Compendium of Diseases and Pests of Tropical Tuber Crops in India

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भाकृअनुप-केन्द्रीय कन्द फसल अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद्)
श्रीकार्यम, तिरूवनन्तपुरम 695 017, केरल,भारत
ICAR-Central Tuber Crops Research Institute
(Indian Council of Agricultural Research)
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Diamond Jubilee of ICAR-CTCRI

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Published by

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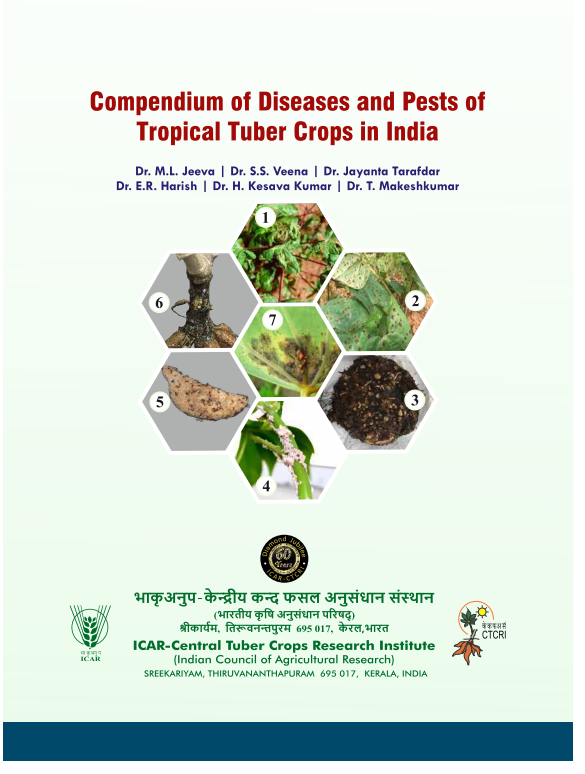

July 2023

Citation

Jeeva, M.L., Veena, S.S., Jayanta Tarafdar, Harish, E.R., Kesava Kumar, H. and Makeshkumar,T. 2023.*Compendium of Diseases and Pests of Tropical Tuber Crops in India*, Techncal Bulletin No. **92**, ICAR- Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, India,56 p.

Design, Layout & Printing

Aden Digital Signage, Thiruvananthapuram, Kerala
Mob: 9605206323, www.adendigital.in

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From the Director

Dr. G. BYJU
Director

The ICAR-CTCRI is the premier research Institute with a mandate of basic, strategic and applied research on 15 tropical root and tuber crops for catering to the needs of farmers and other stakeholders across the nation. Systematic research and extension programmes of the Institute during the last six decades have led to development of 71 improved varieties of different tropical tuber crops for various traits such as nutrition, biotic & abiotic stress resistance/tolerance and higher productivity. Besides, a number of potential technologies on production, protection, pre and post-harvest processing, value addition, smart farming etc. have also been developed and demonstrated for enhancing the productivity and profitability of tuber crops farming across the country. Tropical tuber crops are grown in an area of 4.20 lakh ha with a production and productivity of 10.75 million tones and 21.30 t ha^{-1} respectively. The productivity of tuber crops can further be enhanced by managing diseases and pests which are causing severe yield and economic loss to the tuber crops sector.

The major diseases and pests which affect tropical tuber crops in India are, cassava (cassava mosaic disease, tuber rot, stem and root rot, mealybugs, whitefly, scale insects, red spider mite), sweetpotato (leaf curl, sweet potato weevil), aroids (collar rot, corm rot, post-harvest rot, leaf blight, nematode), yams (anthracnose) and Chinese potato (nematode). The identification, symptoms, mode of spread, diagnostic tools and management practices for all major diseases and pests of tropical tuber crops have been systematically done by the scientists of Division of Crop Protection in coordination with 21 AICRP TC centres of India.

Assessing the crop and yield loss due to diseases, pests and nematodes in view of changes in the ecosystem and climate is one of the research goals of ICAR-CTCRI. Hence, for the improved understanding of the crop protection aspects 'Compendium of diseases and pests of tropical tuber crops in India' has been prepared by the experts. The book covers various details on causal organism, symptoms, mode of spread, and integrated management of major diseases, pests and nematodes of tropical tuber crops.

I am sure that the Compendium will provide the insights for the researchers, developmental professionals, farmers and other stakeholders both at national and international arena to formulate effective strategies for tackling the diseases and pests of tropical tuber crops. I congratulate the Editors for bringing out the compendium on time.

G. BYJU
Director

CONTENTS

CASSAVA
(*Manihot esculenta* Crantz)

DISEASES

CASSAVA MOSAIC DISEASE

Cassava mosaic disease (CMD) is one of the main biotic constraints in cassava production, limiting the productivity of cassava and thereby becoming the most important threat to food security worldwide in all cassava growing areas especially in Africa and Asia. In India, CMD causes yield loss upto 88 percent.

Causal organism

Indian cassava mosaic virus (ICMV) and *Sri Lankan cassava mosaic virus* (SLCMV). Among these two, the later one occurs predominantly in major areas and cause severe symptoms.

Spread

Primary spread of this disease occurs through infected planting material and secondary spread in the field through the vector whitefly (*Bemisia tabaci*).

Fig. 1. Various symptoms of cassava mosaic disease

Symptoms

Cassava plants infected with cassava mosaic virus express a range of symptoms which depend on the virus species/strain, environmental conditions, and susceptibility of the cassava host. The most typical symptoms consist of yellow or pale green chlorotic mosaic on leaves, commonly accompanied by distortion and crumpling. Affected leaves are reduced in size, deformed, twisted and distorted to give shoe string appearance. In severely infected plants the deformed plants result in stunting with bushy appearance (Fig. 1).

Management

- Growing of resistant varieties like Sree Reksha, Sree Suvarna and Sree Sakthi
- Use of disease free planting material obtained from healthy plants
- Removal of infected plants and strict field sanitation
- Vector control- spraying of Imidacloprid 17.8 SL (0.3 ml L^{-1}) or Thiamethoxam 25 WG (0.3-0.4 g L^{-1}) at 14 days interval

CASSAVA TUBER ROT

Cassava tuber rot disease is a major problem in cassava growing areas of Tamil Nadu which cause 50% yield loss and in severely affected fields under conducive conditions of high rainfall and poor drainage, it may cause total loss.

Causal organism: *Phytophthora palmivora* (E.J. Butler)

Spread

The pathogen survives in the infected tubers and soil. Under water logged condition the pathogen produce lot of sporangia in soil and infect the tubers.

Symptoms

The disease is characterized by the appearance of dark coloured round to irregular shaped water soaked lesions on mature tubers in the field (Fig. 2). White mycelial mats of the fungus develop around these lesions. On advancement of infection, the lesions enlarge causing internal browning, oozing of internal fluids and rotting of the tubers. The infected tubers emit a characteristic foul smell and rot within 5-7 days depending on the soil conditions. However, the leaves and stem of infected plants show no apparent symptoms.

