

Destructive Journey of Phytophthora...

Diversity in *Phytophthora* causing diseases
in horticultural crops

The *Phytophthora* species are major pathogens of many horticultural crops, causing incalculable losses. The genus *Phytophthora* is a destructive plant pathogen. Association of *Phytophthora* in destruction of citrus plants was recorded in 1836 in Azore island much before the potato famine in Ireland in 1845. However, scientific discipline of plant pathology born in early 1860s when Anton de Bary recognised the *P. infestans* as the pathogen causing potato late blight. Ever since, the genus was erected, several plant pathogenic species have been described. Only 59 *Phytophthora* species were recorded till 1996. Since then several new *Phytophthora* species have been described from different parts of the world. Now, 100 species have been recorded. The taxonomy of the genus has also undergone an evolution in the way it has been studied. Most of the species of the genus have wide host range, for example about 2,000 plant species are thought to be susceptible to infection by *P. cinnamomi* in Australia. There are also some species with narrow host range like *P. sojae* and *P. infestans*

INDIA with different agroclimatic regions is most suitable for growing various horticultural crops like fruits, vegetables, flowers, nut and plantation crops, spices and ornamentals. Though India is the second largest producer of fruits and vegetables in the world, the productivity of many horticultural crops is comparatively low in India. One of the reasons for low productivity is the attack of pests and diseases. Among diseases, *Phytophthora* is significant causal agent for most of the horticultural crops.

Population displacement of 'old' population or sexual recombination within the more aggressive 'new' population has resulted in severe outbreaks of late blight caused by *P. infestans* worldwide in recent decades. In India, late blight was first introduced in the Neelagiri hills between 1870 and 1880. Very soon, it spread to the Darjeeling district in the Himalayas after the introduction of English potatoes. Later on, incidences of late blight disease on potato was recorded from various parts of India and the attack of this disease leads on an average of 20-25 % loss annually. Though late blight was a major threat to potato in north India, it was not considered as major problem on potato or tomato in south Indian states until 2006. However, introduction of 13_A2 clonal lineage of *P. infestans* from Europe has been attributed to severe late blight epidemic on tomato and potato in south Indian states after 2008 onwards.

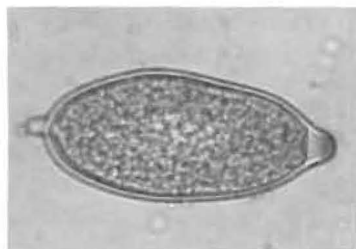
RICH DIVERSITY IN PHYTOPHTHORA

Phytophthora infestans

Late blight caused by *P. infestans* is devastating disease of potato and tomato worldwide. The pathogen's centre of origin is central Mexico from where it was introduced to North America and Europe during 1840 s and caused the infamous Irish famine. The disease spread to rest of the world during subsequent decades. Later on, the fungus caused severe late blight epidemics of potato and tomato in many countries. Still, it is continuing to be a most devastating disease with the emergence of new races or fungicidal resistant strains. Both A1 and A2 mating types of pathogen were prevailing only in its place of origin in Mexico. Until 1980s, only A1 mating type of *P. infestans* was widely and commonly distributed across the world. Outside Mexico, populations of *P. infestans* were dominated by a particular clonal lineage (US-1). However, A2 mating type of fungus was introduced to Europe during 1970s through sale of infected tubers and now presence of both A1 and A2 mating types of the



Sporangia of *P. infestans* with short pedicel



Sporangia of *P. palmivora* with short pedicel



Chlamydospore of *P. palmivora*

pathogen has been reported in many Asian countries, including India. In addition to A2 mating types, isolates of A1 mating type that were quite different from US-1 began to appear in other locations worldwide.

