



IPM SCHEDULE FOR BANANA PESTS



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IPM SCHEDULE FOR BANANA PESTS

A. INSECTS

1. Rhizome (corm) weevil (*Cosmopolites sordidus* Germar)

The grub of corm weevil attacks the plant by feeding on the corm portion and thereby making bore holes and tunnels in the corm. Infestation at the early stage reduces the plant vigour. Sick appearance and yellow lines on the top leaves are early symptoms. Where as in advanced stage of infestation, plant show tapering of the stem at crown region, reduction in leaf size, poor bunch formation and choked throat appearance due to grub damage in corms (Fig. 1 &2). The weevil spreads through infested suckers to different places.



Fig. 1 Weevil infested banana stem



Fig. 2 Banana suckers infested by weevil

Management

- Field should be cleaned by removing the dried leaves and plant debris from the field and destroy it by burning or by dumping of leaves in mulching pit and covering with soil.
- Use healthy, uninfested sucker or rhizomes for planting time. Wash the suckers and dip in a solution of Chlorpyrifos 20 EC @ 2.5 ml/l before planting.
- Soil application of carbofuron @ 20g/plant during 3rd, 5th & 7th month after planting.
- Regular monitoring of weevil by keeping banana traps viz. (i) longitudinal cut stem trap of 30 cm size @ 10-15 per acre. In case once weevil is attracted to the laid traps, place longitudinal split banana traps @ 100 ha with bio control agents like entomopathogenic fungus *Beauveria bassiana* or entomopathogenic nematode, *Heterorhabditis indica* @ 20 g/trap. These bio control agents have to be swabbed on the cut surface of the stem traps and keep the cut surface facing the ground.
- In case of post-planting infestation, spray the pseudostem and drench around the base of the tree with Chlorpyrifos 20 EC @ 2.5 ml/l. After one week spray and drench with Malathion 50 EC @ 2 ml/l.
- Cut the banana plant after harvest at the ground level and treat it with carbaryl (1g/liter) or chlorpyrifos (2.5 ml/lit) at the cut surface.

- Keep pheromone (cosmolure) trap @ 5 traps / ha. The position of traps should be changed once in a month.

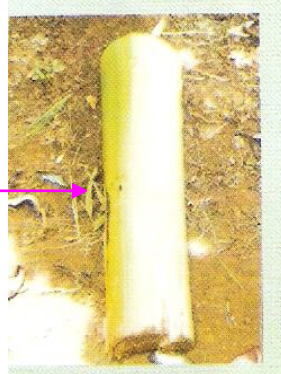


Fig. 3 & 4 Monitoring of weevil on cut pseudo stem



Fig. 5. Dead weevil due to *Beauveria bassiana*

2. Pseudo stem borer (*Odoiporus longicollis* Olivier)

The banana Pseudo stem weevil attacks the plant during flowering and bunch formation stage and cause severe yield loss by preventing the bunch development. The early symptoms are the jelly exudation on the banana stem which indicate the weevil and grub activity in side the stem. Due to feeding of stem by grubs the Pseudo stem becomes hallow and break at the apical region due to gush of wind (Fig 6& 7).



Fig. 6 Damaged due to weevil and grubs inside the Pseudo stem



Fig. 7. Breaking of weevil infected plant

Management

- Follow clean cultivation practices. In case of severe infestation uproot and burn the plants.
- Remove old and dead leaves.
- Monitor the banana weevil activity in a garden by keeping banana stem traps
 - i) Longitudinal split trap (30 cm),
 - ii) Disc-on-stump trap at the rate of 10-15 traps /ha.
- Swab the cut surface of the longitudinal split traps with 20 g of the formulation either entomopathogenic fungus, *Beauveria bassiana*, *Metarhizium anisopliae* or

