Pest Management in Sweet Potato

C. A. Jayaprakas, E. R. Harish, and Anjali Vinod

Abstract As many 80 species of insects and non-insect species are known to attack sweet potato. The important pests include sweet potato weevil *Cylas formicarius*, vine borer *Omphisa anastomosalis*, leaf folder *Brachmia convolvuli*, sweet potato Hawk moth *Agrius convolvuli*, Bihar hairy caterpillar *Spilosoma obliqua*, syntomid caterpillar *Euchromia polymena*, tortoise beetle *Aspidomorpha miliaris* and spiny beetle *Oncocephala tuberculata.* Management of the key pests is also discussed.

1 Sweet Potato Weevil: *Cylas formicarius* F. (Coleoptera: Apionidae)

Cylas formicarius is known to inflict direct damage, yield loss and at times total destruction of the crop (Rajasekhara Rao et al., 2010).

Biology: Eggs are deposited in small cavities created by the female in the sweet potato root or stem. The female deposits a single egg at a time. The egg is oval in shape and creamy white in colour. A single female on an average lays 180 eggs in its life span. The incubation period is 3–5 days. When the egg hatches, the larva usually burrows directly into the tuber or stem of the plant. Those hatching in the stem usually burrow down into the tuber. The larva is legless, white in colour, and displays three instars. Duration of each instar is 8–16, 12–21 and 35–56 days, respectively. The mature larva creates a small pupal chamber in the tuber or stem. Initially the pupa is white, but with time this stage becomes greyish in colour with darker eyes and legs. Duration of the pupal stage averages 7–10 days. Normally the adult emerges from the pupation site by chewing a hole through the exterior of the plant tissue. The total lifecycle may take about 1–1½ months. The adult is striking in form and colour. The head is black, the antennae, thorax and legs orange to reddish brown, and the abdomen and elytra are metallic blue. The snout is slightly curved and about as long as the thorax. The beetle appears smooth and shiny. The adult

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longevity is about 90. Sex ratio found was 1.5: 1 for male to female. Seven to nine overlapping generations are completed in a year.

Damage: The grubs bore and feed by making irregular tunnels. Both adults and grubs cause damage to the crop both in field and in store. Adult weevil feeds on all parts of the plant while the attack of the grubs is restricted to vines and tubers. The grubs bore and feed by making irregular tunnels. As a result of feeding by a number of grubs, the collar region usually bulges out due to hypertrophy and proliferation of tissues. At times of severe damage the region breaks off from the root zone. The emerging adult weevils get access into the tubers through the cracks and crevices formed in the soil during bulking. The feeding causes a characteristic terpenoid odour and a bitter taste on cooking, thus rendering the tubers unsuitable for human consumption. The yield loss goes up to 70%.

Life stages of *Cylas formicarius*

Egg **Larva** **Pupa** **Adult**

Generally the weevil damage was higher in summer crop. The crop grown in red loam and clay loam had higher incidence than that of sandy loam probably due to cracking nature of the soil. In North India the crop raised in Kharif and Rabi seasons showed varying weevil damage. In Rabi, the weevil damage was lower while it was higher in the Kharif; this phenomenon can be mainly attributed to low soil temperature (Palaniswami & Mohandas, 1991).

Tuber damage by sweet potato weevil

Natural enemies: Forty percent of the grubs are found parasitized by *Rhaconotus* sp. and *Bracon* sp. Higher larval parasitism is observed during July–October. Entomopathogenic fungus *Metarhizium anisopliae* Metschnikoff is found to infect sweet potato weevil. Entomopathogenic nematode, *Heterorhabditis indicus*, is known to infect the grubs up to 90%. Release of the parasitoid *Rhaconotus* sp. and

soil drenching of the fungus at 50 days after planting (DAP) and again at 60 DAP are quite effective against the weevil (Palaniswami, 2000). Spraying of *B. bassiana* solution (isolated from *C. formicarius*) at a concentration of 1.6×10^4 conidia/mL at planting and rootstock formation, and broadcasting soybeans containing *Beauveria bassiana* into the rows at planting controlled *C. formicarius* effectively (Su, 1991).

Integrated pest management

This IPM programme results in drastic reduction of sweet potato weevil damage in tubers and enhanced marketable tuber yield (Pillai et al., 1987, 1996; Rajamma et al., 1993; Palaniswami & Mohandas, 1992; Palaniswami & Chattopadhyay, 2006; Palaniswami et al., 2000).