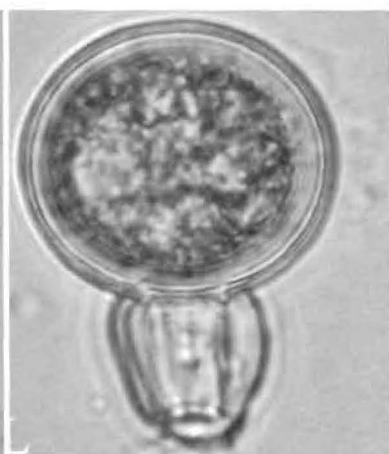
Phytophthora palmivora

The occurrence of *Phytophthora* diseases on palms in India was reported in early 1900s by Edwin J Butler. Bud rot of coconut caused by *P. palmivora* is a fatal disease. Its pathogen can infect and cause disease on a large number of plants. The disease is sporadic in nature. However, outbreak of epidemics is also common. The intensity of disease is increasing year after year with the inoculum build-up, leading to heavy losses to coconut growers in endemic areas. Traditionally, farmers use to cut open the rotten bud portion and cover the portion with mud pot. Later on, application of Bordeaux paste to the cut surface and covering with polythene sheet till the new shoots emerge is recommended. The *Phytophthora* propagules can survive on coconut debris on crown and initiate disease under favourable condition. Prophylactic spraying of 1% Bordeaux to the crown region of the palm and regular crown cleaning are recommended to manage the disease.

Damping off caused in many Solanaceous vegetables is also common. In addition, tropical plantation crops like cocoa, macadamaia, betel vine, are also be infected by *P. capsici*. Once introduced to a field site, *P. capsici* is difficult to control and often impossible to eradicate. The incidence and severity of diseases caused by *P. capsici* increased in the recent decades. There has also been a similar increase in the development of new tools and resources to study this devastating pathogen. The *P. capsici* has been listed as one of the top 10 Oomycete pathogens in molecular plant pathology. A high-quality reference genome and a high-density single nucleotide polymorphism-based genetic linkage map have been completed recently.



Sporangia of *P. capsici*



Oospore of *P. capsici*

Phytophthora capsici

The *P. capsici* is highly dynamic and destructive broad-host range pathogen. Diseases caused by *P. capsici* causes huge loss annually in spices and vegetables in India. The foot rot of black pepper was reported in 1902 from India. Though the association of *Phytophthora* species was recorded, its taxonomic position remained controversial for some time naming its species as *P. palmivora* strains. However, it is now resolved that the pathogen causing foot rot of black pepper is *P. capsici*. On vegetables, *P. capsici* causes root rot, crown rot, fruit rot, aerial blights and damping off etc. *Phytophthora* blight first recorded on bell pepper in New Mexico in 1922. Now, it is a devastating disease on bell pepper and cucurbit crops like cucumber, watermelon, squash and pumpkin worldwide. It also causes root rot and crown rot, fruit rot, aerial blights of leaves and stem on bell pepper, tomato and many cucurbit crops.

Phytophthora meadii

Fruit rot of arecanut, abnormal leaf fall of rubber and capsule rot of cardamom are economically important diseases caused by *P. meadii* in India. Annual loss due to fruit rot of arecanut is ranged from 10-90%. The same pathogen also causes bud rot and crown rot of arecanut causing death of the areca palm. The fungus causing fruit rot of arecanut was first described as *P. arecae* in 1918. However, the species concept of *P. arecae* was controversial since it was merged with *P. palmivora* and *P. meadii* due to lack of sufficient diagnostic characters. Later it was resolved that the fungus causing fruit rot of arecanut is *P. meadii*.

The same *Phytophthora* species has also been attributed as etiological agent of abnormal leaf fall of rubber and fruit rot of cardamom. Abnormal leaf fall in rubber is another serious disease affecting rubber production. The intensity of leaf fall in rubber has been reported high as the rubber growing regions in Kerala receive an annual average rainfall of more than 3000 mm, which is three times above the national average. Leaf fall, apart from causing a reduction in crop yield, also adversely affects timber output. *P. meadii* of A2 mating type is the predominant *Phytophthora* species involved in capsule rot.



Sporangia of *P. meadii* with intermediate pedicel

Table 1 *Phytophthora* species causing diseases on horticultural crops in India

Crop	Disease	<i>Phytophthora</i> species
Apple	Collar rot	<i>P. cactorum</i>
Areca nut	Fruit rot, bud rot	<i>P. meadii</i>
Betel vine	Collar rot, leaf rot	<i>P. capsici</i> , <i>P. parasitica</i>
Black pepper	Collar, root, leaf rot	<i>P. capsici</i>
Cardamom	Capsule rot	<i>P. meadii</i>
Carnation	Collar	<i>P. nicotianae</i>
Cassava	Tuber rot	<i>P. palmivora</i>
Chilli	Collar, blight, fruit rot	<i>P. capsici</i>
Citrus	Root rot, gummosis, fruit rot	<i>P. capsici</i> , <i>P. palmivora</i> , <i>P. nicotianae</i> (= <i>P. parasitica</i>), <i>P. citrophthora</i> , <i>P. bothmeriae</i> , <i>P. insolita</i>
Cocoa	Pod rot, canker	<i>P. palmivora</i> , <i>P. capsici</i>
Coconut	Bud rot	<i>P. palmivora</i>
Colocasia	Blight	<i>P. colocasiae</i>
Crossandra	Wilt	<i>P. nicotianae</i>
Cucurbits	Fruit rot	<i>P. capsici</i>
Gerbera	Wilt	<i>P. nicotianae</i>
Palmyra palm	Bud rot	<i>P. palmivora</i>
Potato	Blight	<i>P. infestans</i>
Rubber	Leaf fall	<i>P. meadii</i>
Tomato	Blight	<i>P. infestans</i>
Strawberry	Red stele, leathery rot, ripe rot	<i>P. fragariae</i> , <i>P. cactorum</i> , <i>P. nicotianae</i>
Vanilla	Fruit rot, stem rot	<i>P. meadii</i>

