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PATHOGENIC CONSTRAINTS OF INDIAN ORCHID GROWERS: A REVIEW

Kalaivanan, N S, L C De, S S Biswas, and Ram Pal

ICAR-National Research Centre for Orchids, Pakyong- 737 106, Sikkim, India

Abstract

Orchids are diversified, fascinating, and highly evolved plants, amongst angiosperms. As they are preferred as cut flowers and potted plants because of their long shelf life and high aesthetic value, the commercial cultivation of orchids is gaining importance in India. The controlled environment under which orchids are cultivated, favours the development of diseases that reduces the yield and market value of the crop. The information on prevailing diseases is required to identify the agent(s) responsible for the diseases and categorize them based on their nature so as to employ appropriate management practices. With a view to compiling orchid diseases reported so far, the present communication reports the review on current status of orchid pathogens in India.

Introduction

CROP DISEASES are outcome of interaction of crops and pathogens favoured by environment and are visualized as symptoms or signs in the crops. Orchids comprised fascinating and attractive floriculture crop known for its flowers with unique shapes, colours, forms, fragrances, and long shelf life. Commercially, orchids are cultivated as potted plants for aesthetic purpose and cut flowers for market demand (NRCO, 2015). India is native to 1256 orchid species comprising of 155 genera (Singh *et al*., 2019). The Himalayas, the NorthEast region, and Western Ghats are the hot spot regions for orchid distribution. Arunachal Pradesh leads in orchid diversity with 612 orchid species followed by Sikkim with 560 species and Darjeeling hills of West Bengal with 479 species (Singh *et al*., 2019). Orchids are cultivated in controlled polyhouses for commercial purpose under which favourable environment for bringing out the crop is maintained. These favourable parameters also assist in the development of insect pests and diseases which bring about quantitative and qualitative loss to crops. Knowledge of diseases is pre-requisite to bring effective management. Some new diseases are on reports, minor diseases are becoming major with more threat to yield and host range of pathogens is getting widened. Eukaryotic fungi, prokaryotic bacteria, and living intermediate viruses cause many diseases in orchids thereby bringing down their yield potential. With a view to compiling orchid diseases reported so far, the present communication reports the review on current status of orchid pathogens in India.

Fungi and Fungi-like Pathogens

Fungal and fungal-like pathogens (moulds) cause several diseases in orchids with common symptoms such as leaf spots, rusts, blights, rots, and wilts (Maketon *et al*., 2015; Sowanpreecha and Rerngsamran, 2018). The genus of these pathogens include soil borne root pathogens like *Fusarium, Phytopthora, Sclerotinia,* and *Sclerotium* as well as air-borne foliar pathogens like *Alternaria, Botrytis, Colletotrichum,* and *Uredo* which are found to be associated from vegetative to reproductive stage of the crop thereby pulling down the quantity and quality of the produce.

Phytopthora sp.

Phytopthora sp., a fungi-like oomycetous causes black rot disease in many orchid species. The species of *Phytopthora* associated with orchids are *P. nicotianae, P. palmivora,* and *P. parasitica.* The disease appears as water soaked small brown patches on the aerial plant parts. Black necrotic lesions develop on pseudobulbs and roots which spread upwards and cause complete defoliation of plant and complete degeneration of roots (Cating *et al.,* 2010). Black lesions are also found in spikes, buds, and blossoms. New shoots also show the black rot symptoms which start from junction attached with the mother plants/pseudobulb. Disease occurrence at young stage of the crop results in damping off of seedlings. Infected bulbs act as major reservoir of pathogen. The sporangial mass of *Phytopthora* on the hyphae appears loose, white, cottony, and shines with tiny water droplets (Uchida and Aragaki, 1991). Black rot is reported in India on number of orchid species and hybrids of Ascocenda*, Cattleya, Coelogyne, Cymbidium, Dendrobium, Epidendrum, Oncidium, Paphiopedilum*, *Phalaenopsis,* and *Vanda* (Pant *et al*., 2013).

Sclerotium rolfsi

The pathogen causes wilt and collar rot in orchids. Symptoms include yellowing of leaves which later gets

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detached from plant. The entire plant becomes dry and senescent. The diseased plants are associated with numerous brown coloured sclerotia and white mass of mycelia at leaf base. It was found to infect *Aerides* sp*., Cattleya* sp*., Coelogyne corymbosa, Dendrobium* sp*., Eria coronaria, Habenaria* sp*., Paphiopedilum venustum*, *Phaius flavus, Spathoglottis* sp*., Vanda coerulea*, and *V. stangeana* (Bag, 2003a,b, 2006a). In *Phalaenopsis,* it is responsible for collar rot symptoms (Meera *et al.,* 2016).