- entomopathogenic nematode, *Heterorhabditis indica* (1×10^8 spores/ mg) and keep the split traps near the banana plant facing cut surface to soil(Fig. 8 & 9)
- Spray Chlorpyrifos 20 EC 2.5 ml/l + 1 ml wetting agent or Azadirachtin (5 ml/litre) for two or three times at three weekly intervals.
 - If infestation is noticed after 7 months of planting, stem injection is the only way to control. Inject Monocrotophos (150 ml/350 ml water) solution @ 2ml/plant or Dichlorvos (0.25%) in the opposite direction one at two feet height and other one at 4 feet above ground level at 30 degree angle on either side of the plant.
 - No injection should be given after flowering.
 - Injection needle should reach only to 2 or 3 leaf sheath depth without touching the central core into the bored hole.
 - After the harvest of banana bunch, cut the tree at the base and treat it with 100 ml carbaryl (2 g/ litre).
 - Avoid matocking (Leaving the plant after bunch harvest for recycling of nutrients) in weevil endemic area.
 - After harvesting, the pseudo stem has to be cut into 30 cm length bits and use it as a trap for weevil collection, instead of keeping it in heaps.



Fig. 8 *B. bassiana* on split banana stem for control of weevil



Fig. 9. Entomopathogenic nematode controlling weevil

3. Banana aphid (*Pentalonia nigronervosa*)

The aphids are persistent vectors of bunchy top disease in banana. The aphids congregate below the leaf base and their direct damage is fairly less. Severe infestation results in progressive leaf dwarfing and curling reduced bunch size and distorted fruits.

Management

- Rogue out the virus-affected plants before spraying.
- Spray Dimethoate 30 EC@ 2ml/l or Oxy-demeton methyl 25 EC @ 2ml/l at first sign of attack.

4. Leaf eating caterpillars

Hairy caterpillar, *Pericallia ricini* (Fabricius), *Asuraila* Moore, *Cretonotus gangis* Linn, *Diacrisia oblique* (Walker), *Euproctis fraterna* Moore, *Eupterote geminata* Walker cause considerable injury to the leaves. Leaf rollers, bag worms, slug caterpillars and tobacco caterpillar (*Spodoptera litura* Fab.) are some of the minor lepidopterous pest feeding on banana leaves.

Management

- Hand picking and mechanical destruction of caterpillars in early stage of attack.
- In case of sever infestation; spray Endosulfan 35 EC @ 2ml/l or Carbaryl 50 WP @ 4g/l during rainy season when incidence is noticed.
- Remove and destroy the rolled leaves with larvae and pupae of leaf rollers.

5. Flea beetles (Fruit / leaf scaring beetle): *Nodostoma sabcostatum*, *N. viridipennis*, *Colapis hypochlora*

The beetles feed on tender unfolded leaves and fruits and remain hidden under unfolded leaves. The leaves of central whirl are worst affected. The beetles scratch epicarp of the tender fruits, blemish them and render unmarketable.

- Follow clean cultivation and sanitation in the orchards.
- Spray Endosulphan (0.05%) or carbaryl (0.1%) during April-September coinciding with emergence of new growth.
- Repeat spray at fortnightly interval if required.
- Stop spraying 15 days before bunch harvesting.

6. Burrowing nematode (*Radopholus similis*)

Symptom

The infected banana plants show yellowing initially which later on appear stunted as the nematode populations increase. Later, the nematodes enter into the rhizomes also and are transmitted to healthy field. Severe infestation cause root decay and at the time of fruit bearing, the plants collapse even with slight winds.

Management:

A: Cultural methods:

1. Fallowing for three months after banana harvest effectively suppressed the burrowing nematode population, while flood fallowing for five months destroyed not only burrowing nematode but also *Fusarium* sp.
2. Oil cakes of Neem, Mahua, Castor, Karanji etc. have shown special potential in reducing the nematodes.
3. Application of neem cake @ 400 g/plant one at planting and second after four months reduced the population of *R. similes* and increased the bunch weight.
4. Crop rotation with paddy, sugarcane, green gram, cotton or turmeric suppressed the nematode population and increased the yield.
5. Leaf extracts of *Glyricidia maculate*, *Ricinus communis*, *Crotalaria juncea*, *Glycosmis pentaphylla*, *Azadiracta indica*, *Kalanchoe pinnata*, *Piper betle* and *Moringa oleifera* were lethal to *R. similes*.
6. Inter-cropping of banana with *Crotalaria juncea* was found to reduce *R. similes* with better growth and yield of banana in India.

