

Important Diseases of Papaya in Andhra Pradesh

T. Nagalakshmi¹, G. Sarada² K. Gopal³ Y. Sharat Kumar Reddy⁴

^{1,3,4}Dept of Plant Pathology, Dr. YSR. Horticultural University, Venkataramannagudem, Andhra Pradesh, India-534101.

²Dept of Entomology, College of Horticulture, Dr. YSR. Horticultural University, Anantharajupeta, Andhra Pradesh, India-516105.

Abstract

Papaya (*Carica papaya* L.) stands as one of the most delectable fruits globally, flourishing primarily in tropical and sub-tropical climates. Despite its widespread cultivation, the potential yield and marketability of papaya are continually threatened by various diseases. The susceptibility of papaya to an array of fungal, viral, and bacterial infections, such as *Phytophthora* root rot, anthracnose, powdery mildew, stem end rot, black spot disease, papaya ring spot, and papaya leaf curl, has impeded commercial production on a global scale. Among these diseases, Papaya ring spot virus, *Phytophthora* foot rot and anthracnose, incited by *Colletotrichum gloeosporioides* Penz. emerging as the most important problems those directly affecting the economic yield. This article delves into a comprehensive exploration of the symptoms, epidemiology, and control measures associated with the predominant papaya diseases prevalent in India. Furthermore, it elucidates effective strategies and control measures that can be employed to mitigate the impact of these diseases, offering valuable insights to farmers, researchers, and stakeholders involved in papaya cultivation.

Key words: Papaya Diseases, *Carica Papaya*, Fruit Rots, Papaya Ring Spot Virus, Leaf Curl

Introduction

Papaya (*Carica papaya* L.) is grown worldwide and it is the most delicious fruit grown widely under tropical and sub-tropical climates. Diseases have been shown to be very important factors in reducing yield and marketability of papaya. The commercial papaya production has been hampered worldwide due to high susceptibility of the crop to various fungal, viral and bacterial diseases viz., *Phytophthora* root rot, anthracnose, powdery mildew, stem end rot, black spot disease and virus diseases like papaya ring spot and papaya leaf curl. Among these diseases, anthracnose caused by *Colletotrichum gloeosporioides* Penz. (Penz. and Sacc.) is the most serious disease affecting the ripened fruit. Since the fruit has very thin skin and thus rough handling during transport leads to heavy losses due to a number of rots caused by fungi and bacteria. In this chapter, the symptoms, epidemiology, and control measures for the important diseases of papaya that occur in India are described.

S.No	Name of the disease	Causal organism
Fungal diseases		
1.	Damping-Off	<i>Rhizoctonia solani</i>

S.No	Name of the disease	Causal organism
2.	Collar rot/ Foot Rot of Papaya	<i>Pythium aphanidermatum</i>
3.	Anthracnose	<i>Colletotrichum gloeosporioides</i>
4.	Powdery Mildew	<i>Oidium indicum, Oidium caricae</i>
5.	Black spot	<i>Asperisporium caricae</i>
Viral diseases		
6.	Papaya Ring Spot (PRSV)	<i>potato virus Y</i>
7.	Papaya leaf curl (PLcV)	Gemini virus
Nematodes		
8.	Nematodes	<i>Meloidoiygne incognita, Rotylenchulus reniformis</i>
Post Harvest diseases		
9.	Anthracnose	<i>Colletotrichum gloeosporioides</i> Penz.
10.	Stem end rot	<i>Botryodiplodia theobromae</i> Pat.
11.	<i>Aspergillus</i> rot	<i>Aspergillus flavus</i> Link <i>Aspergillus niger</i> Van Tiegh
12.	<i>Fusarial</i> rot/ soft rot	<i>Fusarium moniliforme</i> Sheld. <i>Fusarium oxysporum</i> Schlecht.
13.	<i>Penicillium</i> rot/ blue mold rot	<i>Penicillium expansum</i> Link.
14.	Soft white rot	<i>Rhizopus stolonifer</i> (Ehrenb. ex Fr.) Lind
16.	Sooty black rot	<i>Alternaria alternata</i> (Fr.) Keissler. <i>Curvularia lunata</i> (Wakker) Boedijn.