1. Removal of alternate hosts, viz. Ipomoea species and *Calystegia soldanella* and *C. hederacea.*
2. Clean cultivation practices like burning of plants residue after harvest and cultural methods like deep ploughing of the field are to be adopted for the control of weevil.
3. Selection of pest-free planting materials from nursery.
4. Proper earthing up whenever there is soil crack especially after tuber bulking.
5. Basal application of mahwa cake or calophyllum cake at 2500 kg/ha or leaves of *Clerodendron* or *Chromolaena* at 5000 kg/ha.
6. Adoption of crop rotation like (a) paddy-paddy-sweet potato, (b) paddy-sweet potato-paddy, (c) paddy-sweet potato-cowpea and (d) *Colocasia*-sweet potato were highly superior in reducing tuber damage and increasing marketable tuber yield. In low land rice fields in India, the cropping sequences such as rice-sweet potato-cowpea, rice-rice-sweet potato and rice-sweet potato-rice were effective in reducing SPW infestation.
7. Intercropping with rice, cowpea or colocasia results in significant reduction in the weevil damage. Planting paired rows of sweet potato and yam bean at 2:1 or alternate rows of sweet potato and yam bean effectively reduced the tuber infestation by SPW. Planting alternate rows of sweet potato and marigold (1:1 ration) resulted in less tuber infestation.
8. Retention of soil moisture in the field.
9. The cultivation of less susceptible or relatively resistant clones S 3, S 13, S 234, S 238 and S 248 under good agronomic practices will help to reduce weevil damage leading to increased production.
10. Several insecticides were tested for the management of SPW by using them after planting, either by foliar spray or basal granular applications. Some of the insecticides are also used for vine dipping for successful control of SPW. Fenvalerate and deltamethrin at 0.003% were the most effective insecticides to *C. formicarius* (Rajamma, 1990; Teli & Salunkhe, 1996) tried dipping cuttings in insecticide solution before planting and spraying the crop 1 month after planting, and further 3 times, at 3-week intervals, subsequently with cypermethrin or fenvalerate at 375 g a.i./ha. It was most effective in reducing damage caused by the insect and the best cost: benefit ratio (1:1.19) was recorded for fenvalerate.

11. Installation of pheromone traps in the field from first DAP to collect and kill the male weevil at a distance of 10 × 10 m using BARC sex pheromone. Continue trapping till fortnight after harvest. One milligram of female sex pheromone, *Z*(3)-dodecen-1-ol-*E*-(2)-butenoate was useful for mass trapping of male adult weevils. Ten micrograms was enough for monitoring, and the results were spectacular in both the seasons (June–September and November–February), and the pheromone traps were installed at 1 trap/100 m^{-2} area from first day of planting till harvest and thereafter for 1 month to collect the residual population. The male weevils were collected and killed in alternate days from the traps. The tuber damage was less than 10% in both the seasons while in the control was about 40%. The synthetic sex pheromone has been found as an efficient tool to contain the population build-up of weevil and consequent damage of the crop. Females were found to be attracted by the kairomone boehmeryl acetate. Use of kairomone and sex pheromone in the IPM has been reported as useful against the weevil.

Traps used for sweet potato weevil

Pheromone trap

Kairomone/ pheromone traps

12. Harvesting at 110 days and destruction of weevil infested crop residues.

Management of sweet potato weevil in storage: Keeping sweet potato tubers in sand helped to prevent weevil damage in storage. Storing tubers as heaps on floor and covering with red earth or wood ash prevented the entry of the weevils and thus protected the tubers for 2 months. Different methods like keeping uninfested tubers in earthen pots or in sand or keeping in heaps covered with straw and plastering with mud paste could protect the tubers from weevil damage up to 45 days. The tubers in such storage retained their freshness without any deterioration. Keeping the tubers in wooden box in layers of sand was effective for the control of storage pests and post-harvest deterioration up to 2½ months and beyond which the tubers got spoiled by rotting either due to microbial or physiological degradation (Rajamma et al., 1993).

2 Vine Borer: *Omphisa anastomosalis* Guenee (Lepidoptera: Crambidae)

Generally wide spread and is of sporadic nature.