B. Physical methods

1. Paring the planting material by trimming away necrotic lesions and immersing it in hot water at 50-55⁰ C for 30 minutes were effective to render the planting material nematode free.

C. Biocontrol methods

1. The promising biological agents such as *Paecilomyces lilacinus*, VA mycorrhiza, *Glomus fasciculatum* and bacterium, *Pasteuria penetrans* are effective in reducing nematode population in soil and root.
2. Application of neem cake @ 500 g with *G. mosseae* per plant was found to be most effective in reducing the nematode population both in soil and roots of banana.

7. Root-knot nematode (*Meloidogyne incognita* & *M. Javanica*)

Symptoms: The root-knot nematodes are root parasites typically cause root galls on the feeder roots, affecting the uptake of nutrition and water. The above ground symptoms are stunting of the plant with yellow foliage often mistaken for nutrient deficiency symptoms.

Management

- Use of nematode free suckers at planting.
- Apply 2 kg of farm yard manure enriched with biopesticide *T. harzianum* and *P. lilacinus* at the time of planting and afterward apply 6 more times the same dosage of bio-agent enriched manure at 6 months interval.
- For a standing crop also apply 2 kg of farmyard manure enriched with bio-pesticide. *T. harzianum* and *P. lilacinus* to be repeated 6 monthly intervals.
- Apply Carbofuran 3G @ 25 g/pit in the field at the start of the monsoon rains.
- The treatment of suckers either by using hot water or chemical before planting as suggested for the control of *R. similes*.

B. DISEASES

8. Sigatoka Leaf Spot Disease (*Mycosphaerella species viz. fijiensis, M. musicola* & *M.eumusae*)

Among diseases caused by fungi, the leaf spot (Sigatoka) caused by *Mycosphaerella fijiensis* (Black Sigatoka), and *M.musicola* (Yellow Sigatoka), and *M.eumusae* (Septoria leaf spot), are considered to be the most serious. Recently Septoria leaf spot has also been recorded to cause significant loss.

Damage:

- Severely affected areas is unsuitable for export because of the shortened shelf life.
- The quality of banana is drastically reduced.
- Small fingers, premature ripening and feel splitting are associated with the disease.
- Bunches are harvested from affected orchards ripens during transit.

Symptoms: The earliest visible symptoms of Sigatoka are light green, narrow speck of about 1 mm in length on the upper surface of the older leaf. The infected tissue then turns brown and dies. The extensive defoliation results in delayed flowering, reduction in number of hands and fingers.

In severe conditions, the whole leaf dries from the tip (Fig 10). Normally 15-18 functional leaves are necessary but due to Sigatoka leaf spot it is difficult to maintain even 10 leaves. The disease inflicts serious yield losses in almost all the commercial cultivars. Fingers do not fill out properly and often immature remain even after attaining the time of full maturity. Peel spitting and premature ripening are also associated with the disease.



Fig. 10. Sigatoka leaf spot

Reasons for the high disease severity

1. Closer spacing (1.25 x 1.25 m)
2. Lack of timely fungicidal sprays
3. No proper regular field sanitation
4. Poor drainage
5. Lack of crop rotation
6. Plantation of banana round the year

Mode of spread

- Through the movement of plants containing infected leaves.
- Through wind borne inoculum of the fungus
- The diseased leaves are used to wrap banana bunches and packing material
- Short distance spread is by wind and water borne conidia.

To get normal yield, there should be

- Minimum 17 to 20 green leaves during vegetative phase (6 months after planting),
- 12 to 15 green leaves during shooting/ flowering phase and
- 7-10 leaves at the time of harvest

Preventive Measures

- Planting of banana strictly in the recommended month i.e. June and October.
- Planting of banana at the recommended spacing (1.5x1.5 m)
- Apply recommended doses of manures and fertilizers.
- Spraying of fungicide before the onset of monsoon.

