2 Tropical Fruit Crops

2.1 Banana, *Musa* spp.

2.1.1 Diseases

2.1.1.1 Panama Wilt, *Fusarium oxysporum* f. sp. *cubense*

Panama wilt is one of the most devastating diseases of banana in the world. The disease is prevalent in Australia, Costa Rica, Hawaii, India, Jamaica, Panama, South America, Surinam and West Africa. In India, it became widespread in Tamil Nadu, Kerala, Karnataka, Bihar and Assam. The disease is also prevalent in West Bengal, Maharashtra and Andhra Pradesh, especially where cultivars. Rasabale, Amritpani, Malbhog and Martban are grown belonging to Rasthali group.

(i) Symptoms: The entry of the fungus is facilitated by root damage caused by the nematodes (*Radopholus similis, Meloidogyne incognita*, etc.). The fungus blocks the vascular system and causes wilting (Fig. 2.1). The infected plants show characteristic yellowing of leaf blades developing as a band along the margin and spreading towards midrib. The leaf wilts and the petiole buckles. The leaf hangs between the pseudo stem while the middle of lamina is still green. All leaves eventually collapse, whereas the petioles join the pseudo stem and die. Often the emerging heart leaf gets affected. After 4–6 weeks after the appearance of first symptoms, only the pseudo stem with dead leaves hanging around it remains. Young and old plants show dwarfing or stunting. When an affected rhizome is cut transversely, the disease is seen localized in the vascular strands (Fig. 2.1). Individual strand appears yellow. Red or brown dots or streaks are also seen. The cut stem smells like rotten fish. The suckers growing out of diseased corms wilt and eventually the whole mat dies.

(ii) Epidemiology: Light textured loam and sandy loam soils, which are acidic, favour the disease development. Such soils are referred as conducive soils for fusarial infection. Soil infestation by nematodes (*R. similis, M. incognita*, etc.) predisposes the plant to infection. The pathogen is soil-borne and survives for long periods in soil as chlamydospores (even up to 20 years in the absence of its host). Ramakrishnan and Damodaran (1956) found that liming of soil reduced the survival period to 2 months. The primary spread of the disease is through infected rhizomes and secondary spread is through irrigation water. Continuous cultivation of banana in the same field results in abundant build up of inoculum in the soil.

(iii) Integrated Management

(a) Cultural, Bioagents and Botanicals: Fallowing for 21 days before planting, soil application of bioagents such as *Trichoderma viride* and *Pseudomonas fluorescens* and incorporation of cassava residue at 10 MT/ha plus rice bran was found to check the occurrence of the disease effectively.

(b) Bioagents and Botanicals: Combination of *T. viride* isolate 6 and neem cake/pongamia cake had inhibitory effect against panama wilt pathogen and increased plant growth parameters (leaf num-

P. P. Reddy, *Biointensive Integrated Pest Management in Horticultural Ecosystems*,
DOI 10.1007/978-81-322-1844-9_2, © Springer India 2014

Fig. 2.1 Panama wilt symptoms on banana

ber, leaf area, pseudo stem girth and root weight). Red soil with pH between 7 and 8 maintained at 60% moisture holding capacity was found to favour the survival of the antagonist (Satish 1996).

2.1.2 Nematodes

2.1.2.1 Burrowing Nematode, *Radopholus similis*

This nematode in India was first reported on banana from the Palghat district of Kerala by Nair et al. (1966). *R. similis* causes 'rhizome rot' or 'toppling' or 'black head' disease of banana and is becoming a serious problem.

(i) Economic Importance and Losses: The burrowing nematode is responsible for 30.76 to 41% yield loss in banana (Rajagopalan and Naganathan 1977b; Nair 1979; Reddy et al. 1996d; Vadivelu et al. 1987). Root population of *R. similis* is indirectly correlated with the yield (Charles et al. 1985).

(ii) Symptoms: It causes retarded growth and extensive root and rhizome necrosis. Wounding of banana roots by the burrowing nematode usually induces reddish-brown cortical lesions, which are diagnostic of the disease (Fig. 2.2). These lesions are clearly seen when an affected root is split longitudinally and examined immediately. Root and rhizome necrosis is manifested by varying degrees of retarded growth, leaf yellowing and falling of mature plants.