Fig. 2. Cassava tubers infested with tuber rot disease

Management

- To prevent water stagnation in the field, avoid overwatering and enhance drainage
- Crop rotation with other crops which are non-hosts for *Phytophthora palmivora*
- Deep ploughing using chisel plough up to 20" to enhance the water percolation (Fig. 3)
- Planting in ridges to avoid exposure of tubers to excess water

Fig. 3. Deep ploughing to break hard pan as cultural measure in tuber rot infested field

- Addition of organic amendments (neem cake @ 250 kg ha^{-1}) to improve the soil structure and to enhance the growth of native microbes antagonistic to *Phytophothora*
- Incorporation of biocontrol agent, *Trichoderma asperellum* (prepared by mixing 2.5 kg of *Trichodema* with 250 kg farm yard manure, incubated under shade by covering with polythene sheet)
- Removal of diseased plants from the field after harvest if any

CASSAVA STEM AND ROOT ROT

Cassava planted only in wet land fields of Kerala have shown the disease which was up to 100% incidence and entire tuber loss based on the weather factors and soil moisture.

Causal organisms: *Fusarium* spp. and *Colletotrichum* sp.

Spread

The pathogen present in the soil infect the collar region and further spreads to stem and root .

Symptoms

Fig. 4 .Various symptoms of cassava stem and root rot

Cassava is affected by the disease at anytime from planting to harvest. Setts near the collar area will first degrade after planting before rooting. The mature plants displayed yellowing and drooping of their old leaves, as well as stem and tuber rotting and finally wilting occur as it advances. The rotten stem close to the soil turns dark and displays fungus pustules with white mycelia (Fig. 4).

Management

- Removal and burning of highly infected plants
- Avoid water stagnation: ensure good drainage in the plot
- Using healthy setts and avoid setts from infected fields for planting
- Crop rotation with suitable crops once in two years
- Application of lime @ 150 to 250 g per plant 10-15 days before planting, where pH of the soil is 4-5 (ensure soil moisture during application)
- Application of neem cake @ 20 g per plant and *Trichoderma asperellum* enriched FYM @one kg per plant
- Sett treatment with Carbendazim (0.05%) for 10 min.
- Drenching with the same fungicide starting from planting-three times at 15 days intervals

CASSAVA BROWN LEAF SPOT

Brown leaf spot is a major fungal disease in heavy rainfall areas. It causes considerable premature defoliation and loss in tuber yield up to 30 % in susceptible variety like Malayan-4 (M-4). Older leaves are more susceptible than younger ones, and the disease is seen mostly in crops over 5 months old.

Causal organism: *Cercospora henningsii* Allesch

Spread

Warm, humid conditions favour the initiation and spread of the pathogen. The pathogen spreads to new plants by rain splash. The fungus survives during the dry season in old lesions, often on fallen leaves.

Symptoms

Small brown spots with dark borders appear on both sides of the leaves. Spots on the lower surface have less distinct margins and appear grayish in the center because of the presence of fruiting bodies of the fungus. The spots expand and become irregular and angular in shape as they are limited by leaf margins and veins. An indefinite halo appears round the lesions. As the disease advances, the infected leaves turn yellow, become dry, and fall off (Fig. 5).

Management

Fig. 5. Different symptoms of cassava brown leaf spot

- Wider spacing reduces the humidity within the stand of cassava and reduces the incidence
- Shifting of planting in a way that the most susceptible growth stage (over 5 months old) does not coincide with the wet season
- Cultivation of resistant varieties, viz., Sree Prakash, Sree Visakham
- Spraying of Copper oxychloride, 0.15% (1.5g L^{-1})

CASSAVA ANTHRACNOSE DISEASE (CAD)

Anthracnose disease is widespread in most of the cassava-growing regions. It is estimated that the disease causes yield loss around 30 % in susceptible cultivars when the conditions are favourable for the pathogen. The disease affects both leaf and stem portions thus reduces yield and affect the availability of planting material for the next season.

Causal organism: *Colletotrichum gloeosporioides* Penz. f.sp. *manihotis*

Spread

The disease usually starts with the onset of rains and worsens as the wet season progresses. The pathogen spreads by wind or by planting stem cuttings with the disease. Dead cassava stems and leaves with the fungus also serve as sources of the disease if they are not destroyed properly.

Symptoms

Cankers on stems, leaf spots, leaf drying and tip die-backs, wilting, shoot death and easy breaking by wind action. Sprouting of new twigs from axillary buds below the necrotic area which shows bunchy appearance (Fig. 6).

Management

- Avoid planting cuttings with cankers
- Removal of crop debris and destroying after harvest from the infected fields
- Spraying of Carbendazim (0.05%) three times at fortnight interval starting from the appearance of symptom

Fig. 6. Different symptoms of anthracnose disease

PESTS

MEALYBUGS

It is a soft-bodied insect which can easily be identified by the presence of white powdery waxy substances all over its body. They are seen in clusters on the stem, petiole, and leaf, particularly on the ventral side. Infestation is very high during warm and dry periods.

Pest

In India, there are three major types of mealy bugs that infest the crop. Striped mealy bug (*Ferrisia virgata* Cockerell), papaya mealy bug (*Paracoccus marginatus* Williams and Granara de Willink), and cassava mealy bug (*Phenacoccus manihoti* Matile-Ferrero) (Fig.7 a, b).

Spread

Young mealy bugs are tiny, light, and easily blown by wind from plant to plant. The pest survives on stem surfaces and is carried to the next crop. Under favorable environmental conditions, mealybug can build up huge numbers in a very short time and cause considerable damage to its host.

Damage

They affect all aerial parts of the plant and while sucking the sap, they inject a toxic substance into the feeding point, causing the deformation of terminal shoots, reduction of internodal length, stunted growth and subsequently the development of 'bunchy tops' (Fig.7 c &d). Honey dew excretion and the associated black sooty mold formation impair photosynthetic efficiency of the affected plants that often leads to heavy yield loss to the extent of 60-80%.

Management

- Monitoring and scouting to detect the infestation, pruning and burning of infested branches
- Removal of weeds/alternate host plants in and around cassava fields

- Avoiding the use of planting materials from infested cassava fields
- Destruction of ant colonies to prevent the spread of mealy bugs
- Maintenance of field hygiene and sanitization of farm equipment.
- Conservation of natural enemies like hymenopteran parasitoid, *Acerophagus papayae, Anagyrus lopezi* and lady beetle predators like *Cryptolaemus montrouzieri, Scymnus* sp. etc.
- Soaking of cassava setts in Dimethoate 30 EC @ 1% (10 ml L^{-1}) for one hour before planting and after the infestation starts
- Spraying neem oil-soap solution (7:3) @ 1 to 1.5% twice at weekly intervals or fish oil resin soap @ 25g L^{-1} of water

Fig. 7a Striped mealy bug

Fig. 7b Papaya mealy bug

Fig. 7c. Cassava mealybug

Fig. 7d. Cassava mealy bug infested plant

- In the case of chemical insecticides, spraying either Thiamethoxam 25 WG @ 0.6 L^{-1} or Imidacloprid 17.8 SL @ 0.6 ml L^{-1} to cover lower surface of the leaves/ infested portions of the plants is recommended
- Drenching of Chlorpyrifos 20 EC @ 2 ml L^{-1} may be done for the destruction of ant colonies-which are notorious for the insect spread

WHITEFLY

The whitefly is a major pest of cassava it is responsible both for the transmission of cassava mosaic viruses and for direct damage due to feeding by high populations. Higher temperature and lower humidity are the congenial conditions for whitefly. Body is covered with waxy powdery materials.

Pest: *Bemisia tabaci* (Gennadius)

Spread

Through planting material and wind

Damage

White small flies and pupa can be seen on the lower side of leaves (Fig. 8). Adults and nymphs are covered with white waxy and powdery scale. They feed on top of the plants. Whiteflies suck the plant sap and devitalize the plant. They cause yellowish speckles with crinkling and curling of leaves. In severe infestation, black sooty mold develops.