Management

- Regular field sanitation
- Planting of banana strictly in the recommendation month i.e. June and October.
- Suckers should be removed in time.
- The drainage system should be proper; water logging will increase the humidity which favours infection.
- Removals of the infected leaves regularly once in a month starting from 2nd month of planting, destroys it by burning outside of field or dump it in manure pit and cover it with soil.
- Chemical control is the only option; it consists of fungicide and mineral oil combination. Spray of banana plantation with 1% petroleum oil + half the dose of recommended fungicides at 15-20 day interval starting from 2nd month after planting. The number of sprays be increased or decreased depending on the severity of disease and also the climatic condition.

Spray schedule *

- 1st Spray- Banole oil 1% +0.5 g of Carbendazim/ litre of water
- 2nd Spray- Banole oil 1% +0.5 g of Companion / litre of water
- 3rd Spray- Banole oil 1% +0.5 g of Carbendazim + 0.5 ml of calixin / litre
- 4th Spray- Banole oil 1% + Propiconazole 0.5 ml/ litre of water
- 5th Spray- Banole oil 1% +0.5 g of Carbendazim / litre of water
- 6th Spray- Banole oil 1% + Propiconazole 0.5 ml/ litre of water
- 7th Spray- Banole oil 1% + 0.5g of Carbendazim/ litre of water
- 8th Spray- Banole oil 1% + Propiconazole 0.5 ml/ litre of water

* About Banana spray oil – Banole

Petroleum oil (Banole (R), which is a biodegradable banana spray oil, is being used extensively in banana exporting countries for the management of Sigatoka diseases. This oil is known to improve effectiveness of fungicides and has the following special features:

- Penetrating effect. When the oil is sprayed along with fungicides, it improves the diffusion of active ingredients through the cuticle of the plant.
 - Fungistatic effect. The oily film on the surface of the leaf slows down the growth of the fungus.
 - It is compatible with commonly used fungicides.
- Continuous use of same systemic fungicide may cause resistance or tolerance in pathogenic population. Hence alternate spray of systemic and contact fungicides at 7-10 days intervals can minimize the risk of development of resistance in pathogens.

9. Panama wilt (*Fusarium oxysporum* f.sp.*cubense*)

Symptom: Fusarium wilt is lethal disease. The symptoms are most apparent on at least 5 months old plants although 2-3 months old plant are also killed under highly favourable conditions. The earliest signs of the disease are faint yellow streaks in the petioles of oldest lower most leaf. Two types of symptoms follow this stage. In the yellowing type there is progressive yellowing of the old leaves and eventual collapse at the petiole. In the non yellowing type, the leaf collapses at the petiole without leaf chlorosis. Often all the leaves but the youngest collapses and the heart alone remain upright.

The stem often shows more or less conspicuous longitudinal splitting of the outer leaf sheath from its outer covering. About 4-6 weeks after appearance of streaks on the petiole only the dead trunk of the pseudostem remains.

Disease cycle:

- The pathogen is a soil-borne surviving in soil mainly as chlamydospores formed by the hyphal and conidial cells.
- Infection is always through injured roots.

Mode of Spread

1. Disease spreads by infected rhizomes or suckers. Since infected suckers may not show symptoms, the pathogen can be unwittingly moved to non infected area when such materials are used.
2. Over short distances, the pathogen moves within root systems of interconnected mats, in soil, running water, and infested tool and machinery.

Reason for severity:

1. In the absence of a living banana host, it survives in previously colonized host tissue in soil.
2. Root injury due intercultural or nematodes.
3. Poor drainage.
4. Lack of crop rotation.

Management

- Restricting the movement of infected suckers to clean or non infested areas.
- Growing of paddy or sugarcane once or twice followed by banana for 2-3 cycles.
- Sanitation by immediate removal of diseased plants with surrounding soil from the field.
- Cleaning of implements used in after planting the infested field before using it in other non infested field to prevent the spread of inoculums to other areas.
- Planting of healthy suckers extracted from healthy plantation.
- Care during cultivation to avoid root injury and control of nematodes.
- Application of powder formulation of bioagents such as *Trichoderma* spp., *Pseudomonas fluorescens* and *Bacillus subtilis* @ 15 gms for 4 times once at time of planting in the planting pits and remaining doses at 3rd 5th and 7th months after planting around the plants.
- Pairing (removal of roots and outer skin of corms) and dipping the suckers for 30 minutes in Solution containing carbendazim (2g/litre) and 0.05% monocrotophos (4 ml/lit.) prior to planting followed by drenching at bimonthly intervals starting

from 5 months after planting or injection of corm with 3 ml of 2% carbendazim solution (20 g/lit) or embedding 50 mg of carbendazim capsule in corm at 5th, 7th and 9th month after planting is useful.

