

DISEASES OF PASSION FRUIT (*Passiflora edulis*)

Pathogen, Symptoms, Infection, Spread & Management

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Passion fruit (*Passiflora edulis*), a native of tropical America, belongs to Passifloraceae family which comprises of about 530 species. Among these, the 'yellow' passion fruit (*Passiflora edulis flavicarpa*), purple passion fruit (*Passiflora edulis*) and Giant variety (*Passiflora quadrangularis*) are widely cultivated in Kerala. The passion-fruit plant is a woody vine (climber) with very fast, vigorous, continuous and exuberant growth. Passion fruit grows well in tropical and subtropical regions, where the climate is hot and humid. Passion-fruit can be grown on a range of soils, sands to clay loams. Generally these vines are grown on deep, relatively fertile and well drained sandy clay soil. There are many factors contributing to reduction in longevity and productivity in passion fruit plants, especially diseases of viral, bacterial or fungal etiologies, among which passion fruit woodiness, bacterial spot, root and collar rot, fusarium wilt, anthracnose and scab are the most important.

FUNGI ASSOCIATED DISEASES

Fungal diseases affect passion fruit from seedling phase to adult plant stage harming roots, stems, leaves, flowers and fruits. During post harvest stage, several fungi affect plants in the field conditions resulting in great loss during the fruit storage, transport and commercialization. Diseases affecting the above ground part of the plant are anthracnose, scab, septoriosis and alternaria spot. Diseases caused by soil microorganisms are very difficult to control, especially fusarium wilt, collar rot and crown rot.

■ COLLAR ROT

Pathogen

Homothallic strains of *Haematonectria haematococca* and *Fusarium solani*

Symptoms

- ♪ First above ground symptom is the mild die back of the plant followed by changing of leaf colour to pale green. Wilting, defoliation and finally plant death occurs resulting from the complete necrotic girdling of the plant collar.
- ♪ Necrosis generally reaches 2 to 10 cm above ground and may migrate to roots. Tumescence and fissures in the affected collar bark show purple lesion borders, where reddish structures appear under high relative humidity.
- ♪ The disease generally affects plants one to two years after planting, although it may occur earlier in replanting areas where the pathogen has previously appeared. (Domsch *et.al.*1980, Nelson *et.al.*1983)

Infection and Spread

Haematonectria haematococca survives for years as chlamydospores in the soil and spreads by any practice resulting in the movement of infested soil. Infected seedlings are also responsible for spreading the pathogen. Wounding has got a profound effect on collar rot disease. The disease is known to interact with phytophthora rot, nematodes, ants and termite attacks. The disease is favored by high temperatures and relative humidity. Resistance to collar rot increases as plants age (Domsch *et.al.* 1980, Nelson *et.al.* 1983)

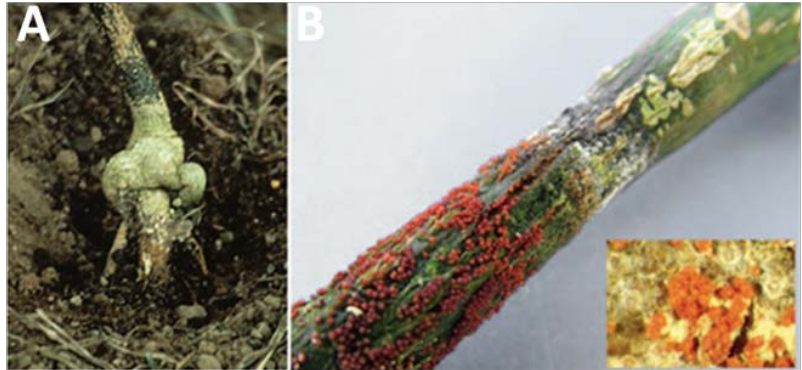


Figure 1 : (A)The swelling at the base of the vine is caused by *Fusarium solani* (B) Base rot on passion fruit showing white mycelium and crimson perithecia of *Haematonectria haematococca* .

