Chapter 8

Forest Diseases and Protection

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Abstract

This chapter deals with the forest diseases and their management strategies. Pakistan is blessed with number of plant species including trees; however, forests are declining rapidly. Major cause of deforestation is the cutting down of trees followed by the diseases caused by pathogens. Both ornamental and forest tree species are susceptible to these pathogens. Both man-made forest plantations and naturally occurring forests suffer from these diseases, especially, the diseases caused by fungi. Most of the fungi attacking on trees are host-specific, which limit the spread of diseases to other non-host species, but such fungi greatly damage the orchards bearing economically important trees mainly of same host species (fruit trees and trees cultivated for timber). In forest plantations and orchards, if one tree is attacked by the fungal pathogen, other trees are likely to suffer. In the current chapter, a brief introduction about forests is given, followed by describing economically important diseases. Care has been taken while suggesting disease control strategies. Keeping in view the high cost and intensive labor involvement, it is difficult to control or manage the forest diseases. Therefore, we have mentioned

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only those disease management practices and remedial measures which have some practical implications.

Keywords: Dieback; Forest trees; Wood rot; Fungal diseases, Leaf spot, Powdery mildew.

8.1. Introduction

Forests are vital to mankind and are essential for life on Earth, as they support biodiversity. Trees releases oxygen by the process of photosynthesis and takes in carbon dioxide, thus giving the life fresh oxygen to breath and provides home to a variety of animals, birds and other organisms. The wood obtained from forest trees is mainly used by man in multiple ways. Generally, the wood of forests is used as timber, lumber, fuel, for the manufacturing of paper, wood extracts and the leaves of trees are used in medicines, cosmetics etc. while some species of trees are religiously important (Anonymous 1999). Forests also bring rainfall and prevent from soil erosion; the trees keep the water bed of land under control. Trees also provide food, fruits and shade to animals, birds and human beings. In general, forest referred to the area in which there is a dense population of trees. Due to severe deforestation, man has promoted social forestry i.e agroforestry, community forestry, urban forestry, irrigated forest plantations etc. Pakistan is fortunate which blessed with large number of tree species; however, according to a survey by World Bank and FAO, the total area of Pakistan under forest has declined to 2.2% during 2010, which is very alarming situation (Anonymous 2014a; FAO 2014; Khan 2014). There is much plantation of trees and shrubs within the country on roadsides, parks, homes and orchards; however, such plantation is not considered as forests. Trees like *Lannea* spp. (Kamlai), *Bombax ceiba* (Semal), *Acacia catechu* (Kath), *Pinus wallichiana* (Kail), *Pinus roxburgii* (chir pine), *Cedrus deodara* (deodar, diar), *Quercus incana* (rin), *Q. dilatata*, *Q. semecarpifolia*, *Abies pindrow* (partal), *Pinus gerardiana* (chilghoza), *Quercus ilex, Junipers macropoda, Salix* spp., (willow, baid), *Ephedra* spp., (asmania), *Ficus religiosa* (peepul), *Platanus orientalis* (chinar) *Eucalyptus* spp., *Dalbergia sissoo* (shisham), *Acacia nilotica* (kikar), *Populus* spp. (poplar), *Morus alba* (mulberry), *Azadirachta indica* (neem), *Capparis decidua* (karir), *Prosopis* spp. (Jhand), *Berberis* (sumbal) *Ziziphus mauritiana* (beri), *Tamarix aphylla* (farash), *Salvadora oleoides* (pilu) etc are commonly found in different forest types of Pakistan (Orwa et al. 2009). These trees are sometimes susceptible to diseases caused by pests, fungi in particular. Fungal plants pathogens like powdery mildew, sooty mold, leaf scorch, die back, anthracnose, stem rust, broom rust, smuts, root rot, root-infecting vascular wilts, stem decays, cankers etc are the common diseases found in forest trees. These fungal pathogens not only produce diseases but cause considerable damage to economy of the country as well. Some of the diseases commonly found in Pakistan on trees in general; and forest trees in particular are described below:

8.2. Powdery Mildew Disease

Powdery mildew is one of the most common, widespread and easily recognizable plant disease; infecting about 10, 000 plants species of 1600 genera (Cooper 2002; Anonymous 2007). Wide host range makes powdery mildew an economically important disease. Fungi causing powdery mildew are obligate, host specific parasites which attack the plants during warm, dry and humid weather (Newman and Pottorff 2013). Fungi belonging to the order Erysiphales are responsible for producing powdery mildew disease (Table 8.1). Powdery mildew seldom kills their hosts, however, the pathogens utilize the nutrients of hosts, reduce photosynthesis, increase transpiration, respiration rate and reduce the yields upto 20 – 40 % (Agrios 2005).

8.2.1. Disease Distribution

Kulkarni (1924) reported this disease for the first time in India. Bertus (1946) reported from West Indies, Dyer (1947) from South Africa, Fieds (1945) from United States (California), Landaeta and Figueroa (1963) from Venezuela and Boesewinkel (1980) from New Zealand. All these first reports of powdery mildew diseases were on mango trees. Erper et al. (2010) reported powdery mildew (*Phyllactiniafraxini*) for the first time from Turkey on Ash tree (*Fraxinus excelsior*) present along road sides. Lee (2012) reported powdery mildew (*Erysiphe arcuata*) on lance leaf coreopsis (*Coreopsis lanceolata*) for the first time from Korea. Lee et al. (2011) reported *E. quercicola* causing powdery mildew on ubame oak in Korea. In Pakistan, it is known to attack 70 different plant species (Anonymous 2007). Species of *Phyllactinia, Erysiphe, Leveillula, Podosphaera, Uncinula, Microsphaera* and *Oidium* etc are responsible for causing powdery mildew on wide host range of forest and ornamental trees (Table 8.1).