- Among the organic amendments tested neem cake (*Azadirachta indica*) at 250 kg/ha was the most effective treatment.
- Providing good draining facilities during rainy season.

10. Leaf Spot /Anthracnose (*Colletotrichum musae* (Berk. & Curt.) v. Arx)

Symptoms: It attacks the plants at all the stages of development. In contrast, non-latent infestation usually begins during or after harvest. Young infection appears as small black circular streaks on the flowers, skin and distal ends of banana heads. Symptoms develop on green fruit following peel injury. Mature lesions dark brown to black diamond shaped upto 8x3 cm in size. The spot are sunken and delimited from healthy green skin by a pale margin and the pulp under the lesion is often affected. On ripening, the fruit develop typical numerous small dark circular spots which enlarge, coalesce and become sunken. On maturity of lesions, salmon pink spore masses are produce.

Reason for severity

1. Severity attains during June to September when temperature remained high 30-35⁰ C accompanied by showers for a number of days.
2. Infected banana trash around plantation.
3. No proper spray schedule followed.

Mode of spared

- Disposal of conidia from lead banana trash through water, rain splash air current and insects to young banana plantation.
- Injury makes the fruit more susceptible.

Management

- Sanitation in plantation and packing house to minimize the inoculum load is necessary in order to check the disease.
- Minimizing injuries to fruit during harvest is also necessary.
- Adopting good cultural practices including removal of dead leaves from plants, refrigeration of fruits and transporting fruits in polyethylene bags.
- Spraying of Prochloraz (1m/lit) or Chlorothalonil (1.5 ml/lit) or carbendazim / Bitertanol/ Thiophenate methyl (2g/ litre) in humid weather was found to be quite effective as a pre harvest treatment before 15 days of harvest.

11. Cigar-end rot (*Verticillium theobromae*(Turc.) Masonet Hughes)

Symptoms: The damage is caused on the young bunches in the form of necrosis at the end. The skin become folded and shrunken as the infection spread slowly along the fingers, grey conidia are formed on the shriveled stalk end of the fruit i.e, like the ash of cigar. The pulp tissue shows typical dry rot that is the characteristic feature of the pathogen. Black pitting and spotting of fruit on account of drying of the finger gives an appearance of a lighted cigar. The pulp undergoes a dry rot and becomes mummified.

Reason for Severity: Frequency of disease increases during high humidity and rainfall.

Mode of Spread: Through wind and infected dying flower parts.

Management

- Removal pistils and Perianth helps in reduction of the disease.
- Bagging of developing fruits is also recommended.
- Application of Benlate @ 0.5% or Thiophenate methyl/ Bitertanol (1 g/litre) or Chlorothalonil as soon as fruits are formed significantly control the disease.

12. Finger tip or black tip rots (*Botryodiplodia theobromae* Pat.)

Symptoms: Surface growth of grayish black mycelial mass is the characteristic of the disease. The infection usually starts from persistent perianth or stem end causing progressive brownish black discoloration. The pathogen invades fruit through wound or bruised tissues and spreads rapidly in pulp turning it in black watery mass. The infected skin becomes black, soft and encrusted with pycnidial growth.

Management:

- Removal of the affected portion of the hand reduces the disease.
- Storage of the bunch at low temperature (10⁰ C) minimizes the incidence.
- Bordeaux mixture (1%) or Dithane M-45 (0.3%) may be sprayed as preventive measures.
- Pre and post-harvest application of Carbendazim/ Bitertanol/ Thiophenate methyl/ Prochloraz (1g/litre) /Rovral (2g/litre) is recommended.
- Wax emulsion with benomyl delays fruit ripening and prevents moisture loss thereby controlling the onset of rot.

13. Banana Bract Mosaic Virus

Banana Bract Mosaic is a disease of economic importance, commonly known as Kokkan disease identified Banana Bract Mosaic Virus (BBMV). Presently this virus is major constraint in southern states of India.

