

## Effective Strategies for Fruit Fly Management in Citrus Orchards of Sikkim

Yamuna Pandey, Prasanga Limbu, Nangsol D. Bhutia, and A. K. Pandey

College of Horticulture, Central Agricultural University, Bermiok Tokal, South Sikkim 737134

<https://doi.org/10.5281/zenodo.11311436>

### INTRODUCTION

Citrus, a globally significant fruit crop, faces substantial challenges due to pests and diseases, hindering its commercial viability. In Sikkim and across India, certain insect pests exacerbate citrus decline, leading to decreased fruit yield. Among these, fruit flies and fruit-piercing moths emerge as primary concerns, inflicting damage on fruit and triggering premature fruit drop (Umeh et al., 1998). The extent of fruit fly damage



**Fig. 1 Fruit fly**



**Fig. 2. An adult fly infesting fruit**

correlates closely with fruit ripeness and the prevailing environmental conditions in the region. The larvae (maggots) of fruit flies cause internal damage to the fruit, leading to premature ripening and decay. Fruit fly infestations left unchecked can result in the destruction of up

to 100% of the fruit. These flies, similar in size to houseflies, are characterized by a yellow body with dark

correlates closely with fruit ripeness and the prevailing environmental conditions in the region. The larvae (maggots) of fruit flies cause internal damage to the fruit, leading to premature ripening and decay. Fruit fly infestations left unchecked can result in the destruction of up



**Fig. 3. Infested fruit**

brown to black markings on the segment where the wings are attached. Mated females lay their eggs within the flesh of host plants' fruits. After a few days, the larvae hatch and tunnel inside the fruit, where they feed on the pulp for 4-12 days. Subsequently, they exit the fruit, dropping to the ground to pupate in the soil. Visible signs of infestation include holes on the fruit's surface and the presence of white larvae inside. Pupae overwinter in the soil, emerging as adult flies after the winter season. Severe infestations, compounded by the combined attack of these insects, can lead to the loss of as much as 70% of the fruits set (Babatola, 1985).

Delayed harvests can result in some fruits becoming overripe, thus increasing their sugar content and attractiveness to fruit flies. These overripe fruits serve as reservoirs for fruit flies, leading to further infestations on neighboring fruits. Failure to address this issue with appropriate interventions could result in a significant decline in citrus production within the state. Unfortunately, farmers often resort to using inappropriate chemical pesticides or incorrect dosages in their attempts to control insect pests, often falling short of their intended goals.

### **Life Cycle of Citrus Fruit Fly**

Understanding the life cycle of the fruit fly is essential to follow different control methods. There are four stages to the life cycle of fruit flies, these are: eggs, larvae (maggots), pupae and adults. A brief description of each of the stages of the life cycle of fruit fly is provided below (Madge & Mildura, 2007).

#### **Eggs**

The female adult fly lays eggs (1-20) into the maturing and ripening fruit of the host plant. The eggs hatch into larvae inside the fruit after a few days (2-4 days). Note that at this stage of the life cycle you are unlikely to be able to recognize the presence of fruit fly eggs in your fruit as the eggs are very small. During its lifetime, a female fruit fly may lay 400 eggs or more.

#### **Larvae**

The hatching larvae (maggots) feed inside the fruit and are accompanied by various bacteria that are introduced when the female fly lays its eggs. The activity of the maggots and the bacteria causes the fruit to rot internally and often affected fruit will prematurely fall from the tree. The larval stage is the most likely stage that you would recognize the presence of fruit fly in your fruit if you cut it open.

#### **Pupae**

As the fruit ripens and rots, it falls to the ground. Fully mature larvae leave the fruit and burrow into the soil to pupate. In the soil, larvae become inactive and change into oval shaped, light to



dark brown, hard pupae. Inside the pupal case, which is the cocoon or chrysalis formed by butterflies, the adult fly develops. At this stage you are unlikely to recognize the presence of fruit fly pupae in the ground.

