can cause defoliation and even death of the plant.
- Mealybugs also affect the development of flowers and stems (especially in succulents with fleshy stems).
- When fruits are infested, they can be entirely covered with the white, waxy coating of the mealybug. Infestation can lead to fruit drop, or fruit may remain on the host in a dried and shrivelled condition. Mealybug infected fruits are unfit for marketing.
- In cotton serious attack results in retarded growth and late opening of bolls, affecting the yield badly. It feeds on soft tissues and injects saliva that causes curling and contortion of leaves.
- Citrus mealybug (*P. citri*), commonly found associated with black pepper (*Piper nigrum*) plants in India was shown to transmit *Badnavirus* associated with stunted disease. Feeding of *Dysmicoccus* species on pineapple produces a toxic effect called mealybug stripe, expressed as green or black striped areas. The most predominant symptom is wilting of leaves, commencing from leaf tips. Reddish-yellow colour develops in the wilting areas and finally the plants rot and develop decaying.

## **ECONOMIC IMPACT**

In its native range, *M. hirsutus* has been recorded causing economic damage to many crops. In India, losses have been reported for cotton; the fibre crops *Hibiscus sabdariffa*, *Hibiscus cannabinus* and *Boehmeria nivea*; grapevine; mulberry; pigeonpea; *Zizyphus mauritiana*. Presumably, many ornamental woody plants are also affected, but populations and damage may be limited by natural enemies. In India, it is a major pest of grapes, reducing yields 50 to 100 per cent. Yield losses on other crops, such as jute and mesta range up to 75 per cent.

## **ASSOCIATION OF ANTS AND MEALYBUGS**

Mealybugs are known to bribe ants with their sugary secretion (honeydew) and in return ants help in spreading of mealybugs and provide protection from predator ladybird beetle, parasites and other natural enemies. Ants also keep their colony clean from detritus that accumulate in the secreted honeydew, which may be harmful to the colony. Species of ants such as *Oecophylla smaragdina*, *Crematogaster sp.* and *Anoplolepis gracilipes* have been found attending mealybug, *P. citri* while feeding on honeydew on Hibiscus.

## Management

- Physical barriers such as ant fences can be applied parallel to the field periphery to keep ants away from field, and subsequently help in controlling mealy bug populations.
- Apply sticky bands like 'Track-trap' or 'Bird Tangle Foot' on arms or on main stem to prevent crawlers of mealybugs reaching the bunch.
- All crop residues in previously infested fields should be removed and burnt. Crop residues and grass left in the field may harbour mealybug populations which may invade the new crop.
- Field borders should be free from weeds and debris that may support mealybugs between plantings. Weeds also provide alternative host for ant populations between periods where mealybug infestations are small. Remove alternate host plants like Hibiscus, okra, custard apple, guava, etc. in and nearby crop.
- Equipment should be sanitized before moving to uninfested portions in a crop.
- Manual picking of bugs can be done in plants that are not severely infested in small conservatory or kitchen gardens or apply strong jet of water to remove bugs (avoid the damage to plants).
- In case of perennial crop remove loose bark to expose hiding population of mealybugs and swab stem and arms with dichlorvos 76 EC @, 2 ml + 2 g of fish oil resin soap in a litre of water.
- Destroy ant colonies during land preparation because their nests are located near the soil surface.
- The coccinellid beetles such as *Cheilomenes sexmaculata*, *Rodolia fumida*, *Seymnus coccivora* and *Nephus regularis* are important predators of mealybug nymphs. Biological control by release of natural enemies has proved very successful. Among the biological control agents introduction of *Cryptolaemus montrouzieri* (Australian Ladybird), *Anagurus pseudococci*, *Leptomastix dactylopii*, *Hypoaspis sp.*, *Verticillium lecanii* and *Beauveria bassiana* are effective in managing the infestation. *Hypoaspis* is a small mite that feeds on crawlers.
- Biological control in grapes includes one to three releases of *C. montrouzieri* at 10 per tree or @ 5,000 beetles/ha, two times in a season especially during August- September and December-January. It is better to release a mixed population of grubs and adults rather than only adults. *Anagurus kamali* is a parasite from China and is being currently used to manage pink mealybug. It has also been recorded in India on mulberry plant. It attacks the

mealybugs in two ways. The adult wasp punctures a mealybug and extracts fluid from the wound. The female wasp feeds on the fluid of the dying mealybug, which provides nutrient to wasp's eggs for development. The female wasp also lays an egg inside mealybug, which hatches and feeds internally, killing the mealybug. Fully developed adult wasp comes out of the "mummy" of the mealybug by cutting a circular hole in the end of the mummy and crawls out. The process can take place in half the time it takes for the entire life cycle of the mealybug. *A. kamali* typically has a 15-day life cycle in tropical climates. During its lifetime, a female wasp can lay single eggs inside 40-60 mealybugs. Foliar spray of *Verticillium lecanii* or *Beauveria bassiana* ( $2 \times 10^8$  cfu/ml) @, 5 g/ ml per litre of water is effective during high humid months in reducing the population of mealybugs.