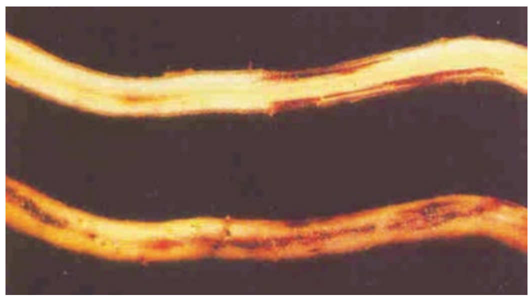

Fig. 2.2 Banana roots infected with *Radopholus similis*. *Upper*—longitudinally cut root, *lower*—complete root. (Courtesy: Union Carbide Agril. Products Co. Inc. 1986)

With the increase in nematode population, feeding roots are invaded and destroyed as fast as they are formed. The resulting setback in the uptake of plant nutrients leads to debility of the plant and production of smaller fruits. The lesioning of the primary roots together with the girdling and death of these anchor roots makes the plant prone to 'tip over' by wind action (Fig. 2.3).

(iii) Integrated Management

(a) Botanicals and Arbuscular Mycorrhizal Fungi (AMF): Integration of neem cake at 200 g/plant with *Glomus mosseae* at 100 g/plant (containing 25–30 chlamydospores/g of inoculum) was most effective in reducing the *R. similis* population both in soil and roots, while

Fig. 2.3 Premature fall of banana plants due to infection of *Radopholus similis*. *Front*—toppled plants from non-treated plots, *back*—treated plants. (Courtesy: Union Carbide Agril. Products Co. Inc. 1986)

karanj cake with *G. mosseae* gave maximum increase in fruit yield of banana. Mycorrhizal root colonization and number of chlamydospores of *G. mosseae* were maximum in neem cake amended soil (Table 2.1; Reddy et al. 2002).

(b) Cultural and Chemical: Double paring of banana suckers along with dipping in 0.5 % monocrotophos for 45 min gave maximum yield (63.283 MT/ha) and recorded higher benefit-cost ratio (2.92) (Patil et al. 1999; Table 2.2).

Integration of paring of banana suckers, dipping in 0.5 % monocrotophos solution for 45 min along with intercropping with marigold or sunn hemp gave higher fruit yield (62.838 and 61.816 MT/ha, respectively) and benefit-cost ratio (1.70 and 1.28, respectively) (Patil et al. 1999; Table 2.3).

(c) Bioagents and Botanicals: Integration of neem cake at 400 g per plant with *Pasteuria penetrans* at 100 g soil (300 spores/g)/*Trichoderma harzianum*/*T. viride* at 250 g/plant while planting was found effective in reducing nematode population both in soil and roots of banana by more than 50 % and increased plant growth parameters. The treatment should be repeated 4 months after planting. The burrowing nematodes on banana were effectively managed by integration of neem cake at 500 g and farmyard manure (FYM) enriched with *T. harzianum* at 2 kg/plant. The above treatment increased the fruit yield to 45 kg/plant and bunches came to harvest 65 to 75 days earlier (Fig. 2.4).

Soil application of FYM enriched with *Paecilomyces lilacinus* (10^6 cfu/g) and *P. fluorescens* (10^9 cfu/g) at 2 kg/plant at the time of planting and subsequent application for four times at an interval of 6 months reduced the root population of *R. similis* by 64.5 % and increased the fruit yield by 21 %. Benefit-cost ratio (calculated for marginal cost of biopesticides and returns accrued by application of biopesticides) was 3.6.

Soil application of 2 kg FYM with *P. fluorescens* (with 1×10^9 spores/g) and *Pochonia chlamydosporia* (with 1×10^6 spores/g) per plant at the time of planting and at an interval of 4 months significantly reduced the burrowing nematode by 64 % compared to control.

(d) Botanicals, Chemicals, Bioagents and AMF: Integration of neem cake at 400 g/plant, carbofuran at 20 g/plant, *Glomus fasciculatum* at 50 g/plant and *P. penetrans* at 100 g soil/plant was most effective in reducing the population of *R. similis* in banana (Channabasappa et al. 1995).

Integration of neemark, carbofuran, *P. penetrans* and *G. fasciculatum* was found effective in enhancing the plant growth and yield of banana besides raising the benefit-cost ratio (2.65) and reducing the *R. similis* population both in soil and roots (Vidya and Reddy 1998).