Cultivars affected: Nendran, Robusta, Poovan, Ney Poovan, Rasthali, Red Banana, Monthan and Karpuravalli are affected.

Transmission: Virus is transmitted through *Aphis craccivora*, *Aphis gossypii* and *Pentalonia nigronervosa* in a non-persistent manner. The virus primarily spreads through infected suckers and tissue culture plants.

Symptoms: Banana bract mosaic disease is characterized by the presence of spindle shaped pinkish to reddish streaks on pseudostem, midrib and peduncle (Fig. 12). Typical mosaic and spindle shaped reddish brown mild mosaic streaks appear on bracts of the inflorescence, peduncle and fingers also observed. The characteristic mosaic symptoms on the flower bracts give the disease its common name necrotic streaks on finger, leaf pseudo stem and mild rich are also recorded in some varieties.

In Nendran, the leaf orientation changes in such a way giving the appearance of 'Travelers palm' plants (Fig.13 & Fig.14). On lower side of the leaf, spindle streaks with

waxy coating, appear corresponding to those, on upper surface of the leaf. In Robusta, fingers of infected plants fail to develop and give the appearance of 'pencil', locally called it pencil kai' (pencil-sized fruit). When the pseudostem is cut horizontally, the necrosis was found deep seated.



Fig. 12. Reddish streaks on pseudostem and suckers (Inset)



Fig. 13. Leaf orientation like "Traveller's palm" in Nendran



Fig 14. Typical mosaic on bract

Selection of mother plants: Symptom expression is more and prominent in winter period or when maximum temperature is below 30⁰ C. During this period the mother plants can be selected based on the visual diagnosis.

Management

- For establishing new banana plantation, virus free certified propagations material should be used.
- Domestic quarantining of this disease may play a major role in limiting the spread to other states.

- The symptom expression is more and prominent in winter period when the temperature is below 30⁰C, during this period the mother plants can be selected based on visual diagnosis for tissue culture.
- Farmers must be aware of the external symptoms and the infected plants should be cut and burnt as and when noticed.
- Detection or indexing the mother plants becomes important for tissue culture companies to assure TC plants free of virus. It is necessary to use appropriate techniques like ELISA or DIBA using highly reliable antiserum.
- Aphid Vector, *Pentalonia nigronervosa* transmits this virus. It can be controlled using systemic insecticide. Spray Neemkosol 2.5 ml per litre or monocrotophos 2 ml per litre to control the aphid vector.
- Do virus indexing before and during tissue culturing.
- Virus free mother block with Vector proof net house is must for extracting suckers for mass propagation to produce disease free plants.

14. Banana streak disease

Streak virus disease has become a major threat to Poovan and other important commercial cultivars of banana. The disease was first noticed on variety “Poyo” belong to Cavendish sub group (AAA) of banana.

Transmission: BSV is transmitted in a semi- persistent manner by mealy bugs, *Planococcus citri*, *P. ficus*, *Dysmicoccus brevipes*, *Pseudococcus*, *longispirus* and *Ferrisia virgata* from banana to banana (Fig.15). This virus is not transmitted mechanically by sap or by tools used for inter-cultivation operations. The primary mode of transmission is through infected suckers.

Symptoms:

The most characteristic symptom of disease is orchlorotic and necrotic streaks on leaves. Initially small dots, with golden yellow colour develop which later it extends to form long streaks. The chlorotic streaks become necrotic giving a blackish appearance on lamina (Fig. 16 & 17). Necrotic streaks appear on midrib, pseudostem and petiole are also observed. The symptoms are erratically distributed over individual leaves as well as in leaves of same plants. The midrib mosaic symptom, one of the symptoms of Banana Mosaic (CMV), is not found with banana streak disease. Bunch choking, abortion of bunch and seediness in fruits are seen in infected plants. Diseases plants may be stunted and fruit may be distorted with a thinner peel and bunches are small in size. Various changes in symptom have been noticed in different varieties. Leaf stripping symptoms are commonly noticed in cultivars Poovan, Grande Nain and Robusta (Fig 18). However, temperature plays a major role in symptoms expression.