Table 8.1 Host range of powdery mildew disease

Causal organisms	Hosts
Phyllactinia dalbergia	*Betula, Fraxinus, Alnus, Quercus, Carpinus, Fagus, Xanthoxylum, Castanea, Magnolia, Acer, Celastrus, Ulmus, Mulberry, Juglans regia, Morus alba, Pyrus communis, P. pashia, Celtisaustralis, Dalbergia sissoo*
Erysiphe acacia	*Acacia catechu*
Microstroma acacia	*Acacia catechu*
Phyllactinia gutlata, P. suffulta	*Morus alba, Dalbergia sissoo, Salix tetrasperma, Alnus nitida*
Microsphaera extensa	*Quercus ilex*
Oidium eucalypti, Erysiphe cichoracearum	*Eucalyptus* spp
Uncinula salicis	*Populus ciliata, Salix daphnoides, S. julacea, S. caprea, S. cinerea, S. viminalis, S. babylonica*
Uncinula adunca	*Salix alba, S. triandra, S. caprea*
Uncinula aceris	*Acer pseudoplatanus, A. oblongum*
Erysiphe largerstroemiae	*Lagerstroemia lanceolata*

Pleochaeta polychaeta	*Celtis australis*
Uncinula tectonae	*Tectona grandis* (Teak)
Erysiphe sikkimensis	*Castanopsis tribuloides*
Uncinula polychaeta	*Celtis australis*
Phyllactinia mespili	*Cotoniaster bacillaris*

Source: Khan (1989)

8.2.2. Disease Symptoms

Powdery mildew produces similar symptoms on all host plant species. Spots or patches of white to grayish, powder like growth of fungus can be seen on upper surfaces of leaves. The powdery mildew fungi in general, produce chasmothecia (cleistothecia), which are first white but later turn yellow-brown and finally black. The disease symptoms first appear on lower (older) leaves of plants and spread towards the upper leaves, causing chlorosis around the infected areas (Wegulo 2010). Commonly stunting and distortion of leaves, buds, growing tips and fruits are observed on infected trees (Hartman 2008) [Figure 8.1].

Fig. 8.1 Powdery mildew of Neem Tree

8.2.3. Disease Description

Powdery mildew fungi over winters survive as dormant mycelium in dead leaves, buds and other parts of living host tissue etc. Powdery mildew fungi produce spores both sexual and asexual, depending upon the type of fungi. The spores germinate giving rise to hypha, which grows on the surface of the host plant. Powdery mildews typically grow superficially and produce appressoria that help in attachment of mycelia to plant surfaces. Haustoria, which are specialized outgrowth, arise and penetrate the cell wall of host to obtain nutrients. The asexual spores or conidia are produced in chain, which can be easily blown by wind and can infect host of the specific type only. For example, powdery mildew of maple trees will infect only other maple trees or members of the same genus. The sexual stage produces cleistothecia (chasmothecia) which releases ascospores.

Appendages are produced on the surface of cleistothecia which is a characteristic feature of this group (Cooper 2002).

8.2.4. Disease Management

Disease can be managed by the following methods (Cooper 2002; Agrios 2005; Hartman 2008; Wegulo 2010).

- Disease prefers warm humid temperature for development. The mycelium or conidia die due to excessive water, therefore, watering the plants directly or washing the infected leaves or high rainfall may reduce this disease, however, excess water may help other pathogens by making the plants susceptible.
- These fungi over winters in folded leaves and fallen leaf litter and other parts of plants tissues. Removal of leaf litter and other debris is recommended near the tree trunks or seedling beds. pruning and cutting of trees are helpful. Properly discard the pruned branches or cuttings, especially branches showing powdery mildew symptoms should be burnt to eliminate the disease.
- For agronomically important trees, resistant cultivars should be used. Much work is needed in this regard, as more and more resistant cultivars are required nowadays.
- Commercially available systemic fungicides can be used to reduce the disease; however, such fungicides can be applied only to the forests which are man-made, for naturally occurring forests like the ones growing on mountains, application of fungicide on such a large scale would be practically impossible.

8.3. Leaf Spot Disease

Leaf spot is a common descriptive term used for several diseases affecting the foliate of various ornamental and forest trees. Most leaf spots are caused by fungal pathogens however; bacteria or insects can also become the reason for leaf spots. Leaf spot disease does not kill the plant, fully established trees can tolerate complete defoliation (defoliation occurs because infected leaves shed due to necrosis); however young seedlings or newly emerging may suffer because of defoliation. Species of Alternaria, Ascochyta, Cercospora, Ciborinia, Coccomyces, Coniothyrium, Coryneum, Cristulariella, Cylindrosporium, Discochora (Guignardia), Elsinoe (Anamorph: Sphaceloma), Entomosporium (telomorph: Diplocarpon), Gloeosporium (various synonyms), Gnomonia (Stegophora), Hendersonia, Marssonina, Microstroma, Monochaetia, Mycosphaerella, Phyllosticta, Physalospora, Rhytisma, Septogloeum, Septoria, Taphrinia, Tubakia (synonym: Actinopette), Venturia, Blumeriella, Colletotrichum etc are some causal agents of leaf spots on wide variety of hosts throughout the world (Table 8.2). These genera include more than 1000 species of fungi which are capable of producing disease (Pataky 1998; Douglas 2012; Anonymous 2014b).

Table 8.2 Host range and causal organisms of leaf spot disease

Causal organisms	Hosts
Cercospora sissoo, Septogloeum dalbergiae	*Morus alba, Poplar, Eucalyptus, Melia azedarach*
Septogloeum sp	*Acacia arabica (Babul)*
Physalospora acacia	*Acacia dealbata, A. catechu, A. cyanophylla*
Calonectria theae	*Acacia decurrens, A. melanoxylon, A. mearnsii, A. dealbata*
Mycosphaerella dalbergia	*Dalbergia sissoo*
Endodothella albizziae	*Albizzia odorastissima*
Calonectria theae	*Albizzia falcate, A. lophantha*
Phleosetpora cassia, Cylindrosporium cassia, Colletotrichum lindemuthianum, Cercospora angustata	*Cassia fistula*
Mycosphaerella mori	*Morus alba, M. nigra*
Cercospora bombacina	*Salmalia malabarica*
Ascochyta quercus	*Quercus ilex*
Glomerella cingulate	*Juglans regia (Walnut)*
Corynespora cassiecola	*Eucalyptus grandis (Sufaida)*
Drapenopeziza popularum	*Populus nigra*
Cladosporium herbarum	*Populus tremuloides*
Helotium epiphyllum, Phiala subhyalina	*Acer oblongum (Maples)*
Mycosphaerella skimiae	*Aesculus glabra (Indian horse chestnut)*
Polystigma ochraceum	*Prunus cornuta (Kalakath)*
Pestalotia guepinia	*Largerstroemia lanceolata*
Phyllostictina artocarpina	*Artocarpus heterophyllus*
Colletotrichum arjunae, Sphaceloma terminaliae	*Terminalia arjuna, T. bellerica, T. chebula,*
Phyllachora bambusae, P. malabarensis, P. shiraiana	*Bamboosa tulda, B. arundinacea*
Microxyphium artocarpi	*Acacia auriculaeformis*
Ravenelia hansfordii	*Accia ferruginea*
Fusarium roseum	*Aegle marmelos*
Cercospora simarubaciensis	*Alianthus excels*
Pestalotiopsis versicolor	*Anogeissus latifolia*
Microthyrium juniper, Trimmatostroma juniper	*Juniperus polycarpos*

Source: Khan (1989)

8.3.1. Disease Distribution

Cercospora species cause leaf spot of Dalbergia sissoo, Morus alba, Populus, and Eucalyptus spp. (Spaulding 1961). In Pakistan, Mycosphaerella dalbergia also

produces leaf spot on Shisham (Ahmad 1956). M. marksii is reported on Morus alba from Australia, UK, Canada, Pakistan, India, Tanzania, and Uganda (Khan 1989). Phillips (1994) reported *Mycosphaerella spp* as causal agent of crinkle leaf disease in *Morus alba*. *Aulographina eucalypti* causes corky leaf disease on adult and juvenile leaves. *Pseudocercospora eucalyptorum* causes leaf spot on adult leaves, while *Septoria pulcherrima* infects both young and adult leaves in *Eucalyptus spp*.