2.1.2.2 Spiral Nematode, *Helicotylenchus multicinctus*

(i) Economic Importance: The spiral nematode causes serious decline of banana yield to the tune of 34 to 56 % with delayed flowering. It is responsible for 33.83 % loss in yield, 55.88 % loss in number of fruits per bunch and delayed fruiting by 134 days (Vadivelu et al. 1987).

(ii) Symptoms: The spiral nematode incites discrete, relatively shallow, necrotic lesions on banana roots. *H. multicinctus* causes extensive root necrosis, die-back and dysfunction leading eventually to debility of the entire plant.

(iii) Integrated Management

(a) Bioagents/AMF and Botanicals: Significant reduction in population of *H. multicinctus* was observed in banana plants treated with *P. fluorescens* at 2 g/*G. mosseae* at 25 g along with press mud at 3 kg/plant. These treatments also enhanced the plant height, pseudo stem girth, number of

Table 2.1 Effect of *Glomus mosseae* and oil cakes on population of *Radopholus similis* and yield of banana

Treatment	Dose (g)/plant	Population of *R. similis*		Yield (kg)/plant
		Roots (10 g)	Soil (250 mL)	
G. mosseae	200	112	122	8.64
Castor cake	400	146	132	8.18
Karanj cake	400	118	128	10.34
Neem cake	400	118	112	8.91
G. mosseae + Castor cake	100 + 200	90	108	12.68
G. mosseae + Karanj cake	100 + 200	76	80	16.61
G. mosseae + Neem cake	100 + 200	48	62	14.80
Control	–	218	184	5.45
Critical Difference (CD) (P = 0.05)		*11.97*	*8.31*	*0.84*

Table 2.2 Effect of paring of suckers and dipping in insecticide solution on nematode population and yield of banana

Treatment	Nematode population in 200 mL soil	Nematode population in 5 g roots	Yield (MT/ha)	Benefit-cost ratio
Unpared sucker	365	27	57	–
Paring + drying for 72 h	209	23	59	1.17
Double paring + drying for 72 h	187	21	59	1.72
Paring + dipping in 0.5 % monocrotophos for 45 min	109	18	61	2.01
Paring + dipping in 0.75 % monocrotophos for 45 min	89	16	60	0.30
Double paring + dipping in 0.5 % monocrotophos for 45 min	85	15	63	2.92
Double paring + dipping in 0.75 % monocrotophos for 45 min	76	12	63	2.22
Paring + pralinage with carbofuran at 40 g/sucker	76	12	63	0.15

Table 2.3 Effect of paring of suckers, dipping in insecticide solution and intercropping on nematode population and yield of banana

Treatment	Nematode population in 200 mL soil	Nematode population in 5 g roots	Yield (MT/ha)	Benefit-cost ratio
Untreated control	454	29	58.439	–
Paring + dipping in 0.5 % monocrotophos	283	18	60.927	1.20
Paring + dipping in 0.5 % monocrotophos + incorporation of sunn hemp at 10 g/m^2	252	14	61.816	1.28
Paring + dipping in 0.5 % monocrotophos + incorporation of cowpea at 10 g/m^2	274	17	60.483	1.04
Paring + dipping in 0.5 % monocrotophos + incorporation of marigold at 2 g/m^2	239	15	62.838	1.70
Carbofuran at 1.25 g a.i./plant	240	14	61.860	1.58

Fig. 2.4 Application of farmyard manure enriched with bioagent to banana plant

leaves, leaf area and bunch weight (Jonathan and Cannayane 2002).

2.1.2.3 Root-knot Nematode, *Meloidogyne incognita*

The root-knot nematodes, *M. incognita* and *Meloidogyne javanica* attack bananas and may interact with other nematodes or soil pests. *M. incognita* caused 30.90% loss in fruit yield of banana (Jonathan and Rajendran 2000).

(i) Symptoms: The infected plants were stunted, having small chlorotic leaves and galled roots (Fig. 2.5). Galling of the plant roots is most commonly found in areas previously planted with sugarcane. The galls vary in size and occur at the tips as well as in other areas along the root. Roots with galled tips cease to grow and sometimes develop secondary roots above the gall. Swollen female nematodes were found inside the galled and sometimes non-galled roots.