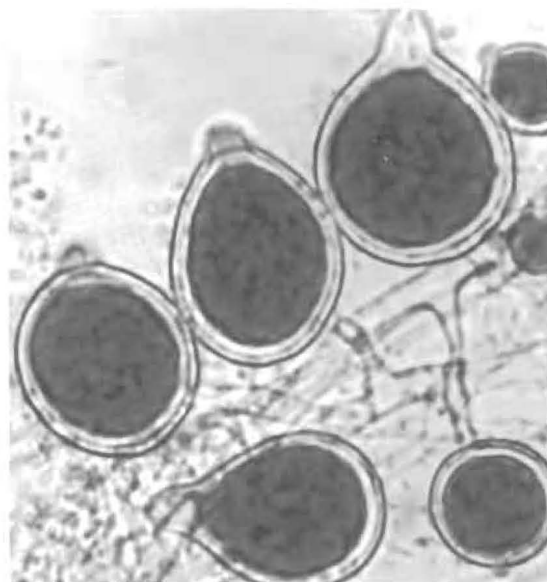
It is the major constraint in the successful cultivation and production of crop in the country. Occurrence of disease is with the onset of south-west monsoon, severe during August-September and continues to prevail up to November, depending on rainfall conditions. A crop loss of around 40% had been estimated.

Phytophthora citrophthora

Different species of *Phytophthora* cause serious and economically important soil borne diseases of citrus throughout the world. Tree and crop production losses occur from damping-off of seedlings in the seedbed, root and crown rot in nurseries, foot rot and fibrous root rot, and brown rot of fruit in groves. Foot rot results from infection of the bark near the ground level producing lesions on the trunk or crown roots that can girdle and kill the tree. *Phytophthora* spp. also attack and cause the decay of fibrous roots especially on susceptible rootstocks in nurseries. In bearing groves, fibrous root rot damage causes tree decline and yield losses. *Phytophthora* spp. infect fruit causing brown rot that leads to fruit drop in the groves and postharvest decay. The most important species include *P. parasitica*, *P. citrophthora* and *P. palmivora*. Management of *Phytophthora*-induced diseases, involves integration of cultural practices (e.g. disease exclusion through use of *Phytophthora*-free planting stock, resistant rootstocks, proper irrigation practices etc.) and chemical control methods.

Phytophthora colocasiae

Leaf blight of taro caused by *P. colocasiae* has become a limiting factor for taro in all taro-growing areas.



Non-caducous Sporangia of *P. nicotianae*



Non-caducous Sporangia of *P. citrophthora*

The disease causes an overall annual yield loss of 25-3%. In addition to leaf blight, *P. colocasiae* causes a serious post harvest decay of corms. The pathogen causing leaf blight of taro as *P. colocasiae* was first described in 1890 from Indonesia by Raciborski. As compared to other species of *Phytophthora*, very little work has been done on the biology and ecology of *P. colocasiae*. The *P. colocasiae* does not seem to survive much longer freely in the soils or in the infected dead leaf tissues. The corm-borne inoculum of *P. colocasiae* would have much more importance in the occurrence of the disease. *P. colocasiae*, like other foliar *Phytophthora*, seems to have a poor competitive saprophytic ability in soil. Another important source of survival is self-sown colocasia plants, which grow as wild plants near ponds or compost pits. Besides, the pathogen can also survive on many collateral hosts, which have been found to be natural hosts of *P. colocasiae*.

SUMMARY

There exists a lot of variability within the species of *Phytophthora*, causing severe outbreak of diseases now and then. Understanding the biology of *Phytophthora* species and managing them is still a challenge to scientific community.

For further interaction, please write to:

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