Fig. 15. Mealy bug feed on the
On the base of pseudostem



Fig.16 Chlorotic gold
yellow streaks



Fig. 17. Necrotic streaks



Fig. 18. Severe Streak symptom of BSD in cv. Grand Nain

Management

- Disease plants should be removed from the field and buried.
- This virus disease can be effectively managed by assuring the plants free of infection by indexing plants with appropriate techniques before mass multiplication.
- The symptom expression varies with the climate and other factors. Plants maintained at 22⁰ C in a glass house will show the symptoms. Hence mother plants can be maintained in temperature controlled glass houses for two to three months to assure the virus freeness.
- Tissue culturing also triggers formation of virus from integral sequences and causes disease.

15. Bunchy Top

It had always been assumed that BBT was caused by a virus, probably a luteovirus but double stranded (ds) RNA has been isolated from infected banana thus it appears that as ssDNA virus either causes or plays an important role in the development of BBT and an RNA virus may also be involved.

Causal organism: The virus is transmitted by the banana aphid, *Pentalonia nigronervosa*.

Symptoms

The primary symptoms of bunchy top of banana are seen if infected suckers are planted. They put forth short, narrow leaves which are chlorotic and exhibit mosaic symptoms (Fig. 19 & 20). The leaves arise in clusters, giving a rosette appearance. They are brittle with numerous dark green dots or patches with the margins rolled upward. The plants do not usually grow taller than two to three feet and they fail to put forth any fruit. The secondary infection is the premature unfurling of leaves and the development of dark green spots and streaks on the blade. These symptoms are common along the secondary veins and on the midrib and petiole. The leaves become pale and much reduced in size and when a few more leaves develop the characteristic rosette or bunchy top symptom is evident. Symptom less infection or latency is reported to last for two seasons. If late infection occurs, the plant may sometime produce a bunch but the fingers never develop to maturity. Fruits of infected plants are malformed (Fig 21 &22)



Fig. 19. Bunchy top in banana



Fig. 20 Dark green dots and streaks on petiole



Fig 21. Healthy bunch of banana

Fig.22. Bunchy top infected bunch

Transmission:

1. Primary mode of BBT transmission is through infested sucker's, corms/bits and also through tissue culture.
2. Secondary transmission is by banana black aphid *P. nigronervosa* in a semi persistent manner.
3. The spread is more during winter in plains and summer season in hills because vector population is very active.

Management

1. A community approach is needed to completely eradicate the bunchy top affected plants increase where severe incidence is noticed.
2. Affected plants should be dugout along with the whole mat, chopped into pieces and incinerate after drying them.

3. A crop holding for two to three seasons in the affected regions should be adopted to eradicate the virus disease in areas where incidence is more than 50%.
4. The only method for controlling disease is by exclusion. Thus, a strict quarantine regulation especially for hill banana in disease free areas may be the best means to prevent its entry.
5. Commercial nurseries have to get certified for the supply of virus free suckers to the banana growers.
6. Regular inspection of all banana plantations and advice to remove the disease infected plant is necessary.
7. Use only certified virus free tissue culture plants for new planting. Suckers from virus affected gardens should not be used. Even if visible symptoms are not seen on suckers, they may contain virus and might be on latency.
8. The affected plants can be killed easily by injecting weedicides. Insert a gelatin capsule containing 200 mg, 2 4-D into the corm 7 cm deep using a capsule applicator or inject 5 ml of 2, 4-D, Solution (125 mg/lit) into the pseudostem by using the injection gun. Allow injected plants to dry completely before removing them off from the field. The corms should be dugout, cut into small pieces and destroy.
9. Removal of alternate hosts, weeds, and unwanted suckers can reduce the aphid population.
10. Injection or spray of systemic insecticide like momocrotophos or Dimethoate @ 0.05 to 0.2 ml per plant at 3-4 weeks interval reduces the vector population. Imidachloprid 0.50 ml/l foliar application at monthly intervals/or when aphid population starts building. The use of insecticides to control the aphid vector does not control BBT effectively.
11. Integrated control measures recommended against BBTV includes early detection, rouging of affected plants after spraying to eliminate vector (aphid), replanting with virus free material and careful cultivation.