(ii) Survival and Spread: Root-knot nematodes survive on dicotyledonous plants, which are usually present in most soils in which bananas are growing. Survival and spread also occurs with the planting material on infected roots and corms.

(iii) Integrated Management

(a) Bioagents and Botanicals: Soil application of 2 kg FYM with *P. fluorescens* (with 1×10^9 spores/g) and *P. chlamydosporia* (with 1×10^6 spores/g) per plant at the time of planting and at an interval of 4 months significantly reduced the root-knot nematode by 76% compared to control.

Application of *T. harzianum* along with FYM has reduced the root-knot nematode population in soil (from 175/100 mL soil in control plot to 42/100 mL soil in treated plot) and roots (from 17/g root in control plot to 4/g root treated plot). Further, application of the bioagent also reduced *Fusarium* wilt incidence and increased the yield by 4.53 MT/ha over control.

Jonathan and Rajendran (2000) reported that application of *P. lilacinus* multiplied on neem cake at 15–20 g/plant significantly reduced root gall index, egg masses, eggs, females and soil population of *M. incognita* in banana.

2.1.2.4 Burrowing, Spiral and Root-knot Nematode Complex

R. similis, H. multicinctus and *M. incognita* cause nematode complex in banana.

(i) Integrated Management

(a) Physical, Cultural, Chemical and Botanical: Integration of paring and hot water treatment (at 55°C for 20 min) of banana suckers along with application of carbofuran 3G (at 16.6 g/plant) and neem cake (at 1 kg/plant) at the time of planting reduced the soil and root population of nematodes besides increasing growth, development and yield of banana (Table 2.4).

2.1.2.5 Burrowing Nematode, *R. similis* and Panama Wilt, *F. oxysporum* f. sp. *cubense* Disease Complex

Incidence and losses due to Panama wilt caused by *F. oxysporum* f. sp. *cubense* is enhanced in association with the burrowing nematode, *R. similis* under high nematode population. This clearly indicates the existence of synergistic interaction between the burrowing nematode and *Fusarium* wilt pathogen in banana.

(i) Symptoms: Newhall (1958) showed that the incidence of Panama wilt in banana caused by *F. oxysporum* f. sp. *cubense* (Fig. 2.6) was doubled in the presence of *R. similis* during the experimental period of 3 months. When Gros Michel

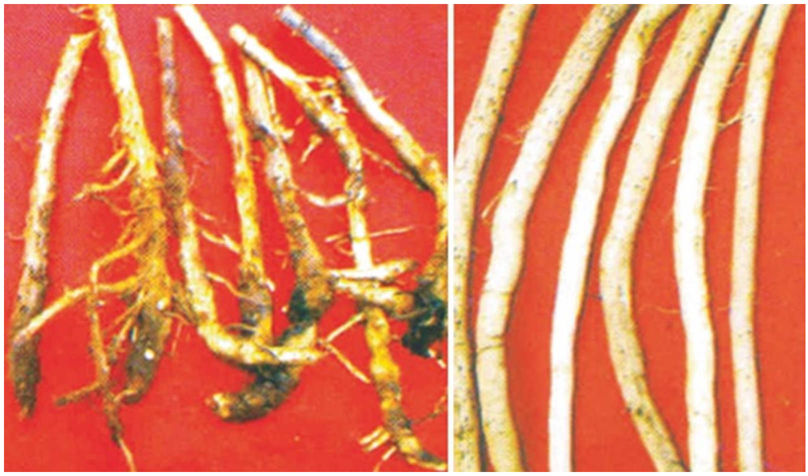

Fig. 2.5 Root-knot nematode on banana roots. *Left*—infected, *right*—healthy

Table 2.4 Management of nematode complex in banana

Treatment[a]	Fruit yield/plant (kg)	Cost: benefit ratio	Nematode population/200 ml soil			Nematode population/5 g roots		
			Rs	*Hm*	*Mi*	*Rs*	*Hm*	*Mi*
Untreated check	4.2	1:1.49	213	150	133	62	51	3
Paring + hot water treatment + carbofuran	5.8	1:2.01	97	78	40	30	19	21
Paring + hot water treatment + carbofuran + neem cake	7.6	1:2.12	74	53	48	20	11	10
Critical Difference (CD) (P = 0.05)	*0.6*	–	*10.6*	*10.6*	*13.9*	*3.0*	*3.5*	*3.3*