Management

- Proper field sanitation and cultivation of CMD resistant varieties
- Installation of yellow sticky trap 1.5 x 1 feet size @ 15-20 ha^{-1}
- Releasing parasitoids *Encarsia* or *Erectmocerus* @ 0.4 $sq.ft^{-1}$
- Spraying entomopathogenic fungi, *Aschersonia, Verticillium, Metarhizium* or *Beauveria* having at least 1 x 10^{8} cfu.
- Spraying either ICAR-CTCRI developed *'Nanma'* 7ml L^{-1} or neem oil 10 ml L^{-1}
- Spraying of any one of the insecticides viz., Thiamethoxam 25 WG @ 0.3 L^{-1}, Imidacloprid 17.8 SL @ 0.3 L^{-1}, only if necessary

Fig. 8. *Bemisia tabaci* infestation in cassava leaves

SPIRALLING WHITEFLY

This is a polyphagous pest infesting a wide range of plants. The flies are snow-white in colour and seen particularly on the lower surface of the leaves. The insect incidence is more in the dry season.

Pest: *Aleurodicus dispersus* Russell

Spread

The spiralling whitefly spreads by active flight and by being transported on stem of planting materials.

Damage

Immature and adult stages suck sap, causing yellowish specks on the leaves and damage the host plant. Severely infested leaves are covered with black sooty mold due to the secretion of honeydew by whitefly, and that hinders the photosynthesis of the host plant. Premature fall of leaf is one of the symptoms of its severe infestation (Fig. 9).

Fig. 9. Spiralling whitefly infestation in cassava

Management

- Spraying neem oil (0.1%) or cotton seed oil at (0.01%)
- Spraying fish oil insecticidal soap @ (2.5 %)
- Installation of yellow sticky traps 1.5 x 1 feet size @ 15-20 ha^{-1}
- Spray Imidacloprid 17.8 SL (0.5ml L^{-1}) or Thiamethoxam 25WG (0.5g L^{-1})

CASSAVA SCALE

This mussel-shaped soft scale is a serious problem in the field as well as during the storage of planting materials. The cassava white scale is present mainly on cassava stem. The scales encrust onto the stem and multiply rapidly.

Fig. 10. Scale infestation in stem

Pest: *Aonidomytilus albus* (Cockerell)

Spread

The first instar larvae crawl over the stem and later lead a sedentary life. Wind current facilitates the distribution of crawlers to the nearby plants. The cast skins of each instars deposit over its body. The pest spreads mainly by wind, during the transport and planting of infested stem cuttings.

Damage

The insect sucks sap from cassava stems (Fig. 10). Due to sucking of sap, the stems dry up. Infestation becomes severe in cassava stems, kept for planting; the consequent drying up reduces germination. Infestation occurs in dry situations and it aggravate during prolonged moisture stress.

Management

- Storing the cuttings in hygienic conditions
- Dipping the setts in Dimethoate (0.05%) for 10 min.
- Spraying ICAR-CTCRI developed *Nanma* (7ml L^{-1}) and Imidacloprid 17.8 SL@1mL/3L

SPIDER MITES

In India four species of mites are reported, viz., *Tetranychus telarius* (Linnaeus), *T. noecaledonicus* Andre, *Eutetranychus orientalis* (Klein) and *Oligonychus biharensis* (Hirst) infesting cassava. *T. telarius*, *T. noecaledonichus* are commonly called red mites, feed on under surface of the leaf.

Pest: *Tetranychus* spp.

Damage

The infested leaf shows yellow specks along the main leaf vein, and during severe infestation, leaf withers off. Feeding by the mite on the lower surface of the leaves causes characteristic blotching (Fig. 11). Lower leaves develop yellow dots along the veins; these dots become reddish, and if the dry season is prolonged, the infestation spreads to higher leaves. Leaves dry up and fall and some plants die.

Management

- Foliar spraying of urea (0.1 %) followed by spraying of water at the beginning of mite infestation
- Spraying of the insecticides, Dicofol 18.5 EC (2.5 ml L^{-1}) or Spiromesifen 22.9 SC (1 ml L^{-1}) at the peak period

Lower surface

Upper surface

Red spider mites

Fig. 11. Mite affected leaves

TERMITE

Pest: *Odontotermes* spp.

Damage

Adults are cream-colored, tiny insects resembling ants with a dark-colored head. They attack the setts and young seedlings; eat the bark away and tunnel the pith. Affected stem cuttings grow poorly, die and rot (Fig. 12). This weakens the stems and makes them easy to break. Termite damage occurs primarily during the dry season and 20-40% plant mortality is observed.

Fig. 12. *Odontotermes* spp. attacking cassava

Management

Soil drenching with Chlorpyriphos 20 EC @ 2.5 ml L^{-1}. The biological control of termites through entomo pathogenic nematodes (EPN), viz., *Steinernema* and *Heterorhabditis*.

SWEETPOTATO
(*Ipomoea batatas* (L.) Lam.)

DISEASES

SWEETPOTATO FEATHERY MOTTLE DISEASE

Sweetpotato feathery mottle disease is a major disease in India. The virus is capable of causing major crop losses between 50 and 80% especially when in combination with other sweet potato viruses.

Causal organism: *Sweet potato feathery mottle virus* (SPFMV) which belongs to Potyviridae

Spread

Only through infected planting material, tubers/vines. Though aphids were reported as vectors in other countries, it was not observed in Indian sweetpotato fields.

Symptoms

Leaf symptoms are generally mild and transient. Different types of symptoms are exhibited in different cultivars which includes, ring spot of pink colour with green or chlorotic centre, feathering, chlorotic specks, mosaic and puckering (Fig. 13). The symptoms are seen more prominently in broad leaved cultivars and best during the active growth period between 45-60 days. Symptoms are more prominent on lower leaves.

Fig. 13. Different kinds of sweetpotato feathery mottle disease symptoms

Management

- Selection of planting materials (vine cuttings) from healthy plants which are free from SPFMV infection.
- Growing of resistant varieties like Sree Nandini and Sree Vardhini
- Use of vines obtained from meristem derived virus free plants
- Roguing of infected plants from field and following strict sanitary measures

SWEETPOTATO LEAF CURL (SPLCV)

The SPLCV have great impact on global sweetpotato production though it is not a serious problem in the Indian farmers' fields at present. Since it is a whitefly transmitted begomovirus, may be a threat to sweetpotato in future.

Fig. 14. Sweet potato leaves showing leaf curl symptom

Causal organism: Begomovirus

Spread: Through planting material, tubers/vines and white fly (*Bemisia tabaci*)

Symptoms: Leaf thickening, cupping, curling of leaves and yellow netting Fig. 14).

Management: Use of healthy planting material

CHLOROTIC LEAF DISTORTION (CLD)

The disease has no effect on yield of storage roots regardless of the severity of the disease.

Causal organism: *Fusarium denticulatum* which was originally identified as *F. lateritium*

Spread: Through planting materials

Symptoms: Leaves nearest the vine tip (1-2 youngest leaves) develop a bright

general chlorosis and are often twisted or distorted. White waxes like substances (mycelia and conidia of the pathogen) are on the upper surface of the young leaves that have just unfolded (Fig.15). As the leaves mature, they regain normal green colour with only diffused chlorosis, however the newly emerged leaves may continue to show chlorosis. The fungus primarily colonizes the surface of the growing vine tip without invading the plant. Mycelia are present on apical meristems and between halves of developing leaves that have not yet opened. Once the leaves open and expose the fungal mycelia, the mycelia appear to stop growing. As a result, individual leaves appear to recover as they mature.