Biology: The adult moth has straw coloured wings with wavy marking. Egg period is about 1 week. Full-grown larvae are pale yellowish white. Larval period is about 28–50 days. The pupa is about 16 mm long and 3 mm wide and nearly cylindrical. It is formed in a slight cocoon in the larval tunnel in the vine. The pupal period lasts 12–16 days.

Life stages of *Omphisa anastomosalis*

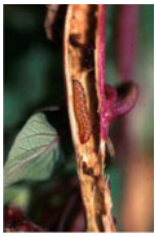
Larva

Pupa

Adult

Damage: Major damage to sweet potato plants, caused by *O. anastomosalis*, results from the larvae boring into the main stem leading to the storage roots. Frass accumulates on the soil surface near the opening of the larval tunnel. Major feeding damage occurs in the crown of affected plants. In older plants there may be several holes in the stem at the crown. These holes result from the emergence of adult *O. anastomosalis* from pupae in the stems at the crown. Vines with severe tunneling show weak growth and poor foliage development; this foliage later yellows and wilts. The distal part of the vine above the damage site often dies.

Stem borer damage



Larval feeding

Swelling and woodiness of the lower stem

Management: Crop hygiene and crop rotation reduces the incidence. Spraying Deltamethrin/Fenvalerate gives effective control of *O. anastomosalis.*

3 Leaf Folder: *Brachmia* (*Helcystogramma*) *convolvuli* Walsingham (Lepidoptera: Gelechiidae)

It is popularly called as black folder.

Biology: The adult is a small slender moth greyish brown in colour. It lays eggs in small groups at the base of the radiating veins on the underside of the leaves. A female moth lays an average of 44 eggs and lives an average of 5 days. The eggs are oval, yellowish white when newly laid and turn pinkish yellow when about to hatch. They hatch in about 3 days. Newly hatched larvae are whitish at first turning greenish yellow later without any markings. Markings appear only in the second instar with distinct black and white marks appearing on the head, thorax and first and second abdominal segments. The later instars retain the black markings which become larger and more prominent as the larvae mature. The larvae feed on the leaves and become fully grown in about 2 weeks undergoing five instars. It pupates within the leaf fold for about a week. Pupae are yellowish brown at first turning dark golden brown later. They have a tuft of hairs at the tip of the abdomen and are enclosed in scanty cocoon. It takes about 25 days to complete the life cycle.

Life stages of *Brachmia convolvuli*

Larva **Damage** **Adult**

(Photo credit: J. O'Sullivan)

Damage: Cream and black larvae spin webs close to the main veins of the leaves, on the underside, while older larvae spin webs across the upper surface of the leaf and draw the two sides together. The leaves eventually dry up, die and drop off.

4 Sweet Potato Hawk Moth: *Agrius* (=*Herse*) *convolvuli* (Linnaeus) (Lepidoptera: Sphingidae)

It is a horn worm feeding voraciously causing irregular holes in the leaf.

Biology: Eggs are spherical and laid singly on the upper surface of the leaf. Egg period is 5–8 days. The horned caterpillar is dark brown or green in colour with oblique red yellow strips laterally. There are five larval instars and larvae mature in

20 days and grow up to a length of about 100 mm. Pupation is in the soil and may take 3 weeks. Pupation occurs in earthen cells several centimetres below the soil surface. The pupa has a very characteristic proboscis, which is enclosed in a looped tube not fused to the body. Pupal period is 10–15 days. Life cycle is completed in 4–5 weeks. The moth has pale-grey wings and has violet bands on the abdomen.

Natural enemies: Four species of parasitoids, namely, *Trichogramma australicum*, *T. achaeae*, *T. agriae* and a species of *Telenomus*, are known to attack the eggs of *A. convolvuli*.

Life stages of *Agrius convolvuli*

Egg **Larva** **Pupa** **Adult**

Management: Ploughing land between crops to expose the pupae thus reducing infestation. Hand picking of the larvae is also found effective in small areas. It is only a sporadic pest. *Theretra oldenlandiae* and taro horn worm *Hippotion celeria* are also known to feed on sweet potato (Subramaniam et al., 1977).

5 Bihar Hairy Caterpillar: *Spilosoma* (*Diacrisia*) *obliqua* Walker (Lepidoptera: Arctiidae)

It is a sporadic pest.