8.3.2. Disease Symptoms

Presence of spots on leaves is a major symptom of this disease. Leaf spot disease develops as small, scattered, and circular to oval dead areas in the leaves. The spots are generally brown, black, tan, yellow, gray or purple in color, while some spots develop color at their margins or might have concentric rings at their margins. Some spots are raised, shiny or coal black, while others may drop over leaving behind a small hole. Spots may combine to form a blotch. The spots or blotches which are angular referred to as anthracnose. Hence, the color and size of spots depends upon the pathogen producing the disease. Spots produced by fungal pathogen may have fruiting bodies known as pycnidia, acervuli, or perithecia. Heavily infected leaves may turn yellow or brown, and finally sloughs off (Pataky 1998; Douglas 2012) [Figure 8.2].

Fig. 8.2 Cercospora Leaf Spot

8.3.3. Disease Description

The fungal pathogen over winters survives in fallen leaves or in infected buds, fruits, twigs and in branches. From early spring to summer, microscopic spores are produced in tremendous numbers on the surface of the leaves or in the speck-sized fungal fruiting bodies. When spores are mature, they are spread due to air current or water splashes. Cool weather, light, frequent rains, high humidity, heavy dew and crowded plantation favors the growth of disease. In the presence of susceptible host and free water, the spores germinate and produce infection in new hosts; hence several generations of pathogens produce in one growing season. The extended periods of cool and moist weather favor the development of leaf spots. As the leaf

spot pathogens are host specific, spores of one host plant can not infect other nearby plant species present but infection can develop in multiple host species at the same time, due to similar growth requirements of the pathogens (Pataky 1998; Douglas 2012).

8.3.4. Disease Management

Disease can be managed by taking following methods (Pataky 1998; Douglas 2012).

- Most trees tolerate leaf spots with little or no apparent damage. If the host plant is properly established infected trees can survive complete defoliation. The tree will re-leaf and chances for the new leaves would be disease free.
- Remove infected leaves, branches and twigs or fruits of trees as the inoculum may over-winter in them. Also prune the trees regularly to allow proper ventilation and sunlight.
- Properly remove the debris present near tree trunk. The fallen leaves, twigs or any other debris present around should be carefully dumped away.
- Avoid close plantation of trees. Clean, well spaced and properly ventilated plantations provided by plenty of sunlight generally give rise to into healthy trees.
- Avoid over head watering to keep the foliage dry. Watering the trees during early hours in the morning is recommended.
- Once the trees develop leaf spot disease, use of fungicide is ineffective because spray can not cure the infected leaves. Spraying should be done before the development of disease.
- Use of resistant cultivars, as the pathogen is host specific, cultivation of non-host species may help in reducing the disease.

Leaf Spot of Eucalyptus Species

Eucalyptus spp., are world's most important and widely planted forest species, used as a source of timber, pulp, firewood, charcoal, honey production, ornamental foliage, shelter and environmental rehabilitation (Turnbull 2000; Sedgley 1997). Leaf spot of *Eucalyptus* species is caused by *Cryptosporiopsis eucalypti*, *Aulographina eucalypti*, *Coniella* spp., *Microsphaeropsis* spp., *Pseudocercospora eucalyptorum*, *Cylindrocladium* spp., and *Mycosphaerella* spp and their anamorphs like *Phaeophleospora* spp (Park et al. 2000; Table 8.2). The fungi are commonly found on the lower crowns of young trees, coppice shoots causing leaf spots of varying shapes and sizes according to the host and environmental conditions.

8.3.5. Disease Distribution

This disease is found in Brazil, New Zealand, Vietnam, Japan, Sri Lanka, Australia, India, Indonesia, Tasmania, Argentina, South Africa, Sabah, Taiwan and Thialand. (Sankaran et al. 1995; Yuan 1999; Old et al. 2002).

a **b** **c**

Fig. 8.3 Leaf spot by (a) Microsphaeropsis (b) *Coniella fragariae* (c) Pseudocercospora spp.

8.3.6. Disease Symptoms

Fungi cause different symptoms according to the host and environment. Dark brown corky leaf spots with elongated or branched fruiting bodies known as hysterothecia are formed which are open by longitudinal slit (Aulographina eucalypti). Reddish-brown lesions are formed by Coniella fragariae. This fungus partially curls the leaf as the tissue desiccates. However, prominent black pycnidia are embedded in lesions and extrude vast numbers of dark brown to black spheroidal conidia on the lesion surface. Infected leaf showed profused angular spots and the tufts of conidiophores bearing needle shaped septate conidia (Pseudocercospora eucalyptorum). Leaves of Eucalyptus grandis showed large brown lesions with raised purple margins. Few pycnidia are produced which are easily seen by naked eye. These pycnidia are embedded in leaf surface and extrude small dark brownish black ellipsoidal conidia which are thick walled (Microsphaeropsis). In case of Cryptosporiopsis eucalypti leaf spots produce on both side of leaves which are vary in size, shape and color. Fungus proliferates by producing a vast number of spores from conidiomata that develop on infected leaves and shoot (Old et al. 2003) [Figure 8.3].

8.3.7. Disease Description

Variation occurs in the causal agents of leaf spot like A. eucalypti is an obligate parasite while Coniella spp., have wide host ranges and to invade the leaves, they require leaf damage or prior infection by other pathogens. They are favored by moist climates and mostly occur on the lower crowns of Eucalyptus (Old et al. 2003). Auglographina eucalypti grew slowly in culture and penetrated in leaves

through appressoria and the fungus produce both surface and sub-cuticular colonizing hyphae. Sporophores formed on the lesion surface and this lesion disturbs the photosynthesis process of healthy parts of infected leaves (Wall and Keane 1984).

8.3.8. Disease Management

No control measures are acceptable with these fungi except for the elimination from provenance or clonal trials (Old et al. 2003).

8.4. Wood Rot Fungi

Members of polyporaceae family called as wood rotting fungi which include *Polyporus, Trametes, Coriolus, Poria, Polystictus, Nigroporus, Pycnoporus, Rigidoporus, Fomes, Daedalea, Globifomes, Cryptoporus, Heterobasidion* and *Lenzites.* Wood decay process is mainly due to microorganism, plant species and microhabitat within substrate. This is due to conidial ascomycetes causing soft rot, basidiomycetes causing white rot and brown rot (Table 8.3).