Hm Helicotylenchus multicinctus; Mi Meloidogyne incognita; Rs Radopholus similis

[a] Hot water treatment at 55°C for 20 min, Carbofuran 3G at 16.6 g/plant, Neem cake at 1 kg/plant

Fig.2.6 Burrowing nematode and Panama wilt disease complex in banana

Fig. 2.7 Leaf miner infestation on leaves of citrus, adult

bananas infected with *R. similis* were inoculated with *F. oxysporum* f. sp. *cubense*, the period between inoculation and the onset of wilt was also considerably shortened (Loos 1959).

Lesions formed after inoculation with both *R. similis* and *F. oxysporum* f. sp. *cubense* were more extensively necrotic and increased in size more rapidly than when *R. similis* alone was used (Blake 1966). *F. oxysporum* f. sp. *cubense* readily establishes itself in the feeder roots of banana when they are invaded by the nematode *R. similis*, but the fungus has seldom been recovered from nematode-free roots (Blake 1966).

Rishbeth (1960) suggested that nematodes breakdown resistance to Panama wilt in Lacatan bananas.

(ii) Integrated Management

(a) Bioagents, Botanicals and Chemicals: Soil application of neem cake + *T. viride* + carbendazim was found effective in reducing the burrowing nematode (*R. similis*) and wilt (*F. oxysporum* f sp. *cubense*) disease complex and in increasing the banana fruit yield (15.147 MT/ha as compared to 9.887 MT/ha in control). This treatment also gave minimum lesion index (1.1) and root-knot index (1.0) as compared to control (4.0) with benefit-cost ratio of 2.72 (Ravi et al. 2001).

2.2 Citrus, *Citrus* spp.

2.2.1 Insect Pests

2.2.1.1 Leaf Miner, *Phyllocnists citrella*

(i) Damage: It is a serious pest of nursery and young plants but even attacks the grown up citrus trees all over India. The larvae feed on the epidermis of tender leaves making serpentine mines, which are silvery in colour (Fig. 2.7). The affected leaves become distorted and crumpled. The larvae may also mine the epidermis of tender shoots. Severe infestation may cause defoliation. Since new flush is attacked, the growth is severely hampered. In case of twig attack in young plants, 'die-back' also occurs. Ventral surface is preferred by the pest, but due to high population pressure, dorsal infestation is also seen. Citrus leaf miner helps in spreading mealy bug infestation and also acts as foci of citrus canker.

Of the total damage caused by the pest complex in citrus, 30% is claimed by the leaf miner alone. Moderate infestation of one to two larvae of leaf miners per leaf on 7-year-old trees was sufficient to reduce leaves and lower yields by 30–40% in the following year. A reduction in yield up to 50% and fruit weight from 120 to 70 g was observed.

(ii) Integrated Management

(a) Two Bioagents: Combined release of *Mallada boninensis* (30 larvae/tree) and *Tamarixia radiata* (40 adults/tree) resulted in 23–26% reduction in leaf miner population.

2.2.1.2 Black Fly, *Aleurocanthus woglumi*

This is a regional endemic pest in parts of Maharashtra and Karnataka. The epidemic proportion of the pest during late 70s and 80s brought havoc on the citrus industry in Central India. The monitory loss was estimated to the tune of Rs. 25 to 50 million annually.

Fig. 2.8 Black fly on citrus

(i) Damage: Both nymphs and adults suck cell sap and secrete voluminous honeydew on which sooty mold grows wildly that leads to fungal manifestation (*Capnodium* sp.) covering entire plant due to which photosynthesis is affected. The adults lay eggs in spiral fashion on new leaves. The nymphs, which are black in colour, suck sap from leaves and devitalize the plants (Fig. 2.8). In severe cases, fruit bearing capacity of the tree is also affected. Fruits are rendered insipid in taste and blackened due to sooty mold. Such fruits fetch low price in the market.

For successful fruit set, a minimum of 2.2 % organic nitrogen in leaf is must. Five to ten black flies/cm^2 area or 50 to 100 nymphs/leaf are sufficient to reduce leaf nitrogen level below 2.2 %.