Management

Areas previously infected with the disease should be avoided for new plantings and nurseries. Badly drained soils have to be avoided and careful irrigation has to be conducted in order to avoid excess water, water stress as well as injuries to plant collar and roots. Biweekly drenching of copper oxychloride reduce the number of plants developing collar disease. Under favorable conditions use of fungicides is ineffective. The use of a resistant root stock is an effective way to deal with the problem in the contaminated areas. (Domsch *et.al.*1980, Nelson *et.al.*1983)

■ FUSARIUM WILT

Pathogen

The fungus *Fusarium oxysporum*, which shows fast growing white pink, salmon or purple colonies in cultures with sparse to abundant aerial mycelium

Symptoms

- ♪ The glossy green leaves of young passion fruit plants show a pale green colour and mild die back. Drop of lower leaves, general plant wilting and sudden death take place as the disease progresses.
- ♪ In adult plants, the disease causes yellowing of young leaves, followed by plant wilt and death. Symptom development may be unilateral or encompasses the entire plant.



- ♪ The vascular system becomes darkened at the root, collar, stem and twig areas. The disease typically affects the xylem vascular system, leading to the impermeability of vascular walls and preventing the translocation of water to other plant parts.
- ♪ Under high relative humidity conditions, lesions and fissures can be found in the plant collar and stems. (Gardner 1989).

Infection and Spread

Resistant chlamydospores enable long term survival of the fungus in the soil. Germinated chlamydospores can infect the passion fruit plant triggering the spread. The fungus penetrates the roots and hypocotyls of plants mainly via injuries. The pathogen can spread systemically through mitochondria produced in infected vascular system and is passively transported by the transpiration flow. As the disease progresses the fungus may invade tissues adjacent to the xylem such as phloem and cortex, causing external cankers or stem fissures. Inside an orchard the fungus is spread by soil movements (machines, implements, shoes etc) and by run off or irrigation water. The disease intensity is greater in sandy soils and favored by high temperatures and relative humidity (Gardner 1989).

Management

Planting areas previously affected may be avoided. Use of healthy seedlings and careful control of weeds to avoid root injury can check the spread of disease. Another control measure that can be implemented is usage of resistant root stocks or resistant hybrids from crosses between purple and yellow passion fruits. (Gerlach and Nirenberg 1982, Nelson et.al. 1983)



Figure 2: Passionfruit vines infected with Fusarium wilt caused by *Fusarium oxysporum* f. sp. *passiflorae*.

■ ROOT AND CROWN ROT

Pathogen

Etiological agents are *Phytophthora cinnamomi* and *Phytophthora nicotianae*

Symptoms

- ♪ Phytophthora root and crown rot disease affects both adult as well as nursery plants. Mild chlorosis is followed by wilting, defoliation and death. Cortical tissues of the plants are exposed.



- ♪ Plant intumescence and bark fissures are found in the collar. Injured leaf shows a burned appearance. Occurrence of foliar blight followed by drop of flowers is observed.
- ♪ There is a change in leaf color from colorless to pale green, with leaves reaching a light copper colour. The affected plant shows burned –like black twig tips and flowers which eventually die. Large grayish- green aqueous spots can be viewed in fruits, which easily fall down. (Inch 1978)

Infection and Spread

The disease appears in specific spots and spreads from one plant to another. High disease incidence is observed in clay soils during rainy periods when temperatures vary between 26 - 30°C. Zoospores produced inside the sporangia and released in the presence of water are attracted by root exudates. Reaching the root surface, the zoospores encyst and germinate, producing hyphae that colonize the intra and inter cells of the plant roots, destroying the external cortical tissue, reaching the cambium avoiding sap circulation. Chlamydozoospores and zoospores are resistant spores capable of surviving in soil and plant tissues for several months. Under favorable environmental conditions and in the presence of a host, chlamydozoospores and oospores can germinate and produce a great number of zoospores. Cardinal temperature for growth is 37°C. (Ploetz *et.al.* 2003)