The main features of genera include fruiting body with a cap, well developed, simple or branched stipe, dimitic hyphal system with arboriform skeleton-binding hyphae, smooth basidiospores, cystida in hymenium are absent. Fruiting bodies in Polyporaceae species may resemble crusts, shelves or mushrooms. When young, the basidiocarps may be soft but at maturity they become tough, leathery, woody or corky. Few species have lamellate hymenium and mouth of tubes which contain basidia may be circular, angular or elongated (Alexopoulos et al. 1996).

8.4.1. Disease Distribution

The disease is common in Pakistan, India, Southern United States, Canada, North Asia, Australia, Europe, Ireland, Britain. Eighteen species of the genus are restricted to North America which includes *Nigroporus, Fomes, Pycnoporus, Rigidoporus, Poria* (Gilbertson and Ryvarden 1987). *P. tomentosus* is widespread on conifers in the temperate zone which causes butt rot whereas mortality of white and black spruce is most common in Northern America. In Asia, *P. tomentosus* is foundin the Himalayas of northern India (Bakshi 1971).

8.4.2. Disease Symptoms

Polypores species attacks living plant tissues and are serious parasites. *Heterobasidion annosum* invades stands of pines that have been thinned. It colonizes the surfaces of the freshly cut stumps and spread to the other trees by way of natural root grafts. Infected trees due to wind throw may die outright [Figure 8.4a, b].

Fig: 8.4a Decay of Pinus tree by Polypores fungi (Picture taken from Ayubia National Park)

All members of polyporaceae produce shelf like or hoof-shaped fruiting bodies which are hard woody structure produced on the sides of dead or dying trees and stumps. Fruiting bodies produced a new hymenophore layer over the old one each year. *P. tomentosus* attacks on trees and causes outright mortality, premature windfall, growth slowdown and butt cull. Fungus causes weakening of root system which increases the susceptibility of a tree to windfall said to be greatest damage of fungus. Continuous killing of roots by *P. tomentosus* over a period of years results in reduction of tree height and diameter increment (Whitney 1962). Fungus might reach to several meters up to the stem in black and white spruce resulting in volume loss of affected trees.

Fig. 8.4b Polypores wood decay (Picture taken from Ayubia National Park)

8.4.3. Disease Description

Basidiocarp of Polyporesis stipitate and annual. According to Dube (1990), fruiting bodies degenerate when the single layer of tubes is exhausted. The hyphae survive inside the trees and next year, the fruiting bodies again form. In *P. tuberaster,* fruiting bodies are bracket or fan shape and produce large underground sclerotium-like structure which in warm and moistened place gives rise to several centrally-stalked, funnel-shaped fruiting bodies. Fan shape fruiting bodies of some of the species of *Polyporus* attached laterally to tree trunks by short stalks. Septate dikaryotic hyphae cause discoloration and decay of wood. Infection of *P. tomentosus* occurs from below ground i.e. by root contacts in which mycelium grow from a diseased root onto a healthy root (Myren and Patton 1971; Whitney 1962). According to Ouellette et al. (1971), dead and deformed roots resulting from the poor planting practices lead to infection. The diseased roots remain in soil for at least 15 to 20 years resulting in the death of host. The inoculum in the old remaining roots leads to infect succeeding generations of trees. Both basidiospores and mycelium within a woody substrate can spread the disease over long distance by wind (Whitney 1962; 1966). In wet years, abundance of sporophores are produced and millions of basidiospores are produced under a wide range of climatic conditions (Bohaychuk and Whitney 1973).

Table 8.3 Host range and causal organisms of wood rot disease

Causal organisms	Hosts
Polyporus sulphurens	Wood rot of oaks
P. squamosus	Heart rot of elms
P. schweintzii	Butt-end rot of several trees
P. glomerata	Wood decay of red maple
P. tomentosus	Butt rot of conifers, white pocket root rot of *Pinus strobus*
Cryptoporus volvatus	Conifers

Source: Dube (1990)

8.4.4. Disease Management

- Disease can be managed by the following methods.
- Urea, creosote and liquid borate can be used to prevent spore germination of *H. Annosum.* Dry borax granules sprinkled directly on the stumps showed much better control of the disease.
- Liquid suspension of *Phlebiopsis gigantea* should be applied to the stumps.
- Fungal fruiting structures on trees should be removed properly at the first sign of infection.
- Deformation of roots in planting techniques should be avoided.
- There is no direct control for disease caused by *P. tomentosus,* infected trees stands should be cut as soon as possible. Those trees showing above

ground symptoms, cutting will not prevent spread of fungus to the remaining trees (Agrios, 2005).

8.5. Sooty Mold on Trees

Sooty mold is a general term applied to the black, sooty mass that appears on certain plants. Sooty mold is basically fungal species having black mycelium, which grows on honeydew secreted by insects. Sooty mold is not a disease; instead it is an aesthetic problem. Sooty mold not only infects trees, but also infects small plants, stuff like fences, or umbrella or surface of anything kept in the open air. Fungi that most commonly causes sooty mold include the genera Capnodium, Fumago and Scorias (Table 8.4). Less common genera include Antennariella, Aureobasidium and Limacinula (Nameth et al. 1996; Lamborn 2009; Laemmlen 2011).

8.5.1. Disease Distribution

Sooty mold is probably present throughout the world. Trees like, *Abies* spp. (Fir), *Acer* spp. (Maple), *Alnus* spp. (Alder), *Camellia* spp. (Camellia), *Carya* spp. (Hickory), *Citrus* spp. (lemon, orange), *Fagus* spp. (Beech), *Fraxinus* spp. (Ash), *Ilex* spp. (Holly), *Juglans* spp. (walnut), *Juniperus* spp. (juniper), *Malus* spp. (apple, crabapple), *Picea* spp. (Spruce), *Pinus* spp. (pine), *Populus* spp. (poplar), *Prunus* spp. (Plum, cherry, peach), *Quercus* spp. (oak), *Salix* spp. (willow), *Viburnum* spp. (viburnum) etc., are more likely to develop sooty mold fungi because of honeydew producing insects (Nameth et al. 1996; Lamborn 2009; Laemmlen 2011).