(ii) Pre-disposing Factors for Citrus Black Fly Incidence: Grown up orchards on heavy clay soils had evergreen canopies intermingling with each other thus creating a microniche underneath. Further, poor drainage in such soils adds to the dampness which together helps in pest buildup. The tall evergreen border shrubs aggravate the pest problem further by sheltering pest population and in a way provide alternative to main host citrus plants.

(iii) Integrated Management

(a) Two Bioagents: Combined release of *M. boninensis* (30 larvae/tree) and *T. radiata* (40 adults/tree) resulted in 28–30 % population, respectively.

2.2.1.3 Green Scale, *Coccus viridis*

The green scale is a serious pest of citrus and coffee in Kodagu (Karnataka) and Palani and Shevroy hills of Tamil Nadu.

(i) Damage: The females breed parthenogenetically producing 500 nymphs or crawlers. The nymphs settle on all parts of the leaves preferring to settle on the under surface of the leaves along the midribs. The nymphs suck sap and excrete honeydew. The vigour of the infested plant is reduced and the black sooty mold fungus develops on the honeydew excreted. The insect passes through 3–4 generations. In cases of severe attack, the fruits also get smudged with black sooty mold and the market value of such fruits is lost.

(ii) Integrated Management

(a) Bioagents and Chemicals: In mixed planted orchards (citrus + coffee) with more shade and less light interception (900–1,400 lx), spray of *Verticillium lecanii* at 10×10^6 spores/ml + 0.005 % quinalphos + 0.05 % teepol just before the onset of rainy season was highly effective against green scale (*C. viridis*) both in citrus and coffee. In pure citrus orchards, the combination was only effective during the rainy season (Singh 1995).

2.2.1.4 Brown Scale, *Saissetia coffeae*

The brown scale is present in citrus and coffee plantations throughout the year. Its outbreaks are recorded which cause more concern than even *Coccus viridis*.

(i) Damage: By and large *S. coffeae* behaves similar to *C. viridis*. The eggs hatch inside the body of the female and the nymphs or crawlers start emerging from the underside of the hemispherical shell. Nymphs settle on the leaves and the damaging cycle begins.

(ii) Integrated Management

(a) Bioagents and Chemicals: In mixed planted orchards (citrus + coffee) with more shade and less light interception (900–1,400 lx), spray of *Verticillium lecanii* at 10×10^6 spores/ml +0.005 % quinalphos +0.05 % teepol just before the onset of rainy season was highly effective against brown scale both in citrus and coffee. In pure citrus orchards, the combination was only effective during the rainy season. *V. lecanii* at 3×10^8 spores/mL is found effective in reducing the population of brown scale in humid areas.

2.2.2 Diseases

2.2.2.1 Damping-Off, *Phytophthora nicotianae, P. citrophthora, P. palmivora, Rhizoctonia solani, Pythium* spp.

Damping-off of seedlings in nursery bed is widespread problem in citrus industry. The disease frequently occurs in field nurseries where maintenance of sanitary measures is difficult. More than 20 % seedling mortality has been observed in Central India due to this disease (Naqvi 2001).

(i) Symptoms: Necrosis of tissue and typical damping-off of seedlings occur due to fungal infection just above the soil level. The seeds/soil infested with the pathogen results in pre-emergence rot of seeds and post-emergence damping-off of seedlings. In infested seed beds, the mortality of seedlings occurs in patches. The seedling mortality increases where excessive soil moisture accompanies the favourable temperature for the pathogen. Pathogens survive in soil either through saprophytic growth (*R. solani*) or production of resistant structures such as chlamydospores or oospores (*Phytophthora* spp.). Seedlings become tolerant to *R. solani* infection on maturity of first true leaf. Flood irrigation in flat bed system spreads the pathogen from one bed to other. However, infection of seedlings with *Phytophthora* spp. in primary nursery beds perpetuates and causes further losses to seedlings in secondary nursery beds. The budded plants show stunted, chlorotic growth with development of poor feeder roots.

(ii) Integrated Management

(a) Bioagents and Botanicals: Mixing 1 kg of *T. viride* in 40 kg of FYM and incubating the mixture for 24 h and application at 250 g mixture/m^2 is effective.