Management

The elimination of diseased tissues during the initial stages of the disease and use of Bordeaux mixture can check the spread of disease. Applications of fungicides effective against oomycetous organisms directly applied on the plant collar soon after the beginning of the rainy season may control the disease. Pulverizations with copper oxychloride at an interval of every seven to ten days can control foliar blight. (Grech and Rijkenberg, 1991)



Figure 3: Crown Rot of Passion fruit caused by *Phytophthora nicotianae*

■ ANTHRACNOSE

Pathogen

Colletotrichum gloeosporioides is the causative agent of anthracnose

Symptoms

- ♪ Intense defoliation, twig wilt and fruit rot



- ♪ Spots, initially 2–3 mm in diameter and oily in appearance, are produced on the leaf. They become dark brown, round or irregularly shaped and 1 cm in diameter. The centers of spots become brittle and may break apart. Lesions also develop on petioles.
- ♪ As foliar lesions coalesce, large areas of the leaf die, resulting, eventually, in abscission. Dark brown spots, 4–6 mm in diameter, are produced on the branches and tendrils, eventually turning into cankers. Severe lesions can cause the death of shoots and a partial blighting of the plant
- ♪ Affected flowers abort, and immature fruit abscise. Lesions on fruit initially are superficial and light brown, and later become sunken and greyish to dark brown. They may be larger than 1 cm in diameter and may reach interior portions of the fruit. As fruit mature, the spots enlarge and become oily or light tan.
- ♪ The fruit skin becomes papery and acervuli are formed on lesions here and on leaves. Under high humidity, masses of red and orange spores form in acervuli. Dieback, characterized by reduced elongation of shoots, shortened internodes and an eventual wilting and death of these structures are the symptoms normally associated with anthracnose.

Infection and Spread

The disease is most observed in the second planting year. The fungus survives and sporulates in infected tissues and crop residues of passion flower. Fungal dissemination in the field is carried out by raindrops infected seeds, seedlings and cuttings. Long raining periods and average temperatures of 27°C are the ideal conditions for the occurrence of epidemics. During winter the incidence of disease is low. The incubation time observed in seedlings is six days. Host injury increase infection, but is not an obligate requirement. Quiescent infections occur on mature fruit where by infections stop development after apressorium formation. (Jeffries *et.al.* 1990)



Figure 4 : (A) Death of Passion fruit shoots affected with anthracnose, (B) Fruit Rot due to anthracnose

Management

Use of pathogen free seedlings, pruning to eliminate affected areas, improved ventilation and light conditions help control the disease. Fruit should not be harvested during wet conditions, unduly exposed to sun light or kept for long in the absence of refrigeration. Pruning should be done when plants are dry and should be followed with applications of fungicides. Applications of mixed formulations of protective and curative fungicides are necessary during favorable



conditions. Under intense rainy periods, fungicides have to be used weekly, while during scattered rain seasons fungicides have to be used in fifteen days interval. Applications can be suspended in dry seasons with no occurrence of dew. Fungicides coated as efficient against anthracnose are benzimidazole, cupric dithiocarbamate, chlorothalonil and tebuconazole. The fungicides prochloraz and imazazil show the best results for the control of post harvest rots. *Tricoderma* spp can control the disease in field or post harvest conditions. Thermal treatment of *Passiflora edulis* fruits at 42.5- 45 for eight minutes significantly reduces the disease incidence in fruits. (Phelps 1991)

■ SCAB

Pathogen

Scab, also known as Cladosporium rot is induced by *Cladosporium oxysporum* (Simmonds 1932).