Fig. 15 . Sweet potato leaves showing chlorotic leaf distortion

Management

Control measures are considered not necessary, since CLD has no effect on tuber yield.

PESTS

SWEETPOTATO WEEVIL

Sweetpotato weevil is the most serious pest of sweetpotato in the world. It causes damage in the field and in storage. All stages of the pest present throughout the year if suitable host material is available.

Pest: *Cylas formicarius* (Fabricius)

Spread: Infested vines and tubers, alternate hosts

Damage

The damage is not apparent until tubers are harvested. The major form of damage to sweetpotato is mining of the tubers by larvae. The infested tuber is often riddled with cavities, spongy in appearance, and dark in color. Even low levels of feeding induce a chemical reaction that imparts a bitter taste and terpene odor to the tubers. Larvae also mine the vine of the plant, causing it to darken, crack, or collapse. The damage by adult is less severe than by larvae. It may feed on the tubers, creating numerous small holes (Fig. 16). Adult feeding on the foliage is seldom of consequence. Yield, storage life, and plant vigour are reduced.

Management

- Careful ridging and regular hoeing
- Regular irrigation to prevent the soil from cracking
- Use of deep-rooted varieties and/or varieties with a short cycle
- Do not leave damaged crops that may regrow in the field and become a source of infestation
- Removal of weeds belonging to the *Ipomoea* genus over a distance of at least 150 m around the field
- Mulching of plastic or rice straw have shown a reduction of weevil damage
- Dipping of the planting material in 0.02% Chlorpyriphos (20 EC) (10 ml of pesticide in 10 litres of water) for 10 min. before planting

- Setting pheromone traps @10 ha^{-1}
- Foliar spray of Imidacloprid 17.8 SL @ 0.6 L^{-1} at fortnightly intervals
- Harvesting the crop at 90-110 days after planting

Fig. 16. a) Weevil attack in sweet potato vine b) Weevil attack in sweet potato tuber c) Weevil adult

SPOTTED TORTOISE BEETLE

Pest: *Aspidomorpha miliaris* (Fabricius)

Damage

Both adults and larvae eat by leaving large round holes in the leaves. Attacks are sometimes sufficiently severe to completely skeletonize the leaves and peel the stems (Fig. 17).

Fig. 17. Feeding by spotted tortoise beetle and holes left

Management

- Controlling weeds
- Spraying with neem oil (0.1%) or ICAR- CTCRI developed *Nanma* (1%)

SWEET POTATO VINE BORER

Pest: *Omphisaana stomosalis* Guenee

Damage

It is a serious emerging pest of sweet potato, which reduced the crop yield

substantially for the past few years in several parts of India. Larvae attack the collar region of the vines, bore holes become visible and they form tunnels inside the vines (Fig.18). Severe attack cause withering and wilting/drying of the plants.

Fig. 18. Vine borer feeding inside the vine

Management

- As most part of its lifecycle is inside the plant, traditional management options are not effective against the pest.
- Spraying and drenching using Thiamethoxam 25 WG @ 1 L^{-1} or Imidacloprid 17.8 SL @ 1 ml L^{-1} in collar region and in field at fortnightly intervals.

SWEET POTATO LEAF MINER

Pest: *Bedellia somnulentella* (Zeller)

Damage

Fig. 19. Sweet potato leaf miner damage

It is a newly emerged pest in India, caused heavy infestation in recent years. They attack sweet potato leaves in between upper and lower leaf surfaces, eat away leaf tissues, leaves become transparent and cause on an average 30 % leaf damage (Fig.19).

Management

As leaf miners can become a potential pest in later crop stages, it is important to manage them in early stage itself.

- Clean cultivation and timely weeding to reduce pupation of the pest is in soil
- Ploughing the field and raking of soil around the vines can kill the pupae
- Mulching with plastic sheet to avoid pupation in soil around the vines

- When there is heavy infestation, apply Spinosad 45% SC @ 0.3 ml L^{-1} at fortnightly intervals.
- Drenching collar region of vines with Imidacloprid 17.8 SL (0.5 ml L^{-1}) at fortnightly intervals

Convolvulus Hawk-moth

Pest: *Agrius convolvuli* Linnaeus

Damage

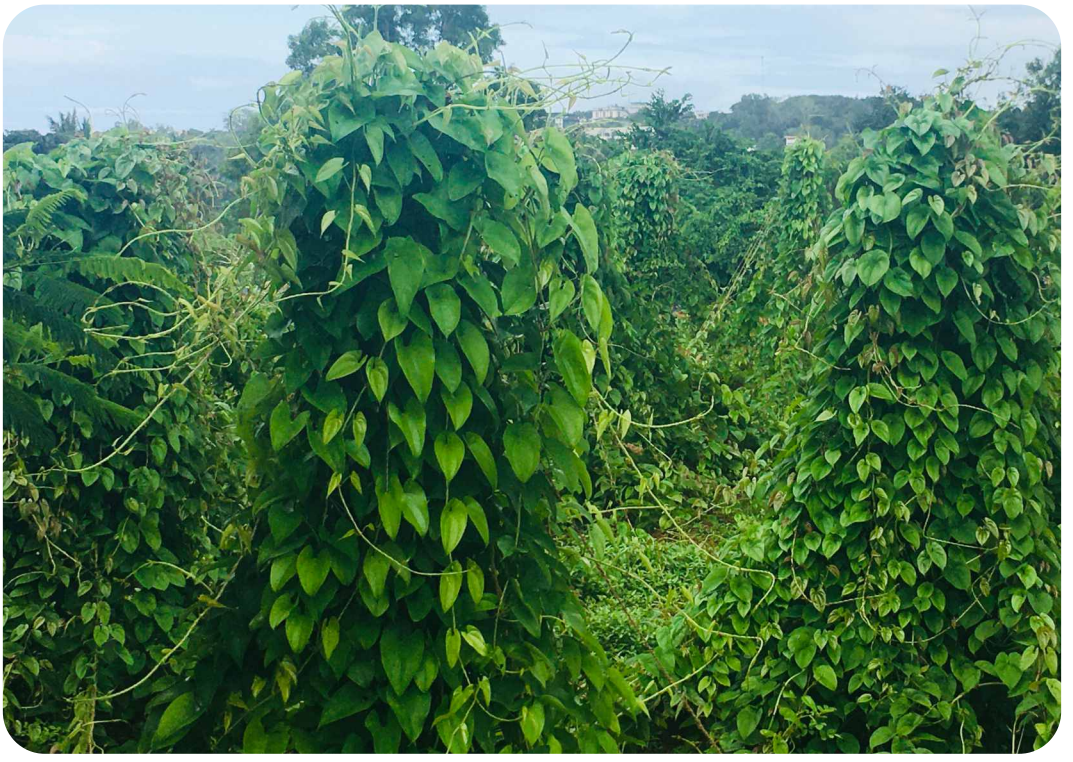
The larvae feed on the leaf blades, causing irregular holes, and may eat the entire blade, leaving only the petiole (Fig. 19). Yield losses can occur due to this pest, if heavy defoliation takes place when the crop is young. A large caterpillar can defoliate a plant and a large population of late instar larvae can defoliate a field overnight.

Fig. 19. Feeding of Hawk-moth on sweetpotato leaves

Management

- Hand picking and destroying the pest is an effective management strategy
- Spraying Emamectin benzoate 5G (0.25 g L^{-1}), or Lamda cyhalothrin 5 EC (1 ml L^{-1}) only if the infestation is severe

GREATER YAM
(*Dioscorea alata* L.)