### **Adult**

The adult flies may emerge from the pupae in as little as seven days during the summer, or after several months over winter. The adult fly looks for the nourishment it needs to reach maturity, breed, and lay eggs in new season crops. At this stage of the life cycle, you may be able to recognize adult flies landing on or sheltering amongst vegetation or landing on fruit.

### **Behavior of fruit flies**

Fruit fly numbers tend to increase, usually in spring, when temperatures are warm and there is continued availability of suitable host plants. Under good conditions, fruit flies develop from eggs to adults within four to five weeks.

### **Characteristics of adult flies:**

- Take about a week from emergence to reach sexual maturity.
- Rest in shady trees (fruit trees, ornamental trees and shrubs) during the day.
- Feed on bacteria that can be present on the host tree or adjacent plants.
- Queensland fruit flies' mate at dusk, while Mediterranean fruit flies' mate at any time of the day.
- Can survive throughout winter.

### **Characteristics of female fruit flies:**

- Sting fruit and vegetables from October to May (though some activity will occur in warmer periods during the winter months).
- Lay eggs into healthy, maturing and ripening fruit (on the tree) and vegetables.
- Need to feed on a source of protein before eggs will mature for laying.
- Reabsorb eggs during extended periods of cold weather.

### **Management strategies**

The following options for fruit fly management are available to organic producers and should be applied to home garden trees as well as commercial orchards.

- **Harvest as early as possible:** As the season progresses, fruit fly populations, the attractiveness of fruit-to-fruit flies and the risk of damage all increase.
- **Keep tree size manageable:** Tall trees are more likely to carry unharvested fruit that can act as infestation sites for fruit flies.
- **Maintain orchard hygiene:** Exclude fallen and damaged fruit from the harvest. Collect and destroy all such fruit quickly, e.g. by cooking or by sealing in plastic bags in the sun for several days, as larvae can develop successfully in fallen fruit. Remember – do not bury



suspect fruit as fruit fly larvae may survive. Inspect trees after harvest, collect any missed fruit and use or destroy it promptly. Remove unwanted and unmanaged fruit trees to reduce the source of breeding sites for fruit fly. This may be especially important for preferred hosts such as stone fruit.

○ **Trapping:** Traps are generally considered useful for monitoring fruit fly populations rather than controlling them. Traps attract fruit flies by using pheromones, food scents or visual cues. Pheromone traps contain a sex pheromone that attracts male flies. Depending on the trap type, the flies drown in liquid bait, get caught on a sticky layer or are killed by a contact insecticide. In the latter case,



**Fig. 4. Fruit fly trap**

the insecticides commonly used are not permitted under organic standards. However, liquid and sticky pheromone traps suitable for use on organic properties are available commercially. Food lure traps (wet traps) are also used by some growers. These traps contain a liquid aromatic food attractive to fruit flies. The acidity of the food attractant appears to be important. Fruit flies seem to prefer a pH around 9 and are less attracted to the lure if it becomes more acidic. Traps need to allow flies to enter easily while excluding rain as much as possible. Clear plastic bottles with several 1cm diameter holes are one option. The holes need to be far enough above the base to allow the bottle to hold a few cm of liquid lure.

**Cover sprays:** These are insecticide sprays applied to whole trees to kill various stages of fruit fly. Currently there are no organically-acceptable materials registered for use in organic farming as cover sprays against fruit flies.

**Physical exclusion:** Individual fruit, branches or whole trees can be protected against fruit fly by bagging, but this is a labor-intensive approach warranted only for very small or valuable crops. In some situations, whole-orchard netting may be justified where protection is required against a number of pests such as fruit fly, light brown apple moth and birds, as well as hail.

**Biological control:** Newly emerged fruit flies require up to 24 hours for their wings to harden before they can fly, making them vulnerable to predation by birds, ants, bugs, and earwigs on the soil surface. Birds, including domestic poultry, can aid in controlling fruit fly larvae in fallen fruit and shallowly buried larvae and pupae. While cultivation increases exposure of larvae and pupae to predators, it's not suitable directly under trees. Parasitic wasps and nematodes also attack fruit fly at various stages,



but their effectiveness in reducing fruit fly numbers to economically viable levels is limited.