Biology: Eggs are laid on the ventral surface of the leaves in rows or clumps. Eggs are yellowish and spherical. About 600 eggs are laid by a single female. Egg period is 4–9 days. Larvae are orange coloured with broad transverse band with tufts of yellow hairs that are dark at both ends. Larval period is 25–30 days: Pupation takes place in a thin silken cocoon by interwoven shed hairs of the larvae. Pupal period is 15–20 days; the life cycle is completed in 5 weeks in summer and is extended to 8–10 weeks in winter. The pest hibernates in pupal stage in India. Adults are crimson coloured moth with black dots and a red abdomen with pinkish wings with numerous black spots.

Damage: Numerous larvae covered in yellow hairs are found to skeletonise the leaves; entire vines may become defoliated.

Life stages of *Spilosoma obliqua*


Eggs


Larva


Pupa


Adult

Natural enemies: The larva is parasitized by *Apantiles obliquae* and *Sarcophago unisera*.

Management: Spraying of quinalphos 25 EC (2 mL/L) or chlorpyrifos 20 EC (2.5 mL/L) or Dichlorvos 76% EC (2.0 mL/L) recommended when the caterpillars are younger.

6 Syntomid Caterpillar: *Euchromia polymena* (Linn.) (Lepidoptera: Arctidae)

Hairy caterpillars feed on the leaves. The adult is a colourful moth measuring 4.2 cm in wing span and 1.6 cm in body length. Wings are black with golden yellow patches and the body has black-blue and crimson stripes. Eggs are laid. Eggs are shiny pale yellow spheres, and laid in masses of 80–100 on the underside of leaves. They hatch in 8–10 days. The caterpillars that grow are orange with bands of black and brown hairs. They become full grown in 3–4 weeks undergoing six instars. The fully grown caterpillar is 35 mm long. It pupates in a cocoon of silk and felted hairs attached to the stem. Moth has longevity of 15–17 days (Subramaniam et al., 1977).


Adult


Larva

7 Tortoise Beetle: *Aspidomorpha miliaris* F. (Coleoptera: Chrysomelidae)

It is a large flat beetle with a reddish patch in the middle and transparent all round. Adults and larvae feed on the leaves making large round holes and eventually skeleteonising the leaves. Eggs are laid on the underside of the leaves in batches. The yellowish green grubs have a raised anal portion with which it covers its back with excreta in a characteristic manner. The larvae are flattened, spiny and usually carry excreta and the skins of earlier instars on anal projections. The cast skin is also carried on its back. Pupation takes place on the leaf itself. Adult tortoise beetles are broadly oval in shape. They are bright sometimes patterned or metallic in colour. Collection and destruction of adult beetles and removal of that weed plants help to reduce the population of tortoise beetles.

Aspidomorpha miliaris

Leaf damage by tortoise beetle

8 Spiny Beetle: *Oncocephala tuberculata* (Olivier) (Coleoptera: Hispidae)

Both grubs and adults mine the leaves and cause them to wither. It is a sporadic pest. Adult is a small beetle with blunt projections all over the body. It lives up to 50 days. Eggs are laid inside the leaf tissues. The grubs scrape the leaf surface and feed. When full grown, the larva constructs a short tunnel in the leaf and pupates inside. Egg, larval and pupal stages last for 7–10, 17–23 and 8–15 days, respectively (Pillai & Palaniswami, 1984).

9 Spider Mites

Tetranychus cinnabarinus and *Eutetranychus orientalis* colonise on the leaf surface and the leaf curl and dry up. Eriophyid mite *Oxypleurites convolvuli* Channa causes severe rusting of the leaves which turn pale brown. These are sporadic pests.

10 Nematodes

Root knot nematode (*Meloidogyne incognita*) cause swelling or knotting of roots and heavy infection can inhibit apical growth. The most obvious symptoms of damage on tubers are longitudinal cracking and general rough appearance of the skin. High degree of resistance to the nematode was found in varieties Sree Nandini, Sree Vardhini and H 268. *Rotylenchulus reniformis* a semi-endoparasitic nematode is found in high numbers (4000–9000/100 cc soil) in sweet potato fields. The nematode penetrates roots and tubers causing injury. Normally this nematode does not produce galls, but on sweet potato the nematode was surrounded by galls formed from the host. The infection causes chlorosis in the foliage and reduction in the yield and size of tubers. Many varieties of sweet potato are resistant to root knot nematode, and resistance has been used either alone or in combination with other measures for the biological suppression of the nematode. The identified resistant varieties can be included for cultivation in the root knot problem areas in order to reduce the population and thereby increasing the yield (Mohandas & Palaniswami, 1996).