DISEASES

ANTHRACNOSE

Anthracnose is widespread throughout tropical countries and is the most prevalent fungal disease infecting yam worldwide. In India, *Dioscorea alata* is highly susceptible to this disease which cause 30 to 60% yield loss. Long periods of rain favour epidemics of the disease because the fungal spores are spread by rain splash. Young foliage is more susceptible to anthracnose.

Causal organism: *Colletotrichum gloeosporioides* (Penzig) Penzig & Saccardo

Spread

The pathogen is not able to survive in soil for more than few weeks. However, it is able to survive between growing seasons on crop debris. Therefore, survival from one season to the next may occur but is unlikely to be important where growers practice crop rotation. The fungus infects many crops and weeds. It is possible that spores from these plants also affect the yam crop. The pathogen survives on crop debris as acervuli. Infection is favoured by wet and humid conditions.

Symptoms

The disease cause different types of symptoms depend on the cultivar. It appeared as small dark brown or black spots or lesion on leaves petioles and vines. In some cases, the lesion is often surrounded by a yellow halo, otherwise enlarged and coalesces, resulting in extensive necrosis of the leaves, leaf fall and die-back of the

Fig. 20. Anthracnose symptoms in greater yam

vines. It causes cupping of the leaves also due to necrosis on the abaxial surface which arrest the interveinal growth of the leaves. The withered leaves and stem die-back gave the plant a scorched appearance (Fig.20). So it is also called as scorch disease.

Management

- Removal of debris of the harvested crop which is the source of propagules
- Summer ploughing after harvest to expose the propagules in soil
- Selection of symptom free tubers for planting
- Soil treatment with *Trichoderma* @50g of 10^7cfu $g^{-1}$and tuber treatment with 5g in fresh cow dung slurry per kg of tuber and foliar spraying of Carbendazim, 0.05% seven times. Spraying after the initiation of symptom three times at 15 days interval and then monthly another 4 times.

LEAF SPOT

The disease is worldwide distributed on all species of yams. Several *Cercospora* spp. are recorded as causal agents of leaf spots on yams (Fig. 21). The disease is more common during warm and wet weather. Though the symptoms are severe, since occur in the later stage of the crop the yield loss is negligible.

Causal organism: *Cercospora contraria* Sydow & P. Sydow

Spread

The fungus survives on crop debris. Conidia are produced on both surfaces of infected leaves and spread by rain.

Symptoms

The symptom starts as chlorotic spots, which turns into dark brown to black necrotic spots with regular margin (Fig. 21).

Management

Spraying 0.15% (1.5 g L^{-1}) Copper oxychloride

Fig. 21. Leaf spot

YAM MOSAIC

It is the most economically important virus diseases of yams causing severe losses in yams in other nations. In India only very mild infection is seen in farmers' fields.

Causal organism

It is caused by three different viruses namely *Yam mosaic virus* (YMV) and *Yam mild mosaic virus* (YMMV) belong to *Potyvirus* group and *Yam chlorotic necrosis virus* (YCNV) belong to *Macluravirus* group.

Spread

Through planting material and tubers. Though aphid are reported as vectors in other countries, it is not observed in India.

Symptoms

The prominent symptoms include, mosaic, green vein banding, green spotting or flecking, blistering, leaf mottling, vein yellowing and leaf deformation (Fig. 22). These symptoms, which mainly affect the foliage, lead to a reduction in the photosynthetic ability of the infected plant with deleterious effects on the tuber yield.

Management

- Selection of planting material from healthy plants which are free from yam virus infection
- Use of tubers obtained from meristem derived virus free plants

Fig. 22. Different kinds of mosaic symptoms in greater yam

PESTS

YAM SCALE

This is an important pest of yams and also affects ginger, turmeric, taro and elephant foot yam.

Pest: *Aspidiella hartii* (Cockerell)

Spread: The pest problem is perpetuated through seed tubers.

Damage

In severe infestation, attacked plants show drying due to continuous sucking and desapping. The infested tubers shrivel affecting the quality, viability and marketability (Fig. 23).

Fig. 23.
Scale infestation in yam

Management

- Shade drying of tubers dipped in 1.5 % *Nanma* or neem soap solution (0.1%.) for 10 min. to make the planting material pest free
- Dipping of the infested tubers in solution prepared using 2% of cassava or yam bean seed oil (Petroleum ether extract) with 0.01% surfactant for 10 min. and shade drying

ELEPHANT FOOT YAM

(*Amorphophallus paeoniifolius* (Dennst.) Nicolson)

DISEASES

COLLAR ROT

Collar rot is the most common and devastating disease prevalent in all elephant foot yam growing areas resulting in considerable yield loss. The fungus is capable of infecting any stage of the crop, though it is usually detected in the later part of crop growth. Apart from causing major damage in field, it is the major contributor for postharvest rot during storage of harvested corms.

Causal organism: *Sclerotium rolfsii* Sacc.

Spread

Sclerotia contain viable hyphae and serve as the primary inoculum source in the disease cycle. *S. rolfsii* needs warm and wet weather to propagate, hence its growth and sclerotial formation is optimal at 27-30 ºC. Warm and humid weather, poor drainage and mechanical injuries caused during intercultural operations and by insect attack are the major predisposing factors for disease incidence.

Symptoms

The pathogen invades the collar region resulting in development of water-soaked lesions on the pseudostem just above the soil surface. The leaves turn yellow from the tip which steadily extends to other portions causing complete chlorosis of the plant. Finally, the pseudostem shrinks and the plant collapses due to rotting of the collar region (Fig. 24). The pathogen is capable of causing sudden death of the plant under favourable conditions.

Management

- Use of disease free corms for planting and removal of infected plants from the field
- Improving drainage in field and ploughing deeply to bury or kill sclerotia and hyphae of the pathogen in the field
- Rotation with non-host crops and mulch the plants with paddy straw or any other organic wastes

- Treating the corms three days before planting with combination fungicide, Mancozeb + Carbendazim @ 2 g L^{-1}. Drench the plants immediately after intercultural operations with the above fungicide @ 2 g L^{-1}. Remove infected plants carefully and give an additional drenching with the fungicide to the nearby plants
- Treating the corms with *Trichoderma* enriched cowdung slurry, three days before planting. Mix *Trichoderma* in cowdung slurry at the rate of 5 g kg^{-1} corm. Apply *Trichoderma* enriched FYM at the rate of 2.0 - 2.5 kg per pit at the time of planting and same to the collar region at the rate of 150 g per plant immediately after intercultural operations
- Removal of infected plants carefully and give an additional application of *Trichoderma* enriched vermicompost to the nearby plants

Fig. 24. Collar rot symptoms in elephant foot yam

POST HARVEST ROT

The corms are prone to several postharvest diseases due to their high moisture content and starch. Besides damaging seed corms, these pathogens inhibit sprouting and make the plants more prone to field diseases. Pre-harvest infection in the field, infected soil adhering to the corms, nematode damage and high moisture content of the corms stimulates microbiological spoilage.

Causal organism

Thirteen fungi and a bacterium cause the rot. The major ones are *Sclerotium rolfsii, Lasiodiplodia theobromae, Fusarium* spp. *Colletotrichum gloeosporioides* and *Erwinia carotovora.*

Spread

Many field disease pathogens continue to attack the corms in storage also. Pre-harvest infection in the field is enhanced with the favourable conditions at storage.