Symptoms

- ♪ Plants infected with the *Cladosporium* show small round spots on the leaves. Spots are initially translucent, later become necrotic showing greenish-grey centers which correspond to fungal fructification.
- ♪ Lesions can perforate leaves, occur on veins and cause them to be deformed leading to abscission. Similar spots may appear on bud sepals or open flowers. High numbers of lesions on flower buds or on peduncles can greatly reduce the number of flower buds.
- ♪ Twigs and twig tips initially show lesions similar to the ones on leaves, which later turn into cankers of elongated and sunken aspect that become greenish – grey, where the pathogen fructification takes place. As scar tissue forms, branches become weakened and break in the wind.
- ♪ On small fruits, symptoms are slightly sunken with small dark circular spots. On bigger fruits lesions on fruit skin grow and become corklike, prominent and brownish. Lesions do not reach the inner fruit and consequently do not affect juice quality. Several lesions may form on the same fruit causing it to be deformed and stunted. (Manicom *et.al.* 2003)
- ♪ The disease mainly affects young tissues of leaves, branches, tendrils, flower buds and fruits, when not controlled cause significant damages. In field conditions it causes death of the twigs, can delay flowering and reduce the commercial quality of fruit.



Infection and Spread

Dissemination of the fungus occurs through infected seedlings, by wind and sprinkler water. High relative humidity promotes the infection with young tissues more susceptible to disease than adult. Incubation period is seven days in fruits and twelve days in leaves. Small necrotic spots appear on seedlings which show burn like symptoms after two weeks and eventually death occurs. The disease severity is high in spring time when temperatures are mild.



Figure 5: Scab Symptoms on Passion fruit (A) Leaf (B) Fruit

Management

High densities of seedlings and excessive irrigation are to be avoided in nurseries. Fungicide applications have to be periodically carried out. Adult plants should be provided with adequate ventilation. Pruning and cleaning of plants should be followed by incineration of infected tissues. Fungicide applications have to be carried out especially during periods of intense growth and flowering. Effective fungicides are tebuconazole, strobilurin, copper oxychloride, mancozeb, captan and chlorotalonil + copper oxychloride (Manicom *et.al.* 2003).

■ SEPTORIA BLOTCH (SPOT)

Pathogen

Three species of *Septoria* namely *Septoria fructigena*, *S. passifloricola* and *S. passiflorae* cause spot disease of which *S. passifloricola* seems to be more widely spread.

Symptoms

- ♪ Leaves are the most affected organs, showing light brown slightly round necrotic spots normally encircled by a chlorotic halo. A single lesion per leaf is sufficient to cause abscission, and even leaves without visible symptoms may fall prematurely.
- ♪ When the disease reaches 15-20% of leaves in the same plant, partial or even complete leaf abscission is observed. In young twigs, lesions may promote girdling leading to wilt and twig tips death.
- ♪ Lesions on flowers are similar to those on leaves. The primary infection in the calyx may reach the stalk, causing the early drop of flowers. The infection may occur at any stage of the development of the fruits, affecting maturation or development. Leaf and fruit abscission, twig wilt and plant death may occur under disease favoring conditions (Louw 1941).



Infection and Spread

S. passiflorae produces dark, spherical and sub-epidermic pycnidia in lesions. They may erupt and become ostiolate. The conidia are released in the hyaline cirri and are agglutinated by a mucilaginous substance. Conidia contained in the cirri are spread by water, dew and insects. The fungus survives in infected tissues, mucilage in the cirrus is thought to aid survival. Prolonged rains and mild temperature favor disease development. The optimum conditions for growth of fungus are temperature ranging from 5° to 35° C (Inch 1978, Manicom *et.al.* 2003, Trujillo *et.al.* 1994).