Table 8.4 Causal organisms and host range of sooty mold disease

Causal organisms	Host
Meliola spp	*Shorea robusta*
Meliola bambusicola	*Bambusa* spp
Fumigo vagans	*Bambusa* spp, *Calotropis* spp
Popularia sphaerosperma	*Bambusa bambos*
Rosellinia congesta	*Bambusa* spp
Capnodiastrum stylosporium	*Trema orientalis*
Meliola palmicola	*Phoenix sylvestris*
Meliola geniculata	*Lannea coromandelina*
Meliola similina	*Hollarrhena antidysenterica*
Astrinella pinastri	*Pinus wallichiana* (Kail)

Source: Khan (1989)

8.5.2. Disease Symptoms

Sooty molds gives the appearance of black layer of soot present on the surface of leaves. Sooty mold appears on trees when insects like aphids, mealy bugs, leaf hoppers, Psyllids, soft scales and white flies are present in the nearby vicinity or on trees.

8.5.3. Disease Description

The insects both adults and juveniles suck sap from plants as their source of nutrition, however they can't digest it completely, so they excrete out the excess sap in the form of honeydew. Honeydew is a sweet, sticky liquid which is consumed by several ant species. The sooty mold fungi present in the air develop on honeydew. The sooty mold does not infect the leaves or plants, but due to excessive growth of fungal mycelium, the passage of sunlight blocks from reaching the leaves surface. As plant produce their nutrient through photosynthesis, the mycelium growing on leaf surface prevent photosynthesis and respiration making leaf weak and finally it falls off. The species of sooty mold present on certain plant are determined by the combination of environment, host and insect species (Nameth et al. 1996; Lamborn 2009; Laemmlen 2011) [Figure 8.5].

Fig. 8.5 Sooty mold on tree leaves

8.5.4. Disease Management

Disease can be managed by the following methods (Lamborn 2009; Laemmlen 2011).

- Growth of sooty mold depends upon the presence of honeydew secreting insects. Eliminating such insects will ultimately eliminate sooty mold.
- Sooty mold can be easily removed by applying water with full pressure. Heavy rain can also remove the black soot.
- Use of chemical insecticides or Neem oil can be effective for the control of insects; however, insecticides should be applied after proper identification of insects producing honeydew.
- Pruning and cutting the affected parts can be helpful in some cases.

8.6. Rust of Trees

Rusts are among the most common fungal diseases of the ornamental as well as forest trees. Rust diseases are caused by the fungi which belong to the phylum basidiomycota. All the rust producing fungi are obligate parasite and to some extent host specific. The fungal pathogens generally produce spores of five types and complete their life cycles on two hosts, however, some may complete their life cycle on one host. Rust infection occurs on almost all tree species however, certain trees like poplar, willow; birch, plum, pinus, Salix, *Betula* spp, *Eucalyptus* spp., ash, maple etc. Rust fungi reduce plant vigor and in extreme cases can kill the host. *Cronartium ribicola* (white pine blister rust), *Puccinia psidii* (Eucalyptus rust), Melampsora (poplar tree rust), Melampsora (willow tree rust), *Melampsoridium betulinum* (birch rust), *Tranzschelia pruni-spinosae* var. discolor (plum tree rust), *Gymnosporangium juniper-virginianae* (Cedar-apple rust), *Cronartium comandrae* (Comandra blister rust), *Melampsorella caryophyllacearum* (fir broom rust) etc., are some examples of rust pathogens (Anonymous 2014c) (Table 8.5).

Table 8.5 Host range and causal organisms of rust disease

Causal organisms	Hosts
Uredo sissoo	*Dalbergia sissoo*
Maravelia achroa	*Dalbergia sissoo, D. latifolia*
Ravenelia sessilis	*Albizzia lebbek*
R. clemensiae	*A. procera*
R. japonica	*A. odoratissima*
Hapalophragmiopsis ponderosa	*Acacia leucophloea*
Ravenelia tandonii	*Acacia catechu* (Khair)
Ravenelia franesianae	*Acacia franesiana*
R. formosana	*A. franesiana*
R. spegazziniana	*A. franesiana, A. decurens*
R. esculenta	*A. eburnean*
R. deformans	*A. Arabica*
Uromyces phyllodiorum	*A. dealbata*
U. bisporum	*A. dealbata*
Cerotelium fici	*Ficus elastic, F. glomerata, F. religiosa, Morus alba, M. nigra*
Phakopsora zizyphivulgaris	*Ziziphus jujube* (Berry), *Z. oxyphylla, Z. mummularia, Z. sativa*
Melampsora pinitorqua, M. populnea	*Populus alba* (Sufaida)
Melampsora ciliate, M. populnea	*Populus ciliate*
Melampsora amygdalinae	*Salix triandra, S. alba*
Melampsora caprearum	*Salix caprea, S. cinerea*
Melampsora epitea	*Salix babylonica, S. hastate, S. alba, S. cinerea, S. viminalis, S. acutifolia, S. caprea*
Pucciniastrum aceris	*Acer caesium, A. mono, A. pictum*
Pucciniastrum areolatum	*Prunus cornuta*
Melampsoridium hiratsukan	*Alnus nitida*

Olivea tectonae	*Tectona grandis*
Uredo artocarpi	*Artocarpus chaplasha*
Dendrocalamus strictus,	*Randia dumatorum, R. brandissi, R. candolleana*
Oxytenanthera abyssinica	*Bambosa* spp
Gymnosporangium clavariiforme	*Juniperus communis*
Gymnosporangium cunninghamianum	*Cupressus torulosa*

8.6.1. Disease Distribution

Generally, all the plant species throughout the world suffer due to rust infection. In Pakistan, it is reported to cause white pine blister rust (Khan 1989).

8.6.2. Disease Symptoms

The pathogens produce lesion like pustules on the under surface of leaves. The pustules contain spores which are yellow, orange, brown, etc in color according to the pathogen species, thus giving the disease its name "rust". Wet conditions and high humidity or rain favors the growth of pathogen; however, this disease grows well during summer season. Presence of secondary host makes the economically important plants/trees more susceptible to the disease. For example, white pine blister rust fungus completes its life cycle in 5 stages and on two different hosts, while western gall rust fungus completes its life cycle on one host (Anonymous 2011; Anonymous 2014c) [Figure 8.6].

Fig. 8.6 White Pine Blister Rust.

8.6.3. Disease Description

The pustules present on leaves burst on maturation releasing the spores in the air. The spores, if susceptible host is present nearby, lands on host plant. The spores germinate and produce haustoria which penetrate the living host cells and drive its nutrients from it. In case of white pine blister rust, one host is pine while other (or alternate/secondary) host is goose berry plant (Ribes spp.). The disease can not spread from pine to pine but is transmitted to white pine by from Ribes trees.

Seedlings and young trees of white pine are more susceptible and thus infected trees dies more rapidly (Anonymous 2011, 2014c).

8.6.4. Disease Management

Disease can be managed by the following methods (Anonymous 2014d).