Symptoms

The affected corms show discoloration, softening of the tissue and rotting. External symptoms may or may not be there. The symptom varies with the organism (s) involved with the rotting. In some cases, white powdery appearance will be seen on the outer surface of the corm. Many a times, the surface of the tuber became completely rotten. Inside tissues shows brown/ black colour spots and the adjoining spots coalesce and form bigger irregular patches. In some cases, inner portion of the corms show putrefaction of the tissue with brown to black discolouration (Fig. 25). Chocolate brown to brown colour oozing from the lesions was also observed. Affected portion may turn to powdery mass of tissue.

Management

- Minimising injury to corms during harvesting, transporting and storage
- Removal of infected portion from the corm carefully and storing in a ventilated place
- Dipping the corms in combination fungicide, Mancozeb+Carbendazim (0.2%) for10 min. shade dry for 2-3 days and store in a ventilated place (OR)

Fig. 25. Postharvest rot symptoms in elephant foot yam corms

Treat the corms with *Trichoderma* enriched cowdung slurry (@5g kg^{-1} corm) or 0.7% ICAR- CTCRI developed bio-formulation *Nanma* for 10 min.,shade dry for 2-3 days and store in a ventilated place

MOSAIC DISEASE

This disease occurs in all major elephant foot yam growing areas and cause yield loss up to 38%.

Causal organism: This disease is caused by *Dasheen mosaic virus* (DsMV) which belongs to Potyvirus group.

Spread

This disease is mainly transmitted through infected planting material and in field through aphids (*Myzus persicae* or *Aphis gossypii*).

Symptom

Various types of symptoms like mild mottling, mosaic, leaf puckering, cupping, fili formy, leaf thickening and narrowing like shoe string are observed on elephant foot yam plants (Fig.26).

Management

- Selection of planting material from healthy plants which are free from DsMV infection
- Growing of plants obtained through meristem tip culture
- Roguing of infected leaves, self-sown elephant foot yam or taro plants
- Vector control- spraying of Imidacloprid 17.8 SL (0.3 ml L^{-1} or Thiamethoxam 25 WG (0.3-0.4 g L^{-1}) at 14 days interval

Fig. 26. Symptoms of DsMV infection in elephant foot yam

PESTS

YAM MEALY BUG

Pest: *Rhizoecus amorphophalli* Betram

Damage

This mealy bug desaps the leaf and the high incidence causes drying of leaves and withering.

Management

- Making sure that planting material and field are free from mealybugs
- Cutting and burning the plants, which are severely infested
- Whitefly traps are equally good to attract adult bugs (1.5 x 1 feet size @ 15-20 ha $^{-1}$)
- Natural predator of mealy bug, *Cryptolaemus montrouzieri* @10 per plant can be used against the pest
- Treating with cassava-based biopesticides, cassava seed extract and also 2% of cassava or yam bean seed oil provides proper control over the pest

Fig. 27. Mealy bug infestation in elephant foot yam

DEFOLIATOR

Pest: *Sphenoraia hopei* Beenen

Damage

Fig. 28. Defoilator infection by chrysomelid beetle

For the last 2-3 years, the shoots were attacked by a chrysomelid beetle, in many parts of Kerala. They feed on the shoots and also bore in them. If attack is severe the whole plant will be dried (Fig. 28).The pest could reduce the crop yield substantially in the future, and become a menace to the farmers.

Management

- Weeding and clean cultivation
- Spraying and drenching of Quinalphos 25% EC @ 2ml L^{-1}

WIRE WORM

Pest

In the last few years, wire worms/ click beetles (Elateridae) are attacking EFY in Kerala by boring in to collar region and tubers (Fig.29) . It can drastically reduce crop yield and also market value.

Damage

Adults do not damage the crop (click beetles), but the larvae or wireworms burrow into the tuber and basal portion of pseudostem while feeding. Wireworms burrow vertically or diagonally to a depth of up to 0.5 inches and causes significant yield reduction in elephant foot yam.

Fig. 29. Wire worm infestation in EFY stem

Management

- Ploughing the field before planting and adequate irrigation
- In the field where the wireworms once seen, further pest attack could be prevented by flooding the field for one week before planting
- Drenching with Fipronil 5% @ 1.5 ml L^{-1} or Chlorpyrifos 20% EC @ 2 ml L^{-1} can manage the pest to some extent

TARO
(*Colocasia esculenta* (L.) Schott)

DISEASES

TARO LEAF BLIGHT

Taro leaf blight (TLB) is the most destructive disease of taro. It is observed at various places in India causing 25-50 percent yield loss. The disease is more prevalent in northern and eastern parts of India, where the crop is widely cultivated. Both *eddoe* and *dasheen* types of taro are equally susceptible to TLB disease. Though *P. colocasiae* is mainly a foliar pathogen, it also affects the petioles and cormels of taro.

Causal organism: *Phytophthora colocasiae* Racib.

Spread

Sporangia get detached from sporangiophores and are spread by rain splash and wind-blown rain. Sporangia germinate on leaves and petioles or are washed into the soil where they can infect taro corms. Cormels and other plant parts left in the field after harvest can also act as inoculum sources for newly planted taro. The pathogen spreads to long distances through infected planting material.

Symptoms

Small, water-soaked light brown spots appear on the leaf surface. The spots enlarge rapidly, increase in size and number, coalesce and lead to complete destruction of leaf lamina (Fig. 30). Bright orange or reddish-brown exudates, oozing from the affected portion is another common symptom and

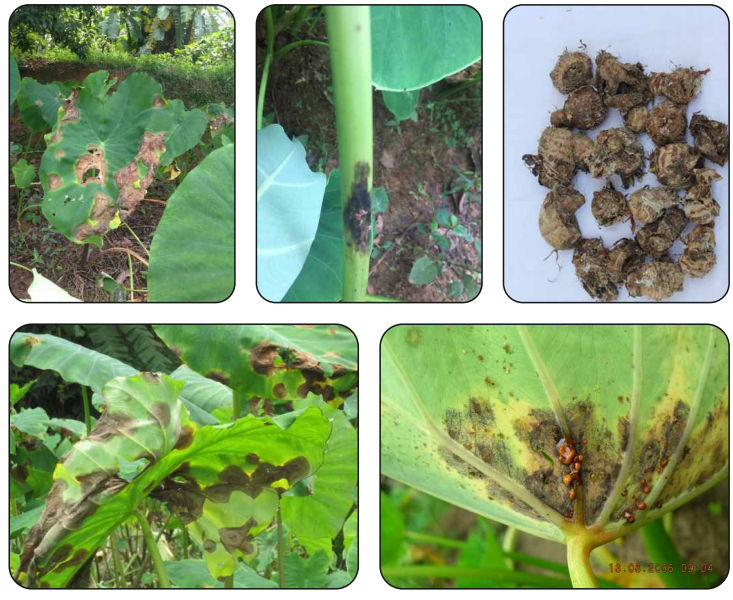


Fig. 30. Different types of symptoms of leaf blight in taro

they become hard globules later. When there is high relative humidity, whitish ring formed by mass accumulation of sporangia is seen around the edge of the lesions. Lesions develop on petioles of susceptible varieties and the brown exudates are seen oozing out from the petiole and the petiole infection causes the plants to collapse. Infected corm tissue is brown, firm, and rotting develops rapidly after harvest.