Management

Control measures used for the above ground diseases such as the use of carbamate and benzimidazole fungicides are generally enough to avoid damages caused by septoriosiis in nurseries and field plants. Thiabendazole or thiophanate-methyl + chlorothalonil applied at 15 days interval is effective against this disease. Benomyl in a mixture or alternated with fungicides of different modes of action can be effective. (Peterson 1977, Louw 1941)

■ BROWN SPOT

Pathogen

Alternaria passiflorae and *A. alternata* are the causative agents



Figure 6 : Septoria blotch symptoms on passion fruit (A) Leaf (B) Fruit

Symptoms

- ♪ *Alternaria passiflorae* causes reddish brown spots on the leaves. Under high humidity, spots normally grow larger up to 2 cm in diameter become round and zonate.
- ♪ Spores can form a black thin mass covering the middle of the lesion, being more abundant on the abaxial surface. Abscission of the affected leaves occur rapidly causing intense defoliation.
- ♪ In twigs dark brown lesions are more elongated and may cause girdling and death of the terminal portion of these organs.
- ♪ Slightly circular spots occur on the mature fruits or when they are half way through their growth process. They are reddish brown, sunken affecting the pulp and damaging the commercial value.



- ♪ *A. alternata* causes smaller spots with chlorotic haloes on leaves and can induce defoliation. The stem lesions rarely kill vines. Spots on fruits have dark green and greasy margins.

Infection and Spread

The conidia are dispersed by wind, water and rain and occasionally by infected seedlings. The disease is more intense under high humidity and abundant rainfall, along with rising temperatures. The disease appears in fruits during the rainy season and disappears during the dry season. In young plants, after four days of inoculation first symptoms appear while typical symptoms appear ten days later. The pathogen survives in infected leaves, twigs and fruits in the plant and on the soil. Lesions are present in plants throughout the year, in sufficient numbers to ensure the continuity of the inoculum. (Brien 1940, Ram *et.al.*1977, Manicom *et.al.* 2003)



Figure 7: Passion fruit affected with brown spot disease

Management

Trimming vines to increase ventilation and penetration by fungicides can reduce disease pressure. The fungicides recommended are copper compounds, carbamates and strobilurins applied 7- 14 days intervals from the onset of symptoms and at greater intervals when conditions are less favorable. Under high humid conditions usage of mancozeb + iprodione are effective at controlling the disease. The use of more tolerant hybrids to *Alternaria spp.* applied with fungicides allowed better commercial fruit yield than the use of susceptible clones applied with fungicides (Hutton 1988, Nakasone *et.al.* 1975).

◆ VIRUS ASSOCIATED DISEASES

■ WOODINESS OF PASSION FRUIT

Pathogen

Passion fruit woodiness virus (PWV) and Cucumber woody virus (CWV)

Symptoms

- ♪ Infection causes a noticeable reduction in the development of plant. Leaves display severe mosaic, rugosity and distortion.



- ♪ Plants affected with PWV and CWV produce woody and deformed fruits. Severe mosaic, epinasty, defoliation and premature death of plants are associated with infection of PWV.
- ♪ Other common symptoms are leaf mottling and ring spot on the younger leaves. Fruits are symptom less or may show mild mottling. Chlorotic spots on the leaves and dappled or faded fruits are often found

Infection and Spread

Viruses are normally transmitted by several species of aphids in a non persistent, non-circulative way. They can also be transmitted through grafting and experimental mechanical inoculation. Mechanical transmission by knives, scissors and nails during cultural practices of trimming are observed. None of the viruses are found to be transmitted through seeds. Species of *Passiflora* when susceptible to this disease develop systemic infection, which may be symptomatic or latent (Chang 1992, Parry et.al. 2004).

Management

Chemical control of vectors is usually ineffective for the virus because of the non persistent relationship between the virus and aphid vectors. Specific recommended cultural practices can be followed for minimizing the woodiness of passion fruit. Usage of virus free seedlings of new plantings, eradication of old and abandoned orchards before starting new crops, care during trimming operations to eliminate mechanical transmission of viruses, avoiding leguminous plants which may harbor the virus near the orchard and rouging of diseased plants by means of systematic inspections during the first five months after transplanting can aid in checking the incidence and spread of potyvirus infection in passion fruit vineyards (Gioria et.al. 2000).