Fusarium sp.

The filamentous fungi *Fusarium* sp., of Nectriaceae family are widely distributed as saprophytes as well as pathogens (Figs. 1-2). The association of *Fusarium* sp., with orchids is pathogenic as well as non-pathogenic. As beneficial association, these help as decomposers (Booth, 1971) or mutualists by aiding in seed germination and seedling colouration (Vujanovic *et al*., 2000) or as bio-control agents against pathogenic *Fusarium* sp., (Alabouvette *et al*., 1993). Orchids of tropical and sub-tropical regions are highly prone to infection with the *Fusarium* sp. (Wedge and Elmer, 2008). Also, many species of *Fusarium* are found to be associated with orchids in same location causing similar symptoms (Srivastava, 2014; Swett and Uchida, 2015). Generalized symptoms of *Fusarium* sp. diseases are circular chlorotic leaf spots which turn into necrotic small and sunken brown to blackish-brown spots; on severe infections, these spots coalesce to form blights leading to death of growing point of the shoot (Swett and Uchida, 2015). On sheath small, dark spots appear and later turn into blackened sheath rots (Leonhardt and Sewake, 1999). The characteristic symptom of *Fusarium* on leaf blade is arrangement in the form of rows of three to four spots across the leaf blade close to the cane (Kawate and Sewake, 2014; Leonhardt and Sewake, 1999). Oval and dark brown necrotic spots are seen on flowers. Though several species of *Fusarium* are related with orchid diseases, in India *Fusarium oxysporum*, a tropical species of *Fusarium* (Srivastava *et al*., 2018) is found to incite various symptoms in different orchid species like complete blighting of *Cymbidium* orchids (Yadav *et al*., 2010a), root, stem, and bean rot of *Vanda* (Vijayan *et al*., 2012) and wilt in *Phalaenopsis* (Meera, 2012). *Fusarium* sp. is also reported as causal organism for inflorescence blight in *Bulleyia yunnanensi* and *Dendrobium moschatum*, inflorescence rot in *Phaius tankervilliae* (Bag, 2006b) and leaf spot in *Arachnis* (Meera, 2012).

Colletotrichum sp.

The genus *Colletotrichum* listed in eighth position amongst most pathogenic fungi (Dean *et al*., 2012) is predominantly distributed in tropical and sub-tropical regions. It causes anthracnose in orchids and brings huge losses to field as well as nursery orchids (Duff and Daly, 2002). The varied environmental conditions of Indian sub-continent favour *Colletotrichum* sp. to infect different hosts throughout the year (Gautam, 2014). It hands multiple strategies ranging from intracellular hemi-biotrophy to sub-cuticular intramural necrotrophy to infect multiple hosts. Species of *Colletotrichum* responsible for anthracnose in orchids includes *C. cliviae* and *C. cymbidiicola* (Chowdappa *et al*., 2014), *C. gloeosporioides, and C. orchidearum* (Damm *et al*., 2019). All the aerial parts of orchids are infected with characteristic symptoms on leaves which include small oblong to circular, oval, sunken, and reddish brown or gray coloured spots intermingled with raised dots giving target board appearance which later coalesces to give blighting symptoms (Figs. 3-4). Leaf tip drying and die back are seen if leaf tip is attacked (Bag, 2007). In *Phalaenopsis* and *Vanda* orchids, the symptoms are visualized as water soaked areas on upper surface and on corresponding lower surface with chlorotic spots (Meera *et al.,* 2016). The disease is found to associate with *Aerides, Bulbophyllum, B. cylindrum, Calanthe, Cattleya, Coelogyne flaccida, Cymbidium aloifolium, Dendrobium nobile*, *Eria, Liparis, Oncidium* sp., *Otochilus, Paphiopedilum, Phalaenopsis* hybrids, and *Vanda coerulea* (Bag, 2006a,b; Ramakrisnan *et al*., 1952; Roy, 1979; Roy and Barman, 1979; Shreedharan *et al*., 1994; Sohi, 1992).

