Diseases of plantation forestry in relation to paper industry and their management

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One of the prime objectives of forestry is to raise forest crops free from diseases and to obtain a profitable harvest. Diseases constitute one of the major biological determinants of forest productivity. Any serious outbreak of the disease either in the nursery or plantation is likely to upset targets of plantations and thereby adversely afftect forest productivity.

Generally the diseases in natural forests are endemic and do not pose a threat to the forest crops. This is mainly because of the genetical variabilty of forest composition. It is the less susceptible and resistant tree species growing in mixture with the susceptible ones which act as natural checks and buffers and do not allow the diseases to assume a serious proportion. However, in the plantations where the tree species are raised as reforested pure crops, the diseases may assume a serious proportion. So emulation of nature is the first safeguard against the dangerous diseases; and mixed cropping instead of monocultures is necessary to avert any such catastrophic situation. There have been cases in the past where monocultures invited serious disease problems. For example poplars raised as a reforested crop in Tarai region in U. P. without removing the stumps and roots of the original tree crop were attacked by *Canoderma lucidum*. a dangerous root rot pathogen resulting in heavy mortality. Similarly, *eucalyptus* plantations raised in industrial Plantation Circle in kerela, where, warm and excessive humid conditions largely prevail, were completely routed due to pink disease caused by *Corticium salmonicolor* against which this exotic species does not appear to have resistance. So choice of species and proper selection of sites are among the important factors which should be taken into consideration for raising forest crops if such disastrous situations affecting forest productivity are to be averted.

Serious disease problems may also arise when the tree crops are raised on stressed sites which are unable to support good growth of plants either due to nutrient deficiency and/or poor availability of water. Mycorrhizal deficiency in unforested sites may also limit the growth of tropical pines which are ectomycotrophic and thus makes the plantations programme unsuccessfull. Moreover, such plants with poor growth are liable to attack by the pathogens which may further complicate the situation. Failure of *Eucalyptus* plantations at Nepanagar, M. P. is a glaring example of water deficiency due to insufficient rainfall being the cause. Under such a situation the plants do not attain any appreciable growth and some of them show the phenomenon of die back and development of epicormic branches indicative of the plants growing under stress and making last efforts to survive. The situation has been further compounded due to heavy infestation of termites and Coelosterna borer whieh have also contributed to killing of a good number of plants in the plantation.

Due to heavy destruction of the forests during last 3--4 decades, the area under good forest cover has dwindled considerably and according to a recent estimate it is not more than 9--11 per cent of the total geographical area in the country. Obviously, the plantation activities are now restricted to the degraded forest areas and other waste and vacant lands unsuitable for raising agricultural crops. Greening of the vast saline-alkaline areas in States like, Uttar Pradesh, Haryana and Punjab is the major challenge posed to the foresters and efforts are now being made to reclaim and revegetate such areas. Obviously, new disease problems are likely to arise in such plantations because of the prevailing hostile edaphic conditions for plant growth.

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In recent years plantations are being raised in unforested areas under agro forestry and farm forestry. Such plantations are exposed to the risk of diseases so far unknown to forest crops. There is a possibility of the pathogens of agricultural crops being transferred to the forest crops and vice versa which may pose new disease problems difficult to surmount. They are likely to become unmanageable at least in the first few years before the effective control of such new diseases is worked out. In such an eventuality the forest productivity is likely to come down and this may affect the wood based industries, the most. The two important cases of this nature may be cited which call for greater care and caution on one hand, and intensive management of forest crops on the other, because of close proximity of forest and agricultural crops in agro forestry and farm forestry plantations. Recently, *Bipolaris maydis*, the cause of serious leaf blight disease of *Populus deltoides*, (G-3 clone) has emerged as one of the most serious pathogens threatening the nursery stock as well as plantations in certain parts of Punjab and Haryana. It is the rapidity of fungal attack due to the toxins the fungus is known to produce and ineffectiveness of most of the fungicides under field conditions, which has dampened the chances of any satisfactory control of the disease in near future. Moreover, such a venture may not prove to be cost effective in view of the disease spreading fast and heavy rains which make such a spraying programme impracticable and ineffective. The situation calls for concerted efforts to evolve resistant clones of C 3 variety of *P. deltoides* to meet the diseasc situation in order to maintain a sustained supply of raw materials to the industry which otherwise is likely to be affected seriously in years to come because of this new disease problem.

Another destructive pathogen which has become the cause of great concern is *Sarocladium oryzae* which, of late, has been reported to cause heavy damage to planted *Bambusa nutans* in coastal districts of Orissa. The disease was for the first time detected in Bangladesh where it caused large scale mortality in *Bambusa balcooa, B. tulda* and *B vulgaris*. The disease is likely to spread to other adjoining states and attack other susceptible bamboo species in the country if it remains unchecked. It is pertinent to mention that the pathogen is known to attack rice causing sheath blight and it has now found the bamboo planted by the farmers vulnerable to attack in coastal areas during warm and humid conditions. This is another example of the pathogen from an agricultural crop having been transferred to the forest crop which is in great demand both by the paper industries and common man for constructional and other purposes.