### **Month wise calendar for scientific management of citrus orchards (Jha et al. 2019).**

#### ***For establishing a new orchard***

##### **January**

- Opt for pest-resistant/tolerant citrus varieties.
- Choose healthy rootstocks/planting material treated with recommended biopesticides.
- Select well-lit land at elevations between 300-1600 meters above sea level.
- Opt for deep, well-drained soil with a depth of 80-90 cm and pH 5.0-6.5, ensuring proper irrigation.
- Conduct deep ploughing before orchard establishment, utilizing weeds for manure preparation.
- Dig pits on suitable terraces (preferably sloped) at 6m × 6m × 5m apart, with pit dimensions of 60cm × 60cm for 250-330 plants per hectare.
- Maintain good sanitation practices to prevent nematode infestations.
- Fill pits with well-decomposed FYM (25 kg), neem cake (2-3 kg), and rock phosphate/dolomite (1kg) per pit, mixed with equal quantities of topsoil. Raise the pit by 2-3 inches and mark the center with a peg.
- Apply *Trichoderma* spp. and *Pseudomonas fluorescens* for nursery treatment and soil application.
- Use neem cake and *Paecilomyces lilacinus* (1×10<sup>9</sup> CFU/ml or 1×10<sup>8</sup> CFU/gm) at 10 liters or 12 kg/ha for soil application to control heavy nematode infestations. Consider growing marigold as an intercrop to reduce nematode attacks.

##### **For existing orchard**

- Ensure fruit harvesting is completed within the designated month.
- Clear orchard weeds and till the soil, followed by pruning dead wood and infested branches. • Utilize grasses for manure preparation.
- Remove loranthus from orange trees.
- Clean mosses and lichens, especially on the trunk (60-75cm), using gunny bag pieces.
- Treat pruned branches with a paste made of Copper Oxochloride 50WP @ 100 gm/250ml of water.

##### **February**

- Clear orchards and perform tillage.
- Apply dolomite at 2-3 kg per tree every 3 years, regardless of plant age, by lightly digging around the canopy area, leaving 30-45 cm near the trunk.

##### **March**

- Flowering starts in this month. New flushes of leaves also emerge.
- Aphid, Asian citrus psylla and leaf miner attack take place on the newly emerged flushes.
- Collect and destroy mined leaves and infected twigs and if required trees should be removed as soon as die-back symptom appears.
- Use yellow sticky trap @ 5/acre.
- Spray Neem oil/NSKE (Nimbecidine EC) @ 5ml/lit of water.
- Apply FYM/compost @ 10kg for 1-5 years, @ 25-30 kg for 6-10 years and @ 50 kg for 11-40 years old trees per plant below the canopy area and mix it in the soil.





- Application of fungicide Myclobutanil 10% WP @ 1.5gm/lit or Penconazole 10% EC 0.5 ml/lit to control powdery mildew.

### April

- Initiation of fruiting takes place.
- Aphid, leaf miner and psyllid attack continue resulting in die back.
- Spray Neem oil/NSKE (Nimbecidine EC) @ 5ml/lit of water can also be sprayed, if required.
- Painting the trunk (up to 2ft-3ft) from ground level with a paste made of Copper oxychloride 50WP (100 gm) + 10-15 gm red colored fine soil + 25 gm botanical oil + 125 gm lime per liter of water.
- Foliar spray 2% ZnSO<sub>4</sub> at fortnightly interval.

### May

- Fruiting continues.
- Rain starts at the end of the May.
- Locate the stem borer holes, remove the wooden frass present in between the joints and plug the holes with wet soil after inserting petrol or kerosene-soaked cotton @ 10 ml/tunnel with the help of syringe.