- Removing of infected plant parts and pruning of trees can help in reducing the infection. Elimination of secondary/alternate host reduces the disease but do not eradicate it.
- Use of chemical fungicides can also be helpful in the reduction of disease in silviculture.
- Use of resistant cultivars in case of orchard trees and gardens can be helpful. For naturally occurring forest trees obviously, this method will be un-applicable.
- Crop rotation in case of orchards or garden trees is a good but expensive method of management. For naturally occurring forest trees this method has no practical implication.
- There should be proper spacing between trees. The pruned trees parts and infected seedlings/trees should be discard away from susceptible host. It is better to burn the infected parts like leaves, branches, twigs etc to eliminate the spores.

8.7. Juniper Blight

Juniper forests are found in Ziarat and Loralai districts of province Baluchistan in Pakistan, are one of the world largest, slow growing and long lived forest, also referred to as 'Living Forest Fossils'. Juniper forest provides essential oils, berries for flavoring, bark for roofing, grazing pastures and are used for the cure of kidney and many other diseases (Sarangzai et al. 2010).

Juniper forests suffer from different fungal diseases like leaf blight caused by *Didymascella thujina,* tip blight by *Coryneum berckmannii,* juniper blight by *Phomopsis juniperovora.* These fungi infect susceptible wound and cause extensive damage (Moore, 1976).

a) Juniper Phomopsis blight

The causal agent of disease is *Phomopsis juniperovora* andthis disease commonly occurs on eastern red cedar and other species of junipers and affects the Chinese and common junipers (Table 8.6).

8.7.1. Disease Distribution

Fungus causing blight disease is widespread in the United States, Pakistan and some countries of Asia (Sarangzai et al. 2010).

Table 8.6 Host range and causal organisms of juniper diseases

Causal organisms	Hosts
Phomopsis juniperovora	*Juniperus sabina, Juniperus scopulorum*
Didymascella thujina	Arbor-vitae
Sclerophoma pythiophila	*Pines, Douglas-fir, Eastern*
Coryneum berckmannii	*Thuja orientalis*
Arceuthobium oxycedri, A. juniper-procera, A. azoricum	*Junpierus excels*
Cercospora sequoiae	*Eastern red cedar*

8.7.2. Disease Symptoms

Healthy hosts are infected from spores of diseased juniper plants in the fall but the symptoms are not seen until late winter or early spring. First symptom noted as browning of needle tips when disease invades young vulnerable tissue. Yellow-green new shoots begin to turn red brown and slowly die from fungal disease. After the infection progress, inward, small lesions are formed at the tip of branches. These lesions are less than one centimeter in diameter, results in death of the entire branch. Repeated blighting results in abnormal bunching called as witches broom.

8.7.3. Disease Description

Blight disease infects *Juniperus sabina, Juniperus scopulorum* and other rocky mountain juniper plants besides attacking red cedar. This blight disease only infects young leaves and branches. However mature juniper plants are usually immune to infection. The fungus reproduces by conidia which are produced in pycnidia. In wet and rainy periods (optimal germination temperature range between 24-28°C), conidia releases from the pycnidia and spread to healthy tissue due to rain splash. Spores germinate and infecting immature needles of trees. Viable spores are produced by *P. juniperovora* within 3 weeks of infection for reinfection. Fungus forming pycnidia in dry shoots for upto two years after the death of tissues (Peterson and Hidges 1982). Secondary inoculum will continue to spread infection in favourable environmental conditions.

8.7.4. Disease Management

- Plants with yellow or grey discoloration on needles and necrotic areas on branches and stems should be removed in healthy juniper seedlings (Peterson et al. 1965).
- Avoid plantation in poorly drained or heavily shaded and prolonged moisture areas.
- When planting provide proper spacing for air movement to prevent the germination of fungi.

- Pruning should be carried out during dry weather. Diseased plant waste should be disposed by burning.
- Spray with fungicide like propiconazole or mancozeb, combination of zinc, manganese and ethylene bisdithiocarbamate will be helpful in preventing the disease development (Peterson and Hidges 1982).

b) Juniper tip blight

This juniper disease is caused by *Phomopsis juniperovora, Kabatina juniperi, Sclerophoma pythiophila.* Despite of juniper, white cedar, cypress, false-cypress and arborvitae are also susceptible to *P. juniperovora* while *S. pythiophila* also cause disease on pines, Douglas-fir and Eastern (Table 8.6).

8.7.5. Disease Distribution

Disease is common in Pakistan and New York (Sarangzai et al. 2010).

8.7.6. Disease Symptoms

The disease starts to show up on lower branches. Infected foliage changed from normal green to reddish brown color and may dropped resulting in unsightly masses of grey stems. Death of entire plant may result where *P. juniperovora* and *K. Juniperi* are involved while *S. pythiophila* does not kill whole plants. Dieback symptoms appear on shoot tips and continue towards the main stem. Leaves near tip turned brown in late spring and the fruiting bodies of the fungus was observed as tiny black bodies on the lower surface of the infected foliage (Moore 1976).

8.7.7. Disease Description

P. juniperovora attacks young succulent shoot tips and enter to plants through wounds and cause infection throughout summer while *K. Juniperi* attacks one year old growth in the fall, enter to plant through wounds and symptoms appears in early spring. However, *S. pythiophila* attacks shoots which become weakened due to winter injury. In the wet weather, these fungi spread throughout the shrub within few years or less. These three fungi killed twigs and bark on the shrub, fruiting bodies of fungi develop in spring and in wet weather many spores are released which are capable of causing new infections.

8.7.8. Disease Management

- Pruning of infected twigs and branches and pruned items should be burned.
- Plantation should be in proper spacing for good ventilation.
- Sterilize the tools used for cutting by using 10% bleach and water solution.
- Use of fungicide like potassium biocarbonate or propiconazole is available for treating *Phomopsis.* Some researchers suggested spray of copper

sulphate in the month of October and November for the prevention of disease (Grant 2015).

8.8. Chestnut Blight Disease (*Cryphonectria parasitica*)

Causal agent of chestnut disease is Cryphonectria parasitica. List of causal agents and host of blight diseases are presented in Table 8.7. Oak tree is most susceptible to this disease. Young trees are not usually affected by blight. The primary host of the disease is American chestnut. However, fungus also attacks and causes minor injury to maple, sumac and hickory trees. Fungus enters trees through wounds, furrows and cracks of mature bark.

Table 8.7 Causal agents and host range of blight disease

Causal organisms	Hosts
Glomerella cingulata, Phyllosticta sissoo, Colletotrichum dalbergia, Phomopsis dalbergia, Phyllachora dalbergia, Phyllachora spissa	*Dalbergia sissoo*
Physalospora eucalypti	*Eucalyptus globules, E. citriodora*
Colletotrichum gloeosporioides	*Alstonia schorlaris*
Endothia parasitica	*Castania sativa*
Cercospora sequoia, Keithia thujina	*Cupressus torulosa*

Source: Khan (1989)

8.8.1. Disease Distribution

Blight disease is present in the entire range of host and moved to the areas of planted chestnut far away from the native range. However, disease is present in North America, Europe, China, Japan (Sarfaraz 1999; Anagnostakis 2007).