Botrytis cinerea

The symptoms caused by gray mold fungus *Botrytis cinerea* (petal blight) are common and visible in all orchids (Fig. 5). It is an air borne pathogen and spreads rapidly with the asexual spores. The disease is carried post harvest and had direct influence on the market value of the orchid flowers. Symptom appears as brown necrotic spots on older flowers. The spots enlarge and number of spots increases on progress of infection. The spots are surrounded by yellowish or pale pink margin depending on the flowers background colour (Smitamana and Govern, 2018). The same fungus was reported to cause leaf blight in Chinese ground orchid, *Phaius tankervilliae*, with its characteristic symptoms of water-soaked lesions with dense gray mold growing on infected tissues (Baiswar *et al*., 2008). In *Calanthe triplicata*, the fungus infection results in drying of flowers along with visible gray coloured fungal growth on infected flowers. Also in young leaf, top leaf blight symptom is seen (Bag, 2006b).

Uredo sp.

The rust fungus, *Uredo* sp. infection causes yellow flecks on lower surface of leaves which later on extends to upper surface. The flecks develop into ruptures

Figs. 1-8. Pathogenic constraints of some Indian orchid species: 1, Dry bulb rot in *Cymbidium* caused by *Fusarium solani*; 2, Dry bulb rot in *Phaius tankervilliae* caused by *Fusarium oxysporum*; 3, Tip burn with leaf shredding symptom in *Cephalatheropsis obcordata* caused by *Colletotrichum gloeosporoides*; 4, Black leaf spot in *Aerides rosea* caused by *Colletotrichum gloeosporoides*; 5, Petal blight in *Phalaenopsis* caused by *Botrytis cinerea*; 6, Brown rot of *Phalaenopsis* caused by *Pseudomonas* sp.; 7, Ringspot symptoms in *Cymbidium* caused by ORSV; 8, Advanced symptom of black specks on leaves of *Cymbidium* caused by CymMV.

pustules. Rust pustules are also seen on leaf petiole, flower stalk, sepals, and petals of unopened and opened flowers. In India, the disease was found in *Calanthe biloba, C. discolor, C. plantaginea, C. trulliformis, Phaius flavus,* and *P. tankervilliae* (Bag, 2006b; Pant *et al.,* 2013).

Bacterial Pathogens

The bacterial disease of orchids include brown and soft rot caused by *Pseudomonas* sp. and *Erwinia* sp., respectively. Bacteria make its entry through natural openings and wounds and once infection is established, it spreads quickly than fungal pathogens. Though the number is less, bacterial diseases are highly contagious and lead to complete loss of crop (Bhat *et al*., 2012; Joko *et al.,* 2014).

Pseudomonas cattleyae

The non-fluorescent *Pseudomonas* causes brown rot diseases in orchids (Fig. 6). The symptoms are seen as small soft, water soaked spots on leaves that later become brown or black forming cavities in the parenchyma which expand quickly over the entire leaf (Smitamana and McGovern, 2018). The pathogen of this brown rot disease is early noted as *Acidovorax avenae* subsp. *cattleyae*. Orchid host of the pathogen includes *Cattleya, Cypripedium, Dendrobium, Oncidium, Phalaenopsi*s, and *Vanda*. The disease was first reported in India from Assam in *Dendrobium* hybrids (Borah *et al*., 2002).

Erwinia sp.

The bacterium *Erwinia* causes the common soft rot in orchids. The species associated with orchids diseases are *E. carotovora* pv. *carotovora* and *E. chrysanthemi*. The symptom resembles like any other bacterial infection and starts with water-soaked lesions at the infection site which later leads to liquefaction of leaf tissues and rotting of entire leaf. The rotting of leaf is associated with characteristic foul smell (Meera *et al*., 2016). The infected pseudobulbs turn soft, pulpy, and become yellow in colour. The disease was reported in orchid species of *Eria, Paphiopedilum, Phalaenopsis,* and number of *Cymbidium* hybrids (Pant *et al*., 2013).

Dickeya fangzhongdai

Dickeya fangzhongdai was reported to cause soft rot disease on *Dendrobium nobile* (Balamurugan *et al*., 2020). The symptoms of the bacterial disease is reported to be characteristic water soaked lesions along the leaf margin that eventually leads to rot of the leaf.

Viral Pathogens

Viruses in orchid plants exhibit diverse symptoms based on nature of the virus, species of orchid infected, and prevailing environmental parameters. The two common ways of virus transmission in orchids are division and back bulb propagation with infected plants. The vegetative propagation in orchids makes an easy means of virus perpetuation and transmission when the infected plants are divided. The *Cymbidium mosaic potexvirus* (CymMV) and *Odontoglossum ringspot Tobamovirus* (ORSV) are most widespread viral diseases of several orchid genera and mixed infections of CymMV and ORSV are common in nature (Pant *et al*., 2007).