### June

- Egg laying in fruits by adult female of citrus fruit fly *Bactrocera minax* (Enderlein).
- Repeat plugging of trunk borer holes.
- Remove sprouts which emerge out from trunk.
- Handpicking and destruction of various stages of citrus butterfly larvae.
- For newly planted and 1-5 years old plants de-shooting/de-budding at basal 40-50 cm height may be done at monthly interval.
- Apply per plant FYM/compost @ 10kg for 1-5 years, @ 25-30 kg for 6-10 years and @ 50 kg for 11-40 years old trees. Apply manure below the canopy area and mix it in the soil.
- Spray Neem oil/NSKE (Nimbecidine EC) @ 5ml/lit of water at weekly interval (in sunny days when available).

### July

- Rain continues.
- Spray Neem oil/NSKE @ 5ml/lit of water at weekly interval (in sunny days when available).
- Fruit growth starts
- Up to middle of July fruit fly egg laying takes place.
- Repeat control of trunk borer and removal of water suckers from trunk and general cleaning.
- Removal of undesirable growth and parasitic plants.
- Spraying of Wettable Sulphur (1.5kg/200 litres of water).

### August

- Fruit growth continues
- Repeat plugging of holes of trunk borer, removal of parasitic growth carefully so that fruits are not damaged.
- If possible, Spray Neem oil/NSKE @ 5ml/lit of water at weekly interval.

### September

- Stink bug attack starts



- Weeding recommended.
- If possible, Spray Neem oil/NSKE @ 5ml/lit of water
- Repeat application of copper fungicide to control powdery mildew.
- Repeat application of fungicide to control citrus gummosis.
- Application of micronutrient mixture (according to availability of market).

**October**

- Rain ceases
- Fruit, green in colour.
- Fruit drop starts at the end of October due to fruit fly and stink bug attack.
- Poly-mulching should be done from 1<sup>st</sup> week of the month and continues up to fruit harvesting.
- Repeat trunk borer control
- Weeding
- Apply copper oxychloride.
- Soil treatment is recommended to control fruit fly larvae
- If possible, Spray Neem oil/NSKE @ 5ml/lit of water.

**November**

- Heavy fruit drop takes place
- Collect infested drop fruit and dip into water kept in a bucket. Apply kerosene in the water.
- Harvesting starts at the end of this month
- Poly-mulching continues.

**December**

- Major fruit harvesting takes place in this month
- Collection of dropped fruits and dip into water kept in a bucket mixing kerosene.
- Light pruning after harvesting
- Paste Copper Oxychloride 50WP @ 100 gm/250ml of water on the cut surfaces of the branches after pruning.

**Conclusion**

Fruit flies present a formidable challenge due to their wide range of host plants, multiple generations per year, high mobility, and long lifespan exceeding three months. A single female can lay over 1000 eggs, and all developmental stages remain hidden: eggs and maggots inside fruits, pupae in the soil, and adults in flight. Effective management strategies include clean culture practices, orchard sanitation, and the removal and destruction of infested fruits through burning or deep burying. Deep burying of infested fruits in 60 cm deep pits helps curb fruit fly emergence from the soil, with proper soil compaction crucial to prevent maggot escape. Regular implementation of these measures in all orchards and host fruit crops is essential. Additionally, fruit growers should diligently remove and destroy undersized fruits left on trees after harvesting to mitigate further infestation risks.

**References:**

- Umeh V.C., Ahonsi S., Kolade J.A. (1988). Insect pest encountered in a citrus orchard in Nigeria, *Fruits* 53 (6); 397-408.
- Babatola J.O., Diseases and Pests of Fruits and their control, in Proc. Ntl. Fruit Production Workshop, 1844



FACU-NIHORT, Ibadan, Nigeria, 1985, pp. 120-132

Madge D. and Mildura. 2007. Organic Farming: Managing Fruit Fly in Citrus, Agriculture notes;  
<http://www.dpi.vic.gov.au/notes>.

Jha S., Pashi R. and Roy S. (2019). Darjeeling Mandarin: Steps to mitigate the challenge of its decline  
Agriculture & Food: e- Newsletter, 1(8): 11-16.