2.2.2.2 Foot Rot, Root Rot, Crown Rot, Gummosis, Leaf Fall and Fruit Rot, *Phytophthora palmivora, P. nicotianae* var. *parasitica*

The disease seems to occur especially in the high rainfall areas. Its prevalence has been reported in south India, Maharashtra, Gujarat, Punjab and Assam states. *P. nicotianae* var. *parasitica* is widespread in Assam, while *P. palmivora* is prevalent throughout India.

(i) Symptoms: Profuse gumming on the surface of the attacked bark is the main ymptom. When gumming occurs on the stem, droplets of gum trickle down the stem (Fig. 2.9). The bark gradually turns brown to dark brown and develops longitudinal cracks. A thin layer of wood tissue is also affected. When gumming starts close to the soil, the disease spreads to the main roots and then around the base of the trunk. As a result of severe gumming, the bark becomes completely rotten and the tree dies owing to girdling effect. The trees usually blossom heavily and die after the fruits mature. In such cases, the disease is called as foot rot or collar rot. The pathogen produces symptoms of decline through rotting of the rootlets, girdling of the trunk and dropping of the blighted leaves. The fruits lying on the ground are liable to invasion by the pathogen and develop brown rot.

Leaf fall and fruit rot phase of the disease is severe on mandarin oranges in heavy rainfall areas of south India. Quick shedding of leaves is

Fig. 2.9 Gummosis on main stem, foot rot and decline of Nagpur mandarin tree

the earliest symptom. The infection starts as water-soaked lesions at the leaf base. By the time the lesions extend to the whole leaf, the leaf drop off. The infection may spread to young twigs and fruits of all stages. The affected fruits show water-soaked patches on rind and subsequently drop off and rot.

(ii) Epidemiology: Severe occurrence of the disease is noticed in sweet oranges, acid lime and lemon. Heavy soil, high water table, high soil moisture, soil pH of 5.4–7.5 and temperature of 25°–28°C are conducive for disease development. Low grafting, deep planting and nearness of bud union to ground level increase the chances for soil-borne infection. The fungi survive on fallen fruits, twigs, leaves and in cracks of the tree and spread by irrigation water, rain splashes, wind and insects to stems, leaves and fruits.

(iii) Integrated Management

(a) Bioagents and Botanicals: Soil application of *Trichoderma* spp. along with organic matter in the ratio of 1:40 at 2 kg/plant or FYM enriched with *Trichoderma* spp. at 2 kg/plant is effective against the pathogen.

T. harzianum has been advocated to have a potent antagonistic action against *Phytophthora* root rot of Coorg mandarin when applied along with coffee waste, poultry manure and FYM (Sawant and Sawant 1989).

2.2.2.3 Penicillium Rot, *Pencillium digitatum, Pencillium italicum*

Green mold (*P. digitatum*) and blue mold (*P. italicum*) decays are important post-harvest diseases which occur in all citrus growing areas and often constitute the predominant type of decay (Gardner et al. 1986). Post-harvest losses of citrus fruits caused by these pathogens can account for more than 90 % of all post-harvest losses in semi-arid production areas of the world (Eckert and Eaks 1989).

(i) Symptoms: A soft water-soaked area is developed at the infection site in both the diseases. Coloured spore mass is developed at the centre of the lesion surrounded by broad band of white mycelial growth in green mold infection, whereas white mycelial growth around the spore mass of blue mold is usually not more than 2 mm wide. Both the pathogens occur frequently, but green mold grows faster at moderate temperature and contaminates the fruit. The spores of green mold are unable to infect healthy uninjured adjacent fruits while the blue mold develops nesting onto uninjured healthy fruits and may cause serious damage (Fig. 2.10).

(ii) Integrated Management

(a) Bioagent and Chemical: Combining 0.2 % glycolchitosan (antimicrobial substance) with the antagonist *Candida saitoana* was more effective in controlling green mold of oranges and lemons than either treatment alone.

2.2.2.4 Canker, *Xanthomonas campestris* pv. *citri*

Citrus canker was first reported from UK and the USA in 1933 on herbarium specimens of *Citrus medica* collected at Dehradun during 1827–1831.

http://www.springer.com/978-81-322-1843-2

Biointensive Integrated Pest Management in
Horticultural Ecosystems
Reddy, P.
2014, XVI, 277 p. 147 illus., 142 illus. in color.,
Hardcover
ISBN: 978-81-322-1843-2