Fungal diseases:

Damping-Off (*Rhizoctonia solani*) : This is a disease of young seedlings. Lesions are seen on the stem at or just above soil level. The stem becomes watery and shrinks, followed by death of the plant (Chitriv and Shinde, 1977). (Figure.1)

Control: Well-drained soil should be used for planting and the crop should not be excessively irrigated. Before sowing the seeds should be treated with fungal culture of *Trichoderma harzianum* (5 g/kg of seed) or Captan (3 g/kg of seed) to protect the newly emerging seedlings. Soil treatment with neem cake at 100 g plus the application of *Trichoderma harzianum* at 50 g/m² of the nursery bed (Nethravati, 2001).



Figure1. Foot Rot of Papaya (*Pythium aphanidermatum*)

Foot Rot of Papaya (*Pythium aphanidermatum*) ((Chritriv and Shinde, 1977; Rawal and Muniyappa, 1983) : It is a severe disease of papaya. It is characterized by the appearance of water-soaked patches on the stem near the ground level. These patches enlarge rapidly and girdle the stem, causing rotting of the tissues, which then turn dark brown or black. Such affected plants withstand strong wind and topple over and die. If the disease attack is mild, only one side of the stem rots and the plants remain stunted. Fruit if formed are shriveled and malformed. Gradually the plant dies.(Figure.2)

Mode of spread and survival: Resting spore, Oospore, germinates and release zoospores which along with irrigation water spread throughout the field.



Figure2. Foot Rot of Papaya (*Pythium aphanidermatum*)

Epidemiology: High relative humidity(>90%) and water logging conditions favors the severe disease development in sick soil.

Control: Application of *Trichoderma harzianum* enriched FYM should be applied around the root zone of the plants at the time of planting. Spraying of Ridomil (0.1%) and Aliette (0.2%) plus Antracol are also helpful in checking the disease development and spread. Alternately, drenching with Dimethomorph 0.4 g + Mancozeb 2.5 g or Metalaxyl M4 + Mancozeb 64 % 2.0 g per litre of water may also be applied.

Anthracnose (*Colletotrichum gloeosporioides*): The perfect stage of *Colletotrichum gloeosporioides* identified as *Glomerella cingulata* (Karunakaran and .: Nair, 1980).The disease prominently appears on green immature fruits. The disease symptoms are in the form of brown to black depressed spots on the fruits. The initial symptoms are water-soaked, sunken spots on the fruit. The centers of these spots later turn black and then pink when the fungus produces spores. The flesh beneath the spots becomes soft and watery, which spreads to the entire fruit. Small, irregular-shaped water-soaked spots on leaves may also be seen. These spots eventually turn brown. On the fruits, the symptoms appear only upon ripening and may not be apparent at the time of harvest. Brown sunken spots develop on the fruit surface, which later on enlarge to form water soaked lesions. The flesh beneath the affected portion becomes soft and begins to rot. (Figure.3)



Figure 3: Papaya Anthracnose on leaf (*Colletotrichum gloeosporioides*):

Mode of spread and survival: The incipient infection is carried by the fruits from the field. The disease is spread through wind-borne conidia. Conidia are also spread by rain splashes.

Epidemiology: Severity of the disease on foliage is increased under conditions of excessive moisture. Older leaves are generally more susceptible. Lesions develop more slowly on the immature fruits than on the mature fruits.

Management: The affected fruits should be removed and destroyed. The fruits should be harvested as soon as they mature. Spaying with Hexaconazole (2 ml/litre of water) or Carbendazim (1 g/litre of water) or Thiophanate Methyl (1 g/litre of water) at 15 days interval effectively controls the disease. Fruits for exports should be subjected to hot water treatment or a fungicidal wax treatment.

Powdery Mildew (*Oidium indicum*, *Oidium caricae*): Munjal and Kapoor (1973) reported powdery mildew of papaya caused by *Sphaerotheca fuliginea* (Schlech ex. Fr.) Poll. from Delhi. The development of powdery mildew in papaya is promoted by high humidity (80-85%) and a temperature range of 24-26°C. The disease appears as on the foliage and pods. Infection is first apparent on the leaves as small slightly darkened areas, which later become white powdery spots. These spots enlarge and cover the entire leaf area. Severely infected leaves may become chlorotic and distorted before falling. Affected fruits are small in size and malformed. (Figure, 4)

Mode of spread and survival : The powdery mildew fungus overwinters in dormant buds. When conditions are favorable for growth of the fungus in spring, spores are produced, released, and cause new infections. Secondary spread of the disease can occur if spores are produced in these new infections

Epidemiology: The development of powdery mildew in papaya is favoured by relative humidity around 80-85% and temperature range of 24-26°C, (Rawal, 1987).