- Plant protection products are of limited effectiveness against mealybug because of its habit of hiding in crevices, and the waxy covering of its body. Most granular insecticides are ineffective, therefore, systemic insecticides are used to control heavy infestations.
- Locate ant colonies and destroy them with drenching of chlorpyrifos 20 EC @ 2.5 ml/lt or apply 5% malathion dust @ 25 kg/ha as the ants provide them protection from parasitoids and predators and also helps in spreading the crawlers to non-infested plants.
- Spray dichlorvos 76 EC 2 ml/l, monocrotophos 36 WSC 1.5 ml/l, methyl demeton 25 EC 2 ml/l, chlorpyrifos 20 EC 2 ml/l, imidacloprid 200 SL 1ml/l or malathion 2.5ml/l of water at 15 days intervals.
- Use dichlorvos (0.2%) in combination with fish oil rosin soap (25 g/l) as spray or for dipping the fruits for two minutes.

## 7. American bollworm

*Helicoverpa armigera* is a pest of national importance on several crops, due to its mobility, polyphagy, high reproductive rate, and diapauses. Its predilection for harvestable parts of essential food and high-value crops such as cotton, tomato, pulses and cereals confers a high economic cost to its depredations. The high level of control required under these circumstances, and the near absence of natural control means that chemical or at best integrated control methods need to be adopted to minimize the losses due to this pest. The key issue of moth immigration, and movement in general, is of general relevance to the long-term effectiveness of any control strategy. Its control on cotton and other high value crops depends on synthetic insecticides, although integration with other control tactics and increased rationalization of insecticide use has been the subject of recent research. A major constraint on moderating chemical control has been the need to deal with a complex of insect pests, often with irreconcilable control needs. It is, therefore, not feasible to forgo early-season insecticide application to preserve the natural enemies. Pest management strategies for *Helicoverpa* require integration of different control tactics to implement a threshold based on the relationship between population density and economic loss

### Host range [ARS Mains 2014]

Group	Crops
<b>Fiber</b>	Cotton and linseed
<b>Pulses</b>	Pigeonpea, chickpea, peas, cowpea, etc.
<b>Vegetables</b>	Tomato, potato, okra, etc.
<b>Fruits</b>	<i>Prunus</i> , <i>Citrus</i> , and forest trees
<b>Cereals</b>	Maize, sorghum, millets, barley etc.
<b>Oilseeds</b>	Sunflower, groundnut, sesame, etc.
<b>Narcotics</b>	Tobacco, <i>Datura</i> , <i>Canabis</i> , and <i>Lathyrus</i>

### ***Helicoverpa* management:**

- Early plantings of pigeonpea result in reduced damage by *H. armigera*.
- The use of short-season cultivars has often been used to avoid pest damage, and has been used effectively to minimize bollworm damage in cotton.
- Deep ploughing of the fields before crop planting and after the crop harvest (to expose the pupae in the soil to biotic and abiotic mortality factors), and interculture during the crop growth are useful in reducing the *Helicoverpa* population. During these operations, the birds such as myna, egrets, and drongos follow the plough-share to pick up the insects that are exposed.
- Heavy fertilizer application results in luxuriant plant growth and the crop suffers greater damage by *H. armigera*. Sprays of superphosphate (1%) have been found to result in a significant
- reduction in oviposition by *H. armigera* females. Plant growth regulators have also been used to shorten the crop maturity. Early termination of flowering and fruiting also reduces the population carryover from one season to another or reduce the number of generations
- Intercropping chickpea with mustard, linseed, or safflower, pigeon pea with cowpea and sorghum, and tomato with radish result in reduced damage by *H. armigera*. Intercropping can also be used as a means of encouraging the activity of natural enemies.
- Marigold, sesame, sunflower, and carrots can be used as trap crops for *H. armigera*. In Australia, chickpea and pigeon pea are used as trap crops in cotton growing regions. *Solanum viarum* is highly attractive to *H. armigera*, and can be used as a trap crop for this pest.
- Destruction of alternate hosts in a region can be helpful in reducing the level of damage in the next generation to an acceptable level. Removing the stubbles at the end of the cropping season can be used to reduce over-wintering populations of *H. armigera*.
- Hand picking of the larvae, nipping the plant terminals with eggs (particularly in cotton) and shaking the plants to dislodge the larvae (particularly in pigeon pea) can also be used to reduce *Helicoverpa* damage. Crops that can serve as perches for insect feeding birds (e.g., sunflower in chickpea and tomato) or provision of bird perches can also be used to increase the predation by insectivorous birds such as myna and drongo.
- Soil moisture and flooding with water also affect pupal survival and moth emergence. Irrigation or flooding of the fields at the time of pupation reduces the pupal survival, and thus leads to decreased population densities in the following generation or season.

## **9. Red Hairy caterpillar**

- Deep ploughing during April-May utilizing the summer showers to expose the pupae of RHC to sunlight and predatory birds.
- With the onset of S-W monsoon showers during June- July, it is recommended to set the bonfires on community basis on the field bunds from 7-10 pm starting from the next day of the rainy day using trash or old tyres etc.
- Set up the light traps to attract and kill the moths during June-August.
- Grow cowpea as trap crop around groundnut as the young larva prefers to feed on cowpea.
- Grow intercrops like castor or red gram 1:11 ratio.
- Collection and destruction of egg masses and just emerged larva.
- Place the vegetative traps like jatropha or Calotropis in and around in and around groundnut fields to attract and kill
- Spray neem oil @ 5ml/ water along with surfactant or NSKE 5% to suppress the eggs and just emerged larva.