Figure 8: Passion fruit woodiness disease. Compare the affected, distorted fruit with the healthy, smooth fruit.

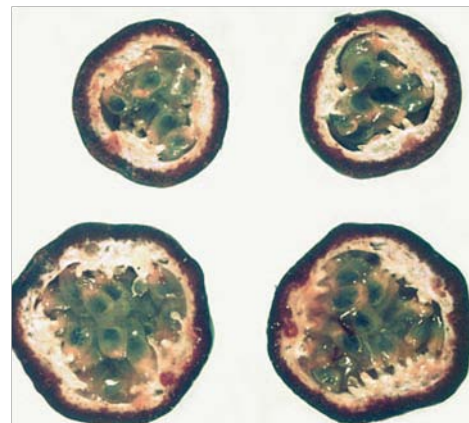


Figure 9 : Passion fruit woodiness disease. Cut fruit showing smaller cavity.





Figure 10 : Crinkled leaf symptoms of woodiness virus disease



Figure 11 : Molting of Passion fruit leaves caused by CWV

■ LEAF MOTTLE DISEASE

Pathogen

Gemini virus tentatively designated as *Passiflora* leaf mottle Virus

Symptoms

- ♪ Severe curling, distortion and mottling of leaves and fruits
- ♪ Reduced yields and fruit quality.
- ♪ Infected passion flower exhibits intense yellow mosaic of leaves and drastic reduction in the leaf lamina.
- ♪ The size of fruits per plant is small and deformed.

Infection and Spread

Virus is transmitted by white fly (*Bemisia tabaci*) from infected passion flower to bean and from the bean to bean but not from the infected bean to passion flower. Virus is not transmitted by sap inoculation or by seeds of infected plants.

Management

Usage of virus free seedlings of new plantings and eradication of old and abandoned orchards before starting new crops can check the spread of viral infection. Periodic rouging of diseased plants by means of systematic inspections can control the spread of disease. Chemical control of viruses is ineffective (Gioria et.al. 2000).



■ MOSAIC DISEASE

Pathogen

Passion fruit yellow mosaic virus (PaYMV)

Symptoms

♪ Infected plants exhibit a characteristic bright yellow mosaic, yellow net and leaf crinkle

Infection and Spread

The virus is not apparently transmitted by seeds. *Diabrotica speciosa*, a polyphagous beetle, found occasionally in passion flower plantations is the natural vector of PaYMV. (Crestani et.al. 1986)

Management

Usage of virus free seedlings of new plantings and eradication of old and abandoned orchards before starting new crops can check the spread of viral infection. Periodic roguing of diseased plants by means of systematic inspections can control the spread of disease. Chemical control of viruses is ineffective.

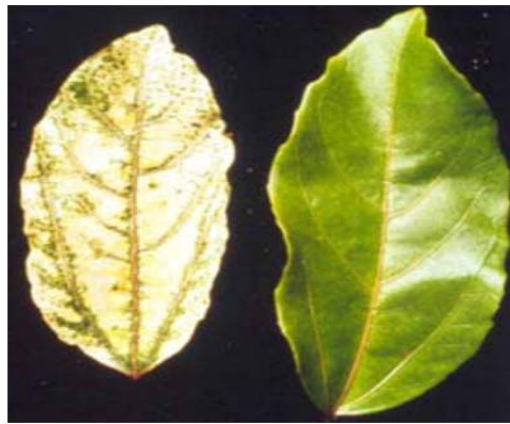


Figure 12 : Symptoms of passion fruit Yellow Mosaic Virus on affected leaf (left) Healthy leaf (right)

■ VEIN CLEARING

Pathogen

Passion fruit vein clearing virus of the Rhabdo virus family is the causal agent

Symptoms

Infected plants show clearing of the veins and reduced size of the leaves. Yield is severely affected and fruits are smaller in size

Infection and Spread

Virus is found in the perinuclear space of the cells. Infected plants show clearing of the veins and reduced size of the leaves. Yield is severely affected and fruits are smaller in size. Virus is



transmitted during grafting but not while sap inoculation. Host range and vectors of this virus are unknown (Pares et.al. 1983).