8.8.2. Disease Symptoms

Appearance of numerous cankers on branches and stem. Wilting and yellowing starts on the foliage of infected branches and the bark starts to spilt and dies in patches. The plant cells in the affected areas gradually die. Browning also starts under the bark where cambium layer is present and reddish orange masses of fungal spores are visible on the bark near the cankers. Spores of fungi spread rapidly by animal and splashing rain to other healthy trees.

8.8.3. Disease Description

C. parasitica is a member of ascomycetes which infects any part of the trunk or limbs and enter through wounds. Once the fungus penetrates bark, produces canker and reaches down to the vascular cambium and functional xylem and phloem. By this transport of nutrients and water are blocked above and below the canker (Smith 2012). Leaves turn brown and eventually stem above the canker dies. Fungus produces two types of spores, ascospores (cause black vase-like structure called

perithecia) and conidia (ooze out of round fruiting bodies called pycnidia after rain).

8.8.4. Disease Management

There is no cure for the chestnut blight disease but the research is still being conducted to find an effective way to eradicate the disease (Smith, 2012; Sarfaraz, 1999).

- Research is being conducted on isolating resistant varieties.
- Development of hypo-virulent (lesser virulence) fungal strains which when applied to the cankers promotes healing in infected trees and attacking the causal agent of the disease.

8.9. Shisham (*Dalbergia sissoo*) dieback

Dieback and decline is a periodic event characterized by premature loss of tree health and stand vitality (Clatterbuck 2006). The illness and mortality of trees are caused by number of reasons which seems to be inexplicable but most of the problems in trees are caused by human disturbances especially to the environment which lead to mortality (Lowman 1991). Different terms like dieback, stand level dieback and canopy level dieback have been used in the literature according to conditions. It is difficult to determine or diagnose the exact cause of dieback or decline as compared to other diseases, because it is a complex issue and may differ from place to place (Manion 1991).

The exact cause of the dieback is still not clear and there are many controversial reports (Bakhshi 1974) because different factors including biotic and abiotic factors were found associated with forest and especially with shisham dieback (Sharma et al. 2000). Aslam (2004) stated that the intensity and causes of dieback varied from region to region in Pakistan. Forestry experts and pathologists have estimated that the high death rate of *D. sissoo* was due to several pathological, entomological, silvicultural, edaphic and age factors (Sah et al. 2003). Afzal et al. (2006) identified the two major causes of *D. sissoo* dieback: according to them the primary cause was physiological drought, lopping and over maturity, whereas the second was attack by pathogens. A wide range of fungi have been reported from shisham trees showing symptoms of dieback, leading to the involvement of pathogens being considered the most likely cause of the problem (Bakshi 1954). Different pathogens isolated from the *D. sissoo* trees include *Botryodiplodia theobromae*, *Fusarium solani, F. oxysporum, F. dimarium, F. semitectum, Pestalotia* spp., *Curvularia* spp., *Drechserla* spp., *Chaetomium* spp., *Cystospora* spp., *Colletotrichum gloeosporioides, Ganoderma* spp., *Phialophora* spp., *Phialocephala* spp., *Dothiorella* spp,. and Oomycota species like *Phytophthora cinnamomi* (Dargan et al. 2002) (Table 8.7). Similarly different fungal and other pathogens including *F. solani, B. theobromae*, *Ceratocystis maginecans*, *Ganoderma lucidum, Phytophthora cinnamomi, Rhizoctonia solani, Alternaria alternata, Curvularia lunata, Aspergillus flavus, A. niger and Colletotrichum gloeosporioides* have been

identified from different parts of Punjab province (Rehman et al. 2006; Al Adawai et al. 2013)). *Ceraocystis fimbriata* fungus was also isolated from diseased shisham trees for the first time in Pakistan (Poussio et al. 2010). However, *F. solani* and *B. theobromae* have been considered as the major factor responsible for the dieback of *D. sissoo* (Bajwa and Mukhtar 2006; Rajput et al. 2008; 2010; Ahmad and Siddiqui 2013).

8.9.1. Disease Distribution for *Dalbergia sissoo*

Shisham (*Dalbergia sissoo*Roxb. Ex DC) is native to Nepal (Bajwa and Mukhtar 2006; Idrees et al. 2006). This species belongs to family *Fabaceae* (sub-family *Papillionaceae*) and genus *Dalbergia* (Southon 1994), which contains 100 species in Asia, America and Australia (Thothathn 1987). History reveales that this tree was grown about 2500 years ago (White 1994; Kumar and Rai 2002) and is an internationally known timber species of rosewood genus. This species has great importance as fuel, shade and shelter wood and is locally known as "tally". It is found in Afghanistan, Bangladesh, Bhutan, India, Nepal and Pakistan. It is also found in the cultivated tracts of tropical and sub-tropical regions of Africa, Asia, Kenya, Maustius, Nigeria, Palestine, South Africa, Sri Lanka and Zimbabwe (Afzal et al. 2006). Being a multipurpose tree it had greatly contributed in the socioeconomic development of the South Asian region (Khan 2000; Bajwa and Mukhtar 2006; Kausar et al. 2009). It is a moderately fast growing tree with an average growth rates of 3.7 m/year, 5 m in 3 years, 11 m in 5 years and 15 m in 10 years have been recorded in favorable environmental conditions. Its rotation age varies from 30 to 60 years. Flower color varies from pale white to dull yellow and pods on an average have 1-4 seeds and number of seeds varies from 45000-55000/kg (Orwa et al. 2009).

Dalbergia sissoo is an important timber tree of Pakistan (Bajwa and Mukhtar 2006) and was introduced in Pakistan almost 150 years ago (Afzal et al. 2006). Its growth is commonly found along the foothills of Himalayan mountains. Normally it extends from the Indus valley up to Attock district but does not dominate in this area (Champion et al. 1965). In Pakistan, it is widely planted along canal banks, along agronomic crops in agricultural fields and as well as on road sides, canopy gaps, disturbed sites and forest margins (Sharmaet al. 2000; Rajput et al. 2008; Kausar et al. 2009).

It is also used for fuel, shade, shelter, soil stabilization and for the control of erosion. It has been considered an important tree for agro-forestry practices because it increased the soil fertility and played an important role in safeguarding the environment (Stewart and Flinn 1984; Sharma et al. 2000; Kausar et al. 2009).