Management

- Cultivation of resistant varieties like Muktakeshi, Bhu Sree and Bhu Kripa
- Using disease - free cormels for planting and remove infected leaves and other plant parts from the field
- Crop rotation and intercropping with non-host crops like okra
- Mulching with paddy straw or any other ground mulch
- Spraying Metalaxyl - Mancozeb (0.1%) / Mancozeb (0.2%) / Potassium phosphonate (3ml L^{-1}) as prophylactic / protective measure at 45 days after planting and again at 15 days interval when significant disease incidence is observed
- Treating the cormels with *Trichoderma* enriched cowdung slurry. Mix *Trichoderma* in the cowdung slurry at the rate of 5 g kg^{-1} of cormel. Applying *Trichoderma* enriched vermicompost at the rate of 100 g per plant $^{-1}$at the time of planting and once again during intercultural operation

GHOST LEAF SPOT

Ghost spot has probably the widest distribution, and is likely to be present wherever the crop is grown. Since not causing severe damage, it is considered as minor disease.

Causal organism: *Cladosporium colocasiae* Sawada

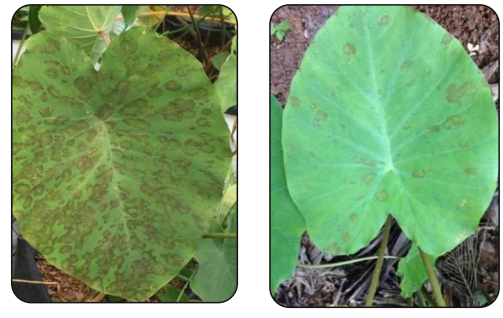


Fig. 31. Taro leaves showing ghost leaf spot symptom

Symptoms

Irregular reddish-brown with light brown centres coalesce and seen as patches, not penetrating to the under surface (Fig. 31).

Management

Since it is a minor disease and the symptoms are superficial, management practices are not needed.

MOSAIC

Causal organism:*Dasheen mosaic virus*

Symptoms

The disease is characterized by interveinal yellowing along the major veins and vein lets. In severely infected plants leaf distortion symptoms like cupping, curling and shoestring appearance are observed (Fig. 32).

Spread

Transmission through planting material (cormels) and aphids

Management

Selection of planting material from healthy plants, which are free from DsMV infection

Fig. 32. Different kinds mosaic symptoms on taro leaves

PESTS

COTTON/ MELON APHID

Pest: *Aphis gossypii* Glover

Damage

Feed on the lower surface of leaves, or on growing tip of veins, sucking nutrients from the plant. The foliage may become chlorotic and die prematurely. Feeding causes distortion and leaf curling, hindering photosynthetic capacity of the plant. Indirect damage is caused by the accumulation of honeydew produced by the aphids. Honeydew serves as a substrate for sooty molds, which blacken the leaves, reducing photosynthesis and plant vigour (Fig. 33). Aphids are vectors of *Dasheen mosaic virus.*

Fig. 33. Feeding by melon aphids and sooty mold formation

BANANA APHID

Pest: *Pentalonia nigronervosa* Coquerel

Damage

This is mainly found in the lower region of the leaf along mid rib. Damage is caused by both nymphs and adults by sucking cell sap. Black sooty molds develop on honey dew secreted by aphids on leaves (Fig. 34). Dry condition favours population flare up.

Management

- Avoid planting taro close to alternate hosts such as melon, cotton, cucumber, or other cucurbits
- Providing hedges to limit movements of aphids from a crop to another and to encourage natural enemies.
- Sprinkler irrigation or sustained rain can reduce infestation.

- Controlling ants in the field, as these will disrupt natural enemy activities.
- Destruction of infested leaves after harvesting
- Selected predators, parasitoids and *Beauveria bassiana*
- Treatment with neem oil (01%) / neem based formulation (7 ml L^{-1}) , Imidacloprid 17.8 SL (0.3 ml L^{-1})

Fig. 34. Feeding by banana aphids

WHITEFLY

Pest: *Bemisia tabaci* (Gennadius)

Damage

The females mostly lay eggs near the veins on the underside of leaves. Both the adults and nymphs suck the plant sap and reduce the vigor of the plant. When the populations are high they secrete large quantities of honeydew, which favours the growth of sooty mold (Fig. 35).

Management

- *Encarcia* sp. and *Erectmocerus* sp. are very common potential parasitoids in India
- Proper field sanitation and cultivation of resistant varieties

- Removal of crop residues and rouging of infested plants check the risk of carryover population
- Set up yellow sticky trap, install sticky cum light trap and operate between 4 to 6 am to attract adults
- Insecticide Imidacloprid 17.8 SL-1ml per 3L

Fig. 35. Feeding by whitefly and sooty mold formation

MEALY BUG

Pest: *Formicococcus polysperes* Williams

Damage

In initial infestation, the tender rhizomes were observed to be covered with whitish powdery mass of mealybugs. In severe infestation, the entire underground portions of the plant were covered with mealybugs along with the black sooty mold in patches on plant parts (Fig. 36). The infected plants showed symptoms of yellowing and withering of leaves accompanied with underdeveloped rhizomes which eventually dried prematurely.

Fig. 36. Mealy bugs along with black sooty mould in tubers

Management

- Burning the severely infested plants
- Using a mixture of neem oil and soap solution (0.1%) for spraying
- Using of ICAR-CTCRI developed bioformulations *'Shreya'* (7ml L^{-1}) followed by *'Nanma'* (7ml L^{-1}) after one week
- Spraying insecticides like Imidacloprid 17.8 SL^{-1}ml per 3L; Profenophos 50 EC@2 ml L^{-1}; Chlopyriphos 20 EC@4 ml L^{-1}; Dimthoate 30 EC@2 ml L^{-1}

LEAF THRIPS

Pest: *Thrips* sp. Haliday

Damage

Thrips hatch from an egg and develop through two actively feeding larval stages and two non-feeding stages, the pre pupa and pupa, before becoming an adult. When the weather is warm, the life cycle from egg to adult may be completed in as short a time as 2 weeks. Thrips feeding on base of leaves, affect plants' appearance with morphological deformity (Fig. 37).

Fig. 37. Thrips feeding in of taro leaves

Management

The management practices followed against mealy bugs is effective against thrips.

BANANA LACEWING BUG

Pest: *Stephanitis typicus* Distant

Damage

Mainly feed on leaves. Females insert tiny, oblong eggs in leaf tissue and cover them with dark excrement. Feeding causes small white spots on the upper leaf surface opposite the feeding site; chlorotic spots and dark excreta marks are left on the lower

leaf surface. On taro leaves, the stylets are inserted through the stomata, rupturing cell walls, and terminating in the phloem.

Management

The management practices followed against mealybugs is effective against lacewing bugs.

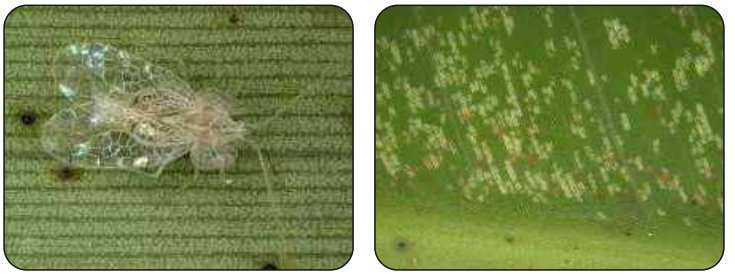


Fig. 38. Lacewing feeding in of taro leaves

RED SPIDER MITE

Pest: *Tetranychus urticae* Koch

Damage

With the increasing infestation level, the mites extract huge amount of chlorophyll resulting in development of numerous non-photosynthetic necrotic spots which in turn coalesces and gives leaves a yellowish hue appearance. Continuous feeding by the mites resulted in complete browning of leaves (Fig. 39). The severely infested leaves become dried and detach from the stem and fail to produce quality stolons.