Preventive strategies for viral diseases

- Selection and planting of disease free vigorous suckers.
- Explants used for propagation should be indexed.
- Production and supply of virus free plants to banana growers. Removal and destruction of virus-infected plants as soon as the symptoms are noticed.
- Keeping the banana field and surrounding areas weed free, as certain weeds normally harbour the viruses.
- Spraying of banana field with systematic insecticides of regular intervals to control the insect vectors.
- It is necessary to enforce legal restriction on intra state movement in order to avoid spread of new banana bract mosaic disease as it is widely prevalent in Southern States but in other States, the incidence is very minimal.

IPM/INM SCHEDULE ON BANANA:-

- Application of 10kg Rice husk ash with 25g phosphobacteria/plant could save 20% NPK fertilizers, produce 29% more yield and generate additional net profit of Rs.39,250/ha., in Rasthali banana.

- Application of 0.5kg cement kiln flue dust per plant and 75 kg of alcohol distillery effluent/hectare could supplement 40% of recommended potassium and increase the yield by 25% in Ney Poovan banana with an additional net profit of Rs.31450/- per hectare.
- Longitudinal split banana stem traps (at the rate of 100/ha) swabbed with 20g of rice chaffy grains formulation of entomopathogenic fungus, *Beauveria bassiana*(1×10^8 spores/mg) controls the banana stem and corm weevil infesting on banana plants.
- The technology by using 50 per cent N applied through neem cake have exhibited significant reduction in root-lesion-nematode population with increased yield in six commercial cultivars of banana.
- The technology by applying Carbofuran granules @ 40 g/plant one at planting and two applications at 3 monthly intervals after planting successfully control the *P.coffeae* population and increase the yield significantly in cvs. Nendran, Karpuravalli and Monthan.
- Identified newer nematicides Rugby 10G @ 10g / plant or Caldan 4G @ 10g / plant applied one at planting and second application after three months for the management of major nematodes infesting on banana. The cost benefit ratio worked out to be much cheaper in newer nematicide Rugby 10 G and Caldan 4G compared to Carbofuran 3G and other treatments.
- The technology by using the plant extracts of *Azadirachta indica*, *Calotropis procera*, *Datura stramonium*, *Vitex negundo* and *Crotalaria juncea* extracts showed higher nematicidal properties which found very effective in reducing the nematode population with increased yield in cvs.Rasthali and Nendran.
- The technology by using biocontrol agents *P.lilacinus* with neem cake or any one of the botanicals namely viz., *Tagetes* spp., (leaf or flower extracts) or *Solanum torvum* was developed for the management of root-knot nematode in banana.
- The technology by using distillery sludge @ 2.5 kg + vermicompost @ 1 kg + neem cake @ 1 kg + poultry manure @ 2.5 kg at 3, 5, 7 MAP in cv.Karpuravalli resulted significant reduction in nematode population with increased yield.
- The technology by using neem formulations such as nimbecidine or juerken or neewin as sucker dip treatment @ 15 ml/litre water for 30 minutes was developed for the successful management of nematodes in banana.
- Marigold (*Tagetes* spp.) plants grown as an intercrop in banana field proved to be very good to manage the banana nematodes as a trap crop and to provide an additional income to the growers.
- Soil application of *Trichoderma viride* as chaffy grain formulation @ 20g/plant(2×10^8 cfu/gm) along with fym at planting and two applications at two monthly interval after planting reduces up to 80% of *Fusarium* wilt disease in tissue cultured as well as sucker derived plants of banana in cv.Rasthali (Silk-AAB).
- Spraying Petroleum oil (Banole ®) @ 1% with the half the dose of any one of the fungicides (ie. propiconazole 0.05 %, companion (0.05 %) carbendazim 0.05 % + calixin 0.05%, carbendazim 0.05 and mancozeb 0.12% in order of preference) effectively reduced the Sigatoka leaf spot incidence (85% to 97%) in all the phases of banana growth.
- Dipping of fruits in water extract of *Solanum torvum* sp. @ 50% concentration effectively reduces the Anthracnose disease of banana (more than 90%) and also increases the shelf life up to 26 days.