In the nurseries damping off continues to be a serious disease problem if the effective preventive measures including cultural practices and use of fungicides/soil fumigants as prophylactants are not employed. These measures are based on the sound principle of prevention is better than cure. *Cylindrocladium* seedling blight is the most destructive disease of *Eucalyptus* taking a heavy toll of seedlings. Though the disease was first reported in highly destructive form in Industrial Plantation Circle in Kerela in late 60's and early 70's, it has now become highly damaging to the seedlings in northern India as well. High incidence of the disease and heavy mortality to the extent of 60-100 per cent has been recorded in recent years in nurseries at Lacchiwala, Karuapani, Satyanarayan, Kalsi, in and around Doon Valley. Another important disease is *Rhizoctenia* leaf web blight which has recently emerged as one of the most damaging foliage disease causing a great concern to nurserymen because of heavy defoliation, to the extent of 60-100 percent at the peak of growing season. The disease adversely affects seedling growth and at times makes establishment of the outplanted seedlings uncertain.

Healthy seeds are required for tree propagation. It is not the number but the quality of trees that is important for maximising forest productivity and this may be achieved by using quality seeds for plantations. However, in the event of fungal deterioration of quality seeds, while on trees or in storage, the production of quality seedlings in the nursery is likely to be affected defeating the very purpose of quality seed production. Recently, seeds of *Leucaena leucocephala* have been reported to be heavily infected by *Fusarium semitectum*. This seed borne pathogenic fungus causes seedling mortality and gummosis in grown up plants. Seeds of albizias are commonly infected by *Fusarium samitectum, F. moniliforme* and *F. oxysporum* of which

the first and the last are quite frequently occurring. These seedborne fungi have been found associated with damping off both in *A. lebbeck* and *A. procera*. In bamboo huge quantities of seeds have to be stored in the years of flowering and spoilage of seeds in storage due to fungal deterioration becomes a major problem if they are not properly stored. Timely collection, proper drying and storage are necessary to prevent loss of seeds. Besides, seed dressing with Thiram or a mercurial fungicide (4g/kg of seeds) is also effective in controlling deterioration of seeds in storage. In poplars, cuttings are exposed to rotting by *Macrophoma* sp. and *Botryodiplodia theobromae* which results in poor sprouting. Failure of sprouting of cuttings to the extent of 20-100 per cent has been reported from western U.P., Haryana and Punjab. The incidence of set rot in poplars may be minimised considerably by prophylactic treatment of cuttings by dipping them in 0.5 per cent suspension of an organic mercurial fungicide prior to planting.

Development of the disease is the result of interaction between three agencies of which two are animate or biological e. g. host and the pathogen and the third one is inanimate non-biological e. g. the environment. For the study of the disease and its management, a sound knowledge of the disease triangle is absolutely necessary. Epidemiological studies are aimed at determining the environmental factors such as temperature and relative humidity that govern the disease development. It is necessary to know that under what conditions the disease is flared up or reduced to an insignificant level. This information is very helpful in timely and effective control of the disease. Another point which is of relevance to disease management is that the control of the disease is not aimed at eradicating the pathogen but reducing it within the economic injury level.

Forest disease management is circumscribed by the fact that forest crops are long rotation crops and their value per unit area is much less as compared to agricultural crops. Therefore, the intensive control measures such as use of chemicals, crop rotation and breeding resistant varieties that are normally employed to control diseases of agricultural crops cannot be used to control the forest diseases. Use of chemicals to control the diseases in the natural stands is prohibitive firstly because of economic consideration and seeondly because of environmental problems that are likely to arise threatening the wild life and other flora (useful soil microflora in particular) and founa. Similarly, crop rotation is not practically feasible because the demand of particular tree species cannot be met by another tree species. Moreover, it is not desirable to wait for a number of years for another tree species to complete its rotation. Breeding resistant variety is a long trem programme with no immediate prospects of providing solution to the diasease problems of forest tree species. However, for the forest crop that are raised on a short rotation basis of 7–10 years for paper industry, there is a distinct possibility of evolving resistant varieties, through genetical engineering, to solve the disease problems. This of course requires strengthening of the genetical base for forest tree species at the Forest Research Institute, Dehra Dun and other Research Institutes under the I. C. F. R. E. Further, use of chemicals to control the disease in the plantation of a short rotation crop for paper industry, may be justified in view of the intrinsic value of the crop and its intensive management. So is the case with nursery disease which may be controlled chemically as any serious nursery disease is likely to upset the planting programme and affect productivity.