Management: The disease is effectively controlled by the spraying of Wettable Sulphur (0.3%) at 10 day intervals. The systemic fungicides like Hexaconazole (0.2%), Carbendazim (0.1%) and Thiophanate methyl (0.1%) at monthly intervals are much more effective than other fungicides.



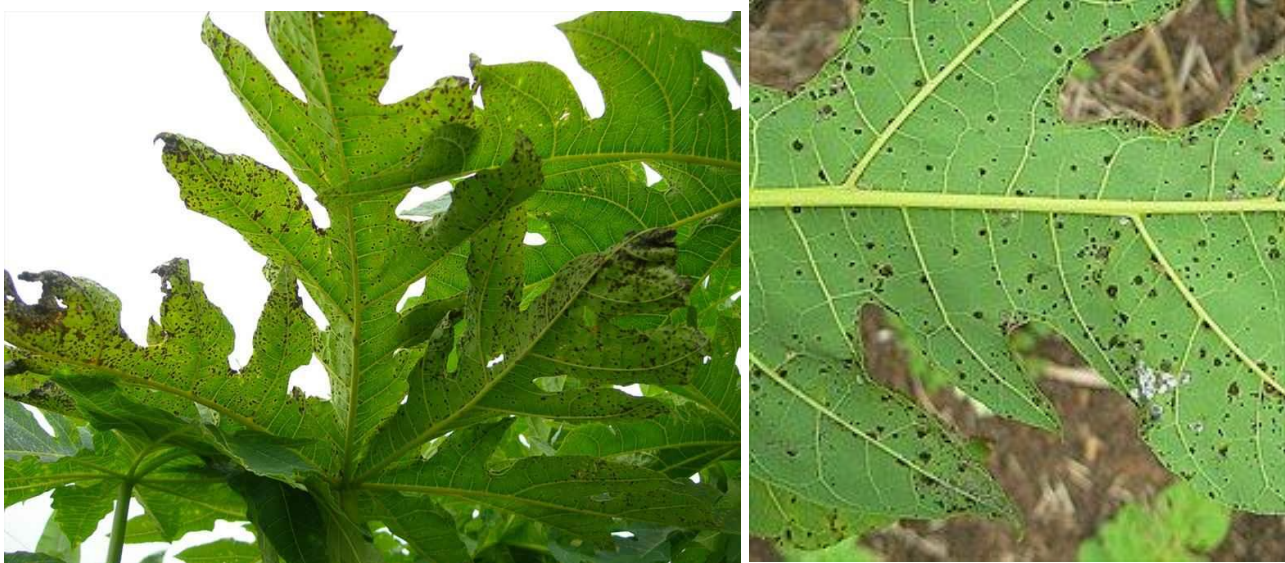
Figure 4. Powdery Mildew of papaya (*Oidium caricae*)

Black spot: (*Asperisporium caricae*; previously *Cercospora caricae*.) Leaf spots, round to irregular, 3-6 mm diameter, develop on the older leaves; they are pale brown above with a yellow margin; below, spores develop turning the spots to dark brown or black (Figure 6). If the leaves are severely infected they turn brown and die. Spots on the fruit are also brown to black and slightly sunken. Usually, the disease is a minor problem, although heavily spotted leaves result in extensive leaf fall. If this occurs, the growth of the trees is affected, and fruit yield is lower than on healthy trees. Infection of young fruit also causes them to fall, and infections on mature fruit affect their market quality.

Mode of spread and survival : The spores from the underside of the leaves are spread in wind and wind-driven rain. Long distance spread occurs when the fruits are traded at markets.

Epidemiology: The disease spreads fast in wet weather.

Management: Cultural control is particularly important in the management of this disease. Removal and burning of infected leaves and fruit as soon as disease is noticed.



(A) (B)
Figure 5 . Black spot of papaya *sperisporium caricae* (a & b)

Viral diseases:

Papaya Ring Spot virus

This virus disease was first reported in 1949. It occurs in China, France, Germany, India, Italy, Mexico, Taiwan and the U.S.A.

Papaya Ring Spot Virus (PRSV) : Papaya Ring Spot Virus belongs to the member of *Potato virus Y* (*PoTY*) group. The virus particles are rod shaped with 760 to 800 nm in length and 12 nm in width and consisting of a single protein subunit of molecular weight 36 kDa (Yeh et al., 1992). Thermal inactivation point of the virus lies between 54 and 60°C and it loses its infectivity at 10⁻³ dilution. The virus is viable upto 10 hours at 27 to 30°C.