Cymbidium mosaic virus (CymMV)

CymMV under the genus *Portexvirus* was first reported in India by Sherpa *et al.* (2003). *Cymbidium aloifolium, C. iridioides, Epidendrum* sp*., Liparis botanensis, Phaius tankervilliae, Pholidota imbricata,* and several *Cymbidium* hybrids are found to be infected with the virus (Fig. 8). The symptom first appears after 6 wks of infection on young leaves as small, indistinguishable, elongate chlorotic areas. The spots and streaks later become clear and prominent. Initially the symptoms are restricted to dorsal side of leaf which advances to ventral side as the leaves become older. Necrotic symptoms on younger leaves are seen at severe stage of infection. Premature drop of leaves with severe and extensive necrotic area are noticed (Sharma and Chandel, 2009). Peculiar symptoms of CymMV associated with different orchid genera include colour breaking in *Cattleya*, brown or black oval spots on ventral surface of leaves in *Epidendrum*, sunken pits on leaves of *Cymbidium* and *Oncidium* which sometimes appear in concentric rings with a few spots breaking through dorsal surface (Bag, 2006b; Pant *et al*., 2013; Rishi, 2009).

Odontoglossum ring spot virus (ORSV)

The ORSV belongs to *Tobamovirus* genus which was first reported in India from Sikkim (Sherpa *et al.,* 2006). The virus is found to be associated with *Aerides, Bulbophyllum, Cymbidium*, *Dendrobium*, *Paphiopedilum*, *Phaius*, *Rhynchostyli*s, *Vanda,* and several hybrids of *Cymbidium* and *Dendrobium* (Fig. 7). The symptoms of ORSV are visualized as chlorotic or necrotic sunken lesions, streak or stripped mosaic, diamond mottle or ringspot on leaves, colour break, crinkle symptom, malformation, distortion, and necrotic streak on petals (Mahfut *et al*., 2016). The flowers may also be deformed and show colour breaking symptoms (Sherpa *et al*., 2006). The virus is known to be

Table 1. Minor pathogens of orchids.

Pathogen	Disease/ symptoms	Host	State	Reference
Pestalotiopsis versicolor	Leaf spot	*Cymbidium aloifolium* (L.) Sw.	Assam	Sahay and Roy (1980)
Alternaria alternata	Leaf spot	*Cymbidium* sp.	Uttarakhand	Yadav *et al*. (2010b)
Phoma exigua	Flower spot	*Phalaenopsis* sp.	Kerala	Meera *et al*. (2016)
Sclerotinia sclerotiorum	Rot	*Anoectochilus lanceolatus* Lindl. and *Goodyera schlectendaliana* Reichb.f.	West Bengal	Pant *et al*. (2013)
Calanthe mild mosaic virus	Mild mosaic and stunting	*Cymbidium pendulum* (Roxb.) Sw. and *C. tigrinum* Par. ex J.D.Hook.	Sikkim	Singh *et al*. (2007)
Cucumber mosaic virus	Mosaic, leaf distortion and stunting	*Vanilla planifolia* Jacks. ex Andrews	Karnataka and Kerala	Madhubala *et al*. (2005)
Orchid fleck rhabdo virus	Chlorotic and necrotic fleck	*Coelogyne elata* Lindl., *C. flaccida* Lindl., and *Pholidota rubra* Lindl.	Sikkim and West Bengal	Pant *et al*. (2013)
Calanthe mild mosaic virus	Mild mosaic and flower color braking	*Phaius tankervilliae* (L'Herit.) Bl.	Sikkim and West Bengal	Pant *et al*. (2017)

transmitted mechanically and can remain for long periods in potting media (Ajjikuttira *et al*., 2002).

Conclusion

The gorgeous architecture and attractive flowers of the orchids make them viable in the consumer preference as cut flowers as well as potted plants and their demand is actively increasing in the recent times in domestic and international market. The cut flowers produced by the domestic growers find lucrative price in foreign markets but are hesitant for the presence of latent pathogen infection which is a point of concern. The knowledge on diseases prevailing in a country is pre-requisite for designing easy and reliable diagnostic tools which help in quick detection of pathogens associated with export and import material as well as to formulate effective management strategy that aids to bring out quality flowers to market so as to get better prices.

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