Dieback of forest trees has been identified as a major problem in different parts of the Indian subcontinent (Shukla 2002). *D. sissoo* (Shisham) an important species of the subcontinent has suffered from dieback, wilt and many other pathological problems (Sah et al. 2003) and in the past few decades dieback of *D. sissoo* is a serious threat affecting millions of trees in South Asia (Vogel et al. 2011). Bakhshi (1954) reported the disease for the first time in the forest stands of Utter Pardesh, India. History of *D. sissoo* decline due to dieback in Pakistan goes back to the early

period of 1900s, but regular research on this very important problem was carried out in 1956 in Khanewal irrigated plantation (Khan 1989). The widespread incidence of shisham dieback was reported in 1998 in central irrigated tract of Punjab, Pakistan (Naz 2002). During this period about 70% shisham trees were affected by dieback disease (Khan 1999). This disease has also been recorded in different agro-ecological zones of Punjab with different severity levels (Bajwa and Mukhtar 2006).

Table 8.8. Causal organisms and host range of die back disease of forest trees

Causal organisms	Hosts
Polyporus gilvus	*Dalbergia sissoo, Quercus, Prunus, Dalbergia latifolia, Shorea robusta, Cedrela toona, Pterocarpus marsupium, Albizzia lebbek, A. procera, Cassia fistula, Acacia arabica, Mangifera indica*
Botryosphaeria stevensii, Cryptosphaeria ramulosa, Microdiplodia phyllodiorum, Cytosporella lignicola, Aposphaeria lignicola, Rhytidhystereum rufulum, Phoma hennigsi	*Acacia Arabica*
Corticium salmonicolor, C. solani	*Albizzia falcate*
Hendersonula toruloidea	*Morus alba* (Mulberry)
Daldinia eschscholzii	*Morus alba*
Nectria cinnabarina	*Melia azedarach* (Bakain)
Hendersonula toruloidea	*Melia azedarach, Azadirachta indica* (Neem)
Phomopsis salmalia	*Bombax cieba* (Semul)
Diplodiella tamaricina, Pilidiella tamaricina, Sirococcus tamaricis, Valsaria tamaricis, Teichospora obducens, Massarina dubia, M. epileuca	*Tamarix articulata* (Tamarisk)
Bulgaria inquinans	*Quercus leucotrichophora*
Glomerella cingulata	*Juglans regia* (Walnut)
Botryosphaeria ribes	*Populus nigra*
Hendersonia populina	*Populus ciliate*
Valsa salicina	*Salix alba, S. viminalis*
Nectria cinnabarina, N. ditissima, N. galigena	*Acer* spp
Diaporthe eres	*Prunus cornuta*
Cytospora stenospora	*Alnus nitida*
Dothiorella Largerstroemiae	*Lagerstroemia lanceolata*
Corticium salmonicolor	*Artocarpus chaplasha, A. heterophyllus*
Trichosporium vesiculosum	*Casuarina equisetifolia, C. muricata*

Source: Khan (1989)

8.9.2. Disease Symptoms

Heatwole and Lowman (1986) stated that several stages are involved in a complete tree dieback which starts from a full healthy tree, then twigs and leaves starts to die. Most of the branches become dry but some remain healthy near ground prior to death of the whole tree. Change in colour and wilting of crown also indicate the symptoms of the disease (Tantauet al. 2005). Two stages have been observed in *D. sissoo* dieback, first was yellowing of leaves, resulting in foliage death, whereas in the second stage, branches become bare after shedding the leaves and ultimately the death of diseased and wilted trees within few months (Sharma et al. 2000). The same fact was also verified by Kumar and Rai (2002). Khan (2000) describing the prominent symptoms of shisham dieback in Pakistan further added that dieback started from the thinning of leaves and crowns progressed downwards and in the final stages crowns were flat and stag headed [Figure 8.7].

Fig. 8.9 Diseased Shisham Tree

8.9.3. Disease Description

The problem is caused by number of factors like mechanical injury by wind, frost, drought or attack by a destructive pathogen or insect but without any identification of causal organism or factor. This ultimately disturbs the physiological functions of twigs and branches of trees to start dieback which may leads to the death of entire plant (Ciesla and Donaubauer 1994). Dieback has been considered a diverse disease of forests by different forest pathologists. In this situation trees are affected by different environmental factors and finally tree tissues are invaded by pathogens which lead to the death of tree (Housten 1967; 1992; Manion 1991).

8.9.4. Disease Management

Following remedial and curative measures have been suggested by different researchers and foresters (Khan et al. 1965).

- Proper silvicultural practices e.g pruning, thinning etc. suggested by forestry experts should be followed.

- Diseased and dead trees affected by dieback should be removed immediately.
- Trees should be harvested at proper rotation age, as older trees are more susceptible to disease as compared to younger plants. It will reduce further spread of infection and termites.
- Only good quality seeds collected from resistant plus trees should be used for raising new plantations.
- Fungicides should be used as seed treatment.
- Asexual propagation method (cuttings) should be promoted, as in the past less disease appeared in vegetatively produced plants as compared to sexually raised plants.
- Fungicides like Bavistin (carbendazim) and captaf (captan) can be effective in reduction of disease.

8.10. Key to Major Tree Diseases

A key to major tree diseases has been given in Table 8.9.

Table 8.9 Key to tree diseases

	Disease Name	Causal Organism
Leaf diseases	Leaf spots	Fungi (*Cercospora* spp., *Alternaria* spp., *Colletitrichum* spp., Septogloeum spp., *Phyllosticta* spp., and *Septoria* spp.)
	Powdery mildews	*Erysiphales* (Mildew fungi)
	Rust	*Melamspora epitea* (Fungus)
	Needle cast/Blight	*Lophodermium pinastri* and *Dothistroma pini*
Stem diseases	Heart Rots	*Phellinus pini* (red ring rot of conifers), *Pyrofomes demodofii* (Juniper heart rot), *Fomes badius* (Acacias), *Fomes fomentarius* (Walnut)
Root diseases	Vascular wilts	*Fusarium oxysporum*
	Root Rots	*Ganoderma lucidum, Fomes annosus, Armillaria mellea, Polyporus schweinitzii*

Source: Chaudhry (1994)

8.11. Conclusion

Diseases like powdery mildew, rust etc are pathogenic and if remain unchecked, the diseases can be fatal to plants. Trees are gigantic, healthy and have more tolerance towards pathogens but constant attack due to fungal pathogens or insects may damage a healthy, fully established tree. By taking little care, many diseases can be avoided. Use of pesticides do not cure the disease, however it may prevent the further spread of disease. But in case of forest trees or road side ornamental trees,

spraying trees with expensive pesticides is near to impossible for developing countries like Pakistan. Hence, alternate methods should be found to cure or prevent tree diseases. More research work is needed to be done in this aspect so that we can have a proper data regarding forest diseases and their prevention in Pakistan

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