Papaya ring spot is one of the most destructive diseases of papaya. The virus (PRSV) is a major disease of papaya and cucurbits and is found in all areas of the world where papaya and cucurbits are cultivated. In addition to papaya, it also attacks cucurbits (Figure 6 (a,b,c&d)) and used to be known as watermelon mosaic virus 1 or PRSV-p. Another closely related virus that infects only cucurbits used to be known as PRSV-w. The latter also causes severe losses in cucurbits but does not infect papaya and is now known as watermelon mosaic virus.

The disease has become a major threat to papaya cultivation throughout India by rendering orchards economically unproductive. *Papaya ringspot virus* was first reported in western India in 1958 (Capoor and Varma, 1958). Since then it has spread to different geographical locations of India irrespective of the agro-climatic conditions, and causing 90 – 100 % incidence and yield losses of up to 50-60% (Nagalakshmi *et al.*, 2019) made the plantations commercially non-viable after the second year.

The disease is characterized by vein clearing, puckering or bulging of the leaf tissues between the secondary veins and veinlets on the upper surface of the terminal leaves. Infected trees show symptoms within 2 to 3 weeks from inoculation. Symptoms consist of intense yellow mosaic on leaves, small shoestring-like new leaves (Figure 6. a), dark green and slightly sunken rings on the fruit (Figure 6. c), numerous oily-looking streaks on the stem, and stunting of the plant (Figure 6. B & d). Fruits produced after infection are usually small, exhibit lichen-like lesions and ring spots, show uneven bumps, and

have an unpleasant taste. Trees infected at a very young age remain stunted and never produce any fruit. Diseased fruits contain low sugar content. Latex quality from diseased plants is poor. (Agrios *et al.*, 2005)

Mode of spread and survival: The virus is sap transmissible. Among insect vectors *Aphis gossypii* and *Myzus persicae* are the most effective vectors. It is also transmitted by *Aphis citricola*, *Aphis craccivora* and *Rhopalosiphum maidis*. The virus is transmitted in a non-persistent manner. It is neither soil-borne nor seed-borne.

Management

Integrated management of PRSV : (Anonymous, 2018)

1. Seedling raising-Papaya seedlings should be raised under Nylon net (40-60 mesh) and spraying of Acephate @ 1.5g / litre, 3 days before planting should be given.
2. Use of border crop- 15 days prior to transplant in main field, two rows of Maize/ Sorghum/Sesbania should be grown as a border crop.
3. Spraying of Neem oil (1500 ppm) 2.5 ml/ litre + Acephate @ 1.5g / litre .
4. Use of nutrient- Urea @ 10g/liter combined with Zinc sulphate @ 1.5g and Boron @ 1.0g per litre should be applied as spray at monthly intervals up to 8 months.



(A)



(B)



(C)



(D)

Figure.6: Symptoms of Papaya Ring Spot Virus in leaf(a) leaf, (b) Plant, (c) Stem and (d) Fruit.

Papaya Leaf Curl

Papaya leaf curl virus belongs to the member of gemini virus group (Goodman, 1981, Saxena *et al.*, 1998). Besides papaya, tobacco and tomato are the additional hosts of the virus (Singh *et al.*, 1978).

The disease is characterised by severe curling, crinkling and distortion of the leaves accompanied by vein clearing and reduction of leaf lamina. The leaf margins are rolled downward and inward in the form of inverted cup. The veins get thickened and turn dark green. The leaves become leathery and brittle and petioles are twisted. Petioles twisted in a zig-zag manner. Affected plants failed to flower properly and thus produced very poor quality fruits with no market value. In advanced stages, defoliation takes place and growth of the tree is stunted.(Figure 7a,7b &7c)

Mode of spread and survival

The leaf curl virus also infects tobacco, tomato, schilli. and several other weeds and ornamental plants. The disease is mainly transmitted by white fly, *Bemisia tabaci*. It is not sap transmissible.

Management

1. Rouging and destroying of the affected plants.

2. Spray with dimethoate or triazophos @ 2 ml / litre of water to control the insect vector and reduce the spread of the disease in the field.



(A)



(B)



(C)

Figure.7: Symptoms of Papaya Leaf Curl Virus in (a) Plant and (b) Leaf (c) Fruits.