11 Rats

In India rats damaging sweet potato in the field are mainly field rat (*Bandicota bengalensis*) and field mouse (*Mus booduga*). Under storage, house rat *Rattus rattus* and house mouse *Mus musculus* cause damage. Yield loss was reported to be 1–10% in India under field conditions and 10–20% under storage. An integrated approach can be used utilizing the following methods: Field sanitation: Removal of bushes and weeds in and around the crop field is important. Trapping: Different types of traps are available, and a suitable one can be used for each species. Catching and killing: Live burrow can be located by plugging the burrows with moist soil and observing for opening the next day. Traditional rat killers can be utilized for this purpose. Smoking: Dry coconut leaves made into small bundle about 50 cm long can be thrust into the live burrow, fired and fanned in such a way that smoke is pressured down into the burrow. Rats die inside the burrow. Poison baiting: Zinc phosphide is the effective poison. It is mixed with some attractive food material like cereal flour, dry fish or groundnut to get 2–5% concentration. When cereal flour is used, some sugar and oil can be added. Pre-baiting using food material alone should be done for

2–3 days before poison baiting as the rats tend to develop shyness. Biological method: Predators like rat snake, owl, etc. need to be encouraged with least ecological disturbance. An owl can kill a rat every 5 min. During nesting period, while a cat devours only 30 per year (Rajamma et al., 1989).

12 Other Pests

Leaf-eating caterpillars include *Junonia orythyia swinhoe* (Butler), *Euchromia polymena* (Linn.), *Creatonotos gangis* Linn., *Estigmene lactinea* (Cramer) and *Pericallia ricini* (F.); tobacco caterpillar *Spodoptera litura* and *Metasia coniotalis* Hampson; leaf rollers *Brachmia engrapta* Meyrick, *Brachmia engrapta* Meys., *B. arotraea* (Meyrick), *B. macroscopa*, *Brachmia convolvuli* Walsingham, *Helcystogramma lambrostoma* (Zeller), *Helcystogramma effera* (Meyrick) and *Spodoptera inquieta* (Wlk.); leaf miner *Trachy ipomeae* Theobold and *Acrocercops prosacta* Meyrick. Leaf-eating beetles include *Aspidomorpha indica*, *A. furcata*, *A. dissentanea*, *Chirida sexnotata*, *Metriona circumdata*, *M. varians*, *Oncocepahala tuberculata* Oliver, *Cassida indicola*, *Glyphocassis trilineata*, *Chiridopsis ornate*, *Conchyloctaemia punctata*, *Cassida circumdata* Herbst, *Chiridopsis bipunctata* (L.), the green leaf beetle *Colasposoma metallicum* Clark, tissue borer *Metasia coniotalis Hampson*, sap sucking bugs *Exitiamus indicus Distant*, *Riptortus linearis Fab.*, *Halticus minutus* Reuter, mealybugs *Pseudococcus* sp. and *Planococcus* sp. and *Geococcus coffeae* Green, thrips *Thrips apicatus* Priesner and *Dendrothrips ipomeae* also feed on the crop. Many insects prevent seed setting by feeding on floral parts. Important among them are *Mylabris thunbergi* Billberg F., *Oxycetonia versicolor* (Fabricius) and *Macroura orientalis.* The weevil *Protocylas coimbatorensis* Subramanian feeds on fruits and seeds. The ground beetles *Anomala dissumieri* Blanchard, *Gonocephalum oivicum* and *G. depressum* feed on the tubers by making irregular shallow galleries. They are found in the soil in large numbers when the crop matures. Damage to the extent of 10–15% was. The spiralling whitefly *Aleurodicus dispersus* (Russell) is also known to cause minor damage to sweet potato in India. *Paracoccus marginatus* is also known to attack sweet potatoes. The mealybugs feed, often in groups, on the undersides of leaves. The mealybug infestations lead to stunted growth, discoloration, malformed foliage and defoliation of sweet potato plants. To control papaya mealybugs on sweet potato plants, gardeners should begin with a biological approach by releasing natural enemies particularly *Acerophagus papayae*.

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