Management

Usage of virus free seedlings of new plantings and eradication of old and abandoned orchards before starting new crops can check the spread of viral infection. Periodic roguing of diseased plants by means of systematic inspections can control the spread of disease. Chemical control of viruses is ineffective (Pares et.al. 1983).

◆ BACTERIA ASSOCIATED DISEASES

■ BACTERIAL SPOT

Pathogen

Xanthomonas axonopodis pv. *passiflorae*, an aerobic gram negative rod which forms bright yellow colonies in the culture medium is the causative agent.



Figure 13 : Vein clearing on passion fruit leaves caused by passion fruit vein clearing virus

Symptoms

- ♪ Diseased plants show well defined translucent, dark green anasaruous small spots encircled by a chlorotic halo on the leaves. Under favorable conditions, lesions become bigger and turn brown in colour affecting the entire leaf causing wilt and leaf fall.
- ♪ On latter stages infection spreads through leaf veins to reach the vascular system of the vines, causing longitudinal grooves, darkening of the vascular systems and portion dry. Transversal cut of infected vines exude bacterial pus. Incidence of this disease greatly reduces fruit production and eventually causes death of plant.
- ♪ Fruits are presented with dark or brownish green, anasaruous circular or irregular lesions with well defined edges. Bacterial exudates when dry form a hard crust over the lesions. These spots penetrate the pulp, causing fruits to fall before maturation or making fruits unmarketable (Fischer *et.al* 2008).



Infection and Spread

Infection occurs through natural openings or wounds followed by colonization of the pathogens in the inter-cell spaces and vascular tissues. Disease severity increases with high temperatures and relative humidity. Local dissemination of the bacterium is favored by wind, rain, irrigation and also through infected seedlings.

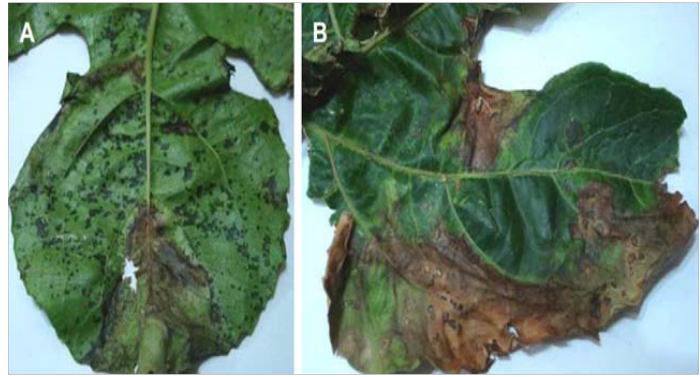


Figure 14 : Bacterial Spot caused by *Xanthomonas axonopodis* pv. *passiflorae* (A) Dark green and anarsarcous lesions (B) Brown lesions

Management

Only preventive measures can be adopted as there are no effective chemical control measures available. Seeds and seedlings should be taken from healthy plants of disease free areas. Seed thermal therapy at 50°C for 15 minutes is efficient to eliminate pathogen without affecting germination of seeds. New plantings should be done in the areas free from pathogens for at least two years. Use of wind breaks and adequate amount of fertilizers can keep the pathogens in distance. Avoid working on wet plants to prevent spreading of diseases. Use adequate amount of nitrogenous fertilizers, especially stimulates new shootings and delays maturation, making plants more susceptible to bacterium. The elimination of diseased parts of the plants and disinfection of pruning tools and hands with bactericide products, such as those using quaternary ammonium and alcohol may reduce the spread of pathogen. Copper oxychloride and its mixture with mancozeb at 7 to 15 days interval decrease the intensity of disease. However under frequent rains and favorable environmental conditions of pathogens the use of cupric fungicides or streptomycin sulfate, highly soluble in water is washed away by rain. If there is no rain or no sprinkler irrigation, the product shows effective protection (Fischer *et.al* 2008).