Management

- Spraying of acaricides Abamectin 1.8 EC @ 9 and 5 g a.i ha^{-1}or Fenazaquin 10 EC@ 100 g a. i. ha^{-1}

Fig. 39 Red spider mite feeding in taro leaves

TOBACCO CATERPILLAR

Pest: *Spodoptera litura* Fabricius

Damage

The early larval stages remain together at first, later radiating out from the egg mass, stripping the interveinal leaf surface and skeletonising the leaves as they advance. Later stages eat all parts of the leaf, including the petioles (Fig.40).

Management

- Manually smash cluster caterpillars with hands when infestations are light.
- Removal and burning of heavily infested leaves
- Plouging the field thoroughly and plant mustard as trap crop
- Spraying of 5 % aqueous yam bean seed extract two times

Fig. 40. Tobacco caterpillar feeding on taro leaves

- Caterpillar eggs are parasitized by *Telenomus* sp. and *Chelonus* sp. and larvae by *Apanteles* sp. Chickens are reported to pick caterpillar larvae from taro leaves. Dipel (*Bacillus thuringiensis* subsp . *kurstaki*) also effective
- Pesticides are seldom necessary. One application of Malathion @0.05%

SILVER STRIPED HAWK MOTH

Pest: *Hippotion celerio* Linnaeus

Damage

Small-to-large holes in the leaf margin are typical damage symptom. The larvae, particularly during the later stages, feed voraciously, leading to severe defoliation; the leaves may be consumed down to ground level. The larvae also feed on young

Fig. 41. Tobacco caterpillar feeding on taro leaves

succulent stems and shoots and the newly sprouted shoots. Infested plants have large areas of leaf missing and the leaf appears ragged. The larvae can be found on the leaves during the day, often on the underside.

Management

- The larvae could be picked from the plants by hand.
- The caterpillars of hornworms are parasitized by a Hymenopteran *Charops hersei* under field conditions. *Hippotion* spp. caterpillars are also preyed upon by a wasp *Polistes* sp.
- Spraying Indoxacarb 14.5 S @ 0.5 ml L^{-1}, Spinosad 45% SC@ 0.2 ml L^{-1}, Bt@ 10^8 cfu

WHITE SPOTTED FLEA BEETLE

Pest: *Monolepta signata* Olivier

Damage

It is an important pest feeding on leaves of taro. Besides the feeding it also predisposes to *Sclerotium* rot. Minute worm-like larvae live in the soil and feed on small plant roots and root hairs. The hard forewings are black with two yellowish markings, one in front and the other behind the middle. Adults make large holes in leaves by feeding leaf tissues (Fig. 42). Adults are conspicuous and commonly found on leaves.

Fig. 42. White spotted flea beetle feeding on taro leaves

Management

- The grubs were preyed upon by *Eocanthecona furcellata* in field.
- Spraying carbaryl (01%)

TARO CORM BORER

Pest: *Aplosonyx chalybaeus* Hope

Regular and endemic pest causing 20-30% damage to the foliage and 80-90% to the corms, resulting in severe losses to the tribal farmers of North Eastern India.

Damage

Adults of the corm-borer are bright metallic blue and pink dorsal, yellowish ventral, with orange head and thorax, and feed on leaves forming circular burrows 2.5 cm (1 inch) in size. They hide in the leaf/leaf sheath. Adult beetles also hide in the cracks and crevices of the soil around the taro plant. The adult female lays eggs in clusters of 80–100 on the petiole sheath above the ground. Shortly after hatching, the tiny larvae burrow into the shoot and consume the developing tuber, causing the plant to die. Damaged plants wilt, turn yellow, give off a foul odor, and wither. The mature plants eat 20-30% of the leaves, while 80-90% of the tubers are damaged. In the case of severe infestation, crop losses are up to 50-60%.

Management

- The adults are picked and destroyed by farmers
- The corm borer incidence is reduced when taro is intercropped with ginger, sweet potato, yam, and maize than the monocrop
- Preliminary experiments suggested that entomopathogenic nematodes and fungi (*Beauveria bassiana*) cause significant increase in mortality of both adults and grubs

Fig. 43. Corm borer feeding on taro leaves

NEMATODES

CHINESE POTATO [*Plectranthus rotundifolius* - (Poir.) Spreng]

Root-knot nematode, *Meloidogyne incognita* is the major nematode species inflicting damage on Chinese potato

Symptoms

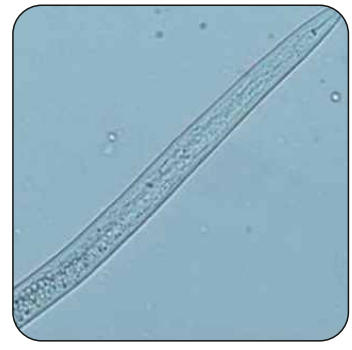
- Yellowing of leaves
- Day-wilting of plants
- Knots on tubers and malformed or distorted tubers
- Discoloration of tissues
- Hollowness of heavily infested tubers (Fig. 43)

Management

- Soil solarization of nursery beds
- Selection of nematode free planting material
- Burning and destruction of severely infested tubers and plants.

Fig. 43. a. Yellowing of leaves

b.Heavy galling on root and tubers



c.Root knot nematode *Meloidogyne incognita*

- Use of nematode antagonistic trap crop, marigold and Sree Bhadra (sweet potato variety)

- Use of *Trichoderma* enriched farmyard manure @ of 12 t ha^{-1}
- Use of newer nematicides, Fluensulfone 2% GR@ 1g per plant and Fluopyram 34.48%SC @ 0.5ml per plant

ELEPHANT FOOT YAM

Pest: *Meloidogyne incognita* and *Pratylenchus coffeae.*

Symptom

- Yellowing of leaves
- Day-wilting of plants
- Knots/galls on corms and cormels (Fig. 44)
- Brown discoloration of tissues

Fig . 44. Nematode infested elephant foot yam corms

Management

- Selection of nematode free planting material
- Following crop rotation with non-host crops
- Burning and destruction of severely infested tubers and plants
- Treatment of corms with *Trichoderma* enriched cowdung slurry at the rate of 5g kg^{-1} corm three days prior to planting
- Apply *Trichoderma* enriched FYM at the rate of 2.0-2.5 kg pit^{-1} at the time of planting
- Use of newer nematicides, Fluensulfone 2% GR@1g $plant^{-1}$ and Fluopyram 34.48% SC @ 0.5 ml per plant

YAM

Pest: *Scutellonema bradys* and *Meloidogyne incognita*

Symptoms

- Yellowing of leaves
- Cracking of tubers
- Malformed tubers
- Brown discoloration of tissues (Fig. 45)
- Tuber rot

Fig. 45. Root knot nematode infested tuber

Management

- Selection of nematode free planting material
- Following crop rotation with non-host crops
- Burning and destruction of severely infested tubers and plants
- Treatment of tubers with *Trichoderma* enriched cowdung slurry at the rate of 5g kg^{-1} tuber
- Use of *Trichoderma* enriched farmyard manure at the rate of 12 t ha^{-1}
- Use of newer nematicides, Fluensulfone 2% GR@1g per plant and Fluopyram 34.48%SC @ 0.5ml per plant

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Cassava stem and root rot

Cassava mealybug

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