Post Entry Forest Quarantine (PEFQ) is aimed at preventing entry of harmful pathogens into the country along with seeds and other planting materials such as cuttings, etc, imported from foreign countries. The PEFQ regulations should be strictly adhered to if the forest crops are to be saved from damaging exotic pathogens. In the past there have been cases of inadvertent entry of dangerous dathogens in the country. *Dothistroma pini*, the cause of needle blight was detected on *Pinua radiata* when raised in a trial plantation in Palni Hills, Tamil Nadu. The pathogen was highly damaging to the crop. The fungus has since been recorded on *Pinus roxburghii* and *P. wallichiana* but no significant damage has so far been reported on these species. This Pathogen is of U.S.A. origin and has proved highly destructive to radiate pine plantations in New Zealand. *Pseudocercospora pini-densiflora* is another exotic pathogen which causes severe needle blight in chir pine and other tropical pines in the country. Both

the above pathogens appear to have been introduced in the country through seed. Very recently, Melampsora *I arici populina* has been detected on *P. deltoides* Clone 65/27 at New Forest, Dehra Dun. Evidently, it is the cause of great concern because of the severe defoliation and growth loss in poplars this pathogen is already known to cause in other countries. The pathogen appears to have been introduced through cuttings of *P. deltoides* imported from Australia. The situation calls for urgent steps before the pathogen spreads over other areas and becomes a serious prblem in the country. Internal Forest Quarantine (IFQ) in this case is the first step in this direction. Cuttings from the susceptible clones should not be used for planting purpose in disease free areas. Suitable variety resistant to the disease should be developed in order to provide solution to the disease problem.

In view of the above problems and limitations in forest disease management emphasis is, therefore, laid on sound silvicultural and management practices to control the forest diseases which are known to create conditions congenial for good growth of forest crops and at the same time unfavourable for disease development. For example mixed cropping, isolation trenching and eradication of stumps and roots of the original crop through mechanised plantations are recommended to control *Canoderma* root rot in poplars. Digging isolation trenches and avoiding injury to the crop due to prunning and illicit lopping are the measures to control stem wilt of *Casuarina*. Also cultural practices and sanitary measures are helpful in minimising the disease incidence in many cases. Morever, the non-chemical methods when used in conjunction with chemical methods, very much reduce the quanitity of chemicals required to control the disease and this is the reason why integrated control of the diseases is now gaining momentum for effective forest disease management.

Decay of wood is also a serious problem affecting the quality of paper. However, chemicals though effective in stemming the decay/rot their use on a large scale is not an economically viable proposition. Proper storage and timely utilization of the raw materials are important steps to minimise loss of wood due to biodegradation. Sap stain is the major problem in poplars which may be checked by treating the logs chemically. However, biological control of sap stain has to be developed because of its being non-obnoxious, non-polluting and non-hazardous.

A brief account of important diseases of bamboo, *Eucalyptus* and *Populus* and their management is given and other diseases and fungi causing decay are listed.

DISEASES OF BAMBOO

Nursery Diseases :

Damping off : It is an important disease commonly occurring all over the country. Seedling rot, stem rot and wilt are some of the usual symptoms the infected seedlings exhibit. *Fusarium* spp. and *Rhizoctonia solani* are commonly associated with damping off in *Bambusa arundinacea, B. tulda* and *Dendrocalamus strictus*. Stem rot caused by *Rhizoctonia solani* and *Sclerotium* sp. is recorded in *B. arundinacea* and *D. strictus*. *Fusarium moniliforme* causes seedling rot in *Ochlandra scriptoyia* whereas *F. oxysporum* and *F. semitectum* are associated with wilt in the same species. Dual infection by *R. soloni* and *Fusarium* sp. are reported to take a heavy toll of vegetatively propagated seedlings of *B. vulgaris*.

The disease can be managed through cultural practices and use of chemicals as prophylactants. Formalin may be applied as soil drench and fungicides such as Thiram, Blitox and Captan as soil mix or soil drench. Solarisation may be used as a tool to reduce the quantity of fungicides if alone it does not control the disease effectively.

Rhizoctonia leaf blight : The disease has been recorded from Kalsi, U.P. and Jabalpur, M.P. The characteristic symptoms of the disease are blighting of leaves, presence of clusters of hyphae at the point of attachment of leaves to the stem, fungal cobweb and sclerotia on the infected plant parts and premature defoliation. The disease spread laterally resulting in group infection of seedlings. It can be kept under check through sanitation and cultural practices.