Nematodes

Nematodes (*Meloidiogyne incognita*, *Rotylenchulus reniformis*) are small, microscopic, worm like organisms, feed on papaya plant roots. The affected plants lose vigor, decline and become more susceptible to toppling down. (Agrios, G.N. 2005)(Figure 8 a&b)

Management:

• Crop rotation and should be planted in areas with clean soils.

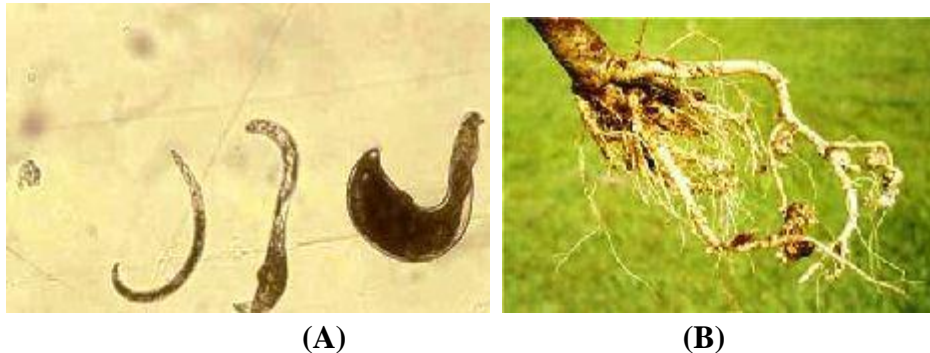


Figure 8 a&b. a) Nematode (*Meloidiogyne incognita*) b) Nematode affected roots in Papaya

Postharvest diseases of papaya

Post harvest losses due to fruit rot is a major problem during transit due to its delicate skin. It was identified as a major problem of papaya affecting fruits. Fruit rot disease incited by a number of fungi. Among those *Colletotrichum gloeosporioides* is the dominant fungus. Fruit rot occurs at different stages of fruit growth but immature fruits are highly prone to this disease.

Anthracnose

Colletotrichum gloeosporioides Penz.

Rot is soft; discolouration of skin develops in to circular light brown spots. At later stage lesion turns brown, sunken at centre with dot like black acervuli appearing on surface in concentric ring producing salmon pink spore. (Misra and Prakash 1986) (Figure 9 a&b)

Anthracnose/Stem end rot

Botryodiplodia theobromae Pat.

Water soaked spots, which turn black with greenish irregular margin. Later in the centre dark green mycelia growth appear on surface.

Aspergillus rot/ Green mold rot

Aspergillus flavus Link

Initial small-scattered spots of infection, increases rapidly on general surface in a greenish yellow conidial mass covering whole surface of the fruit. (Figure 9 a)

Aspergillus niger Van Tiegh.

Small localized patches with black conidial heads. Do not spread rapidly but degrades the pulp rapidly and becomes sunken.

Fusarial rot/ soft rot

Fusarium moniliforme Sheld.

Saxena and Saksena (1983) reported a new *Fusarial* rot of papaya. Soft rot, water soaked lesion enlarges rapidly and turns light brown, later centre of lesion gets depressed, white mycelia growth profuse, appear on surface.(Figure 9 a&b)

***Fusarium oxysporum* Schlecht.**

Soft rot, white mycelial growth but less severe localized lesion/patches, leaves purple colour/patches below mycelium.

Penicillium rot/ blue mold rot

Penicillium expansum Link.

Initial small white suppressed mycelial outgrowth with beautiful greenish blue conidial compact mass, degrades the pulp quickly, disease localized at infection region, seldom covers whole fruit.

Soft white rot

Rhizopus stolonifer (Ehrenb. ex Fr.) Lind

Soft water soaked lesions with spreading irregular margin. Later lesion increases and white mycelial growth and dark brown sporangiophores appear on surface. Fruit collapses, sometime mummifies releasing foul odor. . (ChatLopadhyay and Mustafee, 1967)(Figure 9 a&b)

Sooty black rot

Alternaria alternata (Fr.) Keissler.

Brown spots change to grayish brown, dry in texture. Surface covered with dark brown conidiophores. Invade the pulp slightly.

***Curvularia lunata* (Wakker) Boedijn.**

Circular black spots, later olive brown mycelia appear on the surface. Restricted spots and invade the pulp slightly



(A)



(B)

Figure 9. Fruit rot of papaya caused by *Colletotrichum gloeosporioides*, *Fusarium oxysporum*, *Rhizopus stolonifer*, *Aspergillus flavus* and *Penicillium expansum*

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