■ BACTERIAL GREASE SPOT

Pathogen

Pseudomonas syringae pv. *passiflorae*

Symptoms

- ♪ This disease affects under-ripe fruits. Fruits develop small dark green areas, turning into golden to brownish greasy necrotic lesions.
- ♪ On a later stage a hard crust harboring several kinds of microorganisms covers the lesions. Leaves show severe necrotic lesions surrounded by a chlorotic halo.



- ♪ Shallow canker lesions can be observed on the vines directing to the death of the tip of the vines. (Baigent and Starr 1963, Bradbury 1986)

Infection and Spread

Penetration of the bacterium occurs most frequently via stomata and hydrathodes. Injury also contributes to the infection process. Infection is favoured by high relative humidity, a water film on the leaf surface and frequent rainfall. Local dissemination of the pathogen is enhanced by wind-blown rain and irrigation, and by workers handling wet plants, whereas long-distance dispersal occurs on seedlings. (Manicom *et.al.* 2003)

Management

Seeds and seedlings should be from healthy plants and, if possible, should be obtained from disease-free areas. Alternatively, seeds should be treated at 50°C for 15–30 min. Other complementary measures that should be adopted include: planting in areas that have not had the disease for the preceding 2 years; use of wind breaks; avoiding work on plants when they are wet; disinfecting pruning tools and hands; and using fertilizers judiciously, especially with respect to nitrogen. Chemical control is based on the use of mixtures of cupric and carbamate fungicides, or products that contain streptomycin or oxytetracycline. These measures have shown variable effectiveness that may be due to crop management, the quality and frequency of applications, the level of infection and susceptibility of the host plant, and virulence of the pathogen (Manicom *et.al.* 2003).

◆ NEMATODE ASSOCIATED DISEASES

■ ROOT – KNOTS AND CYSTS

Pathogen

Meloidogyne javanica is the causative agent

Symptoms

- ♪ Root system becomes deficient and weak with poor absorption of water and nutrients. Consequently plant shows lower growth and foliar yellowing with reduced productivity

Infection and Spread

Meloidogyne spp attacks the passion fruits by injecting the roots with certain toxic substances leading to the formation of root – knots and cysts.



Management

The use of healthy seedlings, crop rotation with plants that are poor hosts of nematodes, solarization, fallow and nematicides are recommended measures to control nematodes (Fischer *et.al* 2008).

◆ PHYTOPLASMA ASSOCIATED DISEASES

■ OVERSHOOTING

Pathogen

Phytoplasma is the causative agent

Symptoms

- ♪ Chlorotic small leaves, shortening of internodes, excessive lateral shoots and abnormal flowers.
- ♪ There may be splitting and falling of fruits during their formation or just a reduction of their size.

Infection and Spread

The Phytoplasma which cause over shooting is a prokaryote without a cell wall which invades the phloem of the plants. It shows fast dissemination by vectors still unknown, sharp shooters are supposed to be involved mainly the one belonging to the Empoasca genus, which is often found in these crops. The pathogen may also spread through grafting (Fischer *et.al* 2008).

Management

To avoid introduction of phytoplasma into new production areas, it is necessary to carry out periodical inspection of plant nurseries and use healthy seedlings. Plants must be periodically inspected in the areas already infected by the disease and diseased plants have to be removed. It is known that phytoplasma infected plants treated with antibiotics belonging to the tetracycline group show a temporary reduction of symptoms (Bradel *et.al.* 2000).



Figure 15: Root –Knot on yellow Passion fruit caused by *Meloidogyne javanica*



Figure 16 : Overshooting caused by phytoplasma



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