Drechslera leaf spot : It is an important disease in nurseries and plantations and is caused by *Drechslera rostrata*. The disease occurs all over the country. The initial symptoms include the appearance of minute pale spots on the leaves with pale green halo, which

later enlarge and become distinct, elliptical in shape with greyish brown centre surrounded by dark brown margin. In case of severe infection the entire leaf becomes necrotic and is shed prematurely. The disease can be controlled particularly in the nursery by spraying 0.2 percent Defolatan or 0.4 percent Fytolan (Harsh et al, 1989).

A number of other foliar pathogens have been reported on different species of bamboo which include rusts (*Dasturella divina* on *Dendrocalamus strictus* all over India; *D. bambusina* and *D. strictus* from Bombay; *D. oxytenantherae* on *Oxytenanthera* sp. from Maharashtra; *Puccinia gracilenta* on *Bambusa* sp. from Darjeeling; *P. melanocephala* on *Arundinaria* sp. from Assam; *P. xanthosperma* on *Bambusa* sp. from Mussoorie Hills. *Tunicospora bagchii* on *D. strictus* from Dehradun), smut (*Ustilago shiraina* on *Bambusa* spp.) and other pathogens including *Phyllachora bambusae* on *B. arundinacea* from Bombay;

P. dendrocalami on *D. strictus* from Mahabaleshwar; *P. graminis* on *Arundinaria* sp. from Poona; P. *malabarensis* on *Bambusa* sp. from Wynaad; Kerela; *P. shiraina* on *Arundinaria* sp. from Assam; and *Bambusa* sp. from Bombay; *Corticium koleroga on Dendrocalamus* sp.; *Ascochyta bambusina* on *Bambusa nana* from Poona; *Alternaria sp.* on *Bambusa* sp.from Coorg; *Balladyna butleri* on Bambusa sp. from Khasi Hills; *Diploszythiella bambusa* on *Bambusina sp.* from Dehradun. *Helminthosporium bambusae* on *Bambusa spinosa* from Assam; *Meliola bambusicola* on *Bambusa sp; Periconia cookeri* on *Bambusa* sp. from Mussoorie Hills and Anekal.

PLANTATION DISEASES

Rhizome bud rot : Bud rot of rhizome in *B. arundinacea* due to *Pythium* sp. and *Fusarium* sp. has been reported from Central India resulting in failure of rooting and culm production. Bud rot also affects proliferation of rhizome and causes stunted growth of shoots.

Culm rot : The culm that just emerges from the soil shows high susceptibility to *F. moniliforme.* Infection appears as a violet or dirty brown discolouration on the culm sheath at the soil level followed by rotting of the culm. The diseased culms do not grow further and are entirely decayed in course of time. Besides, the culms of *B. arundinaceae, B. vulgaris and D. strictus* are attacked on emergence by *F. equiseti Fusarium* species resulting in die back. In *Thrysostachys oliveri,* culm rot caused by *F. oxysporum* is initiated at the base of the culm and it spreads upwards resulting in die-back of the entire culm.

Rhizome and Root rot : The disease is caused by *Merulius similis* which is one of the most potential pathogens of bamboo causing mortality. The disease has been reported on *B. arundinacea* and *B. flabellifer* from Hoogly and around Calcutta (Bose, 1919; Banerjee, 1947) and *Thyrsostachy oliveri* from Haldwani. The fungus develops characteristic fruit bodies at the base of the culm and also on the humus around the infected clumps.

Canoderma root rot : It is an important disease of bamboo caused by *C. lucidum.* The pathogen has a wide host range. The infected bamboo is killed outright. The disease spreads in the clumps through root contact. The disease has been reported on *B. arundinacea* from Uttar Pradesh and West Bengal (Banerjee and Ghosh, 1942; Bakshi, 1957). The characteristic sporophores of the fungus develop at the base of the infected bamboo culms at the ground level and on exposed rhizomes.

Bamboo blight: This is one of the most destructive diseases of bamboo recorded in the Indian subcontinent in recent years. The first record of the disease was made by Boa and Rahman (1987) who observed large scale mortality in *Bambusa balcoa, B. tulda* and *B. vulgaris* in village grooves in Bangladesh. The pathogen was identified as *Sarocladium oryzae* (Boa and Rahman, 1983). Bridge et al (1989) have given a detailed taxonomic account of *Sarocladium* based on biochemical and morpnometric analysis. The fungus is well known to cause sheath blight in rice and has found the bamboo as a highly susceptible collateral host. In bamboo, new culms arise from buds and subterranean rhizomes from early June until late August. Expansion of culm continues till October. The blight disease appears in August and assumes a serious proportion by mid-November. Subsequently, there is little or no increase in the number of blighted

culms (Boa, 1985a, 1985b). (Boa and Rahman, 1987) worked out integrated control of the disease which included measures such as removal of blighted culms, burning of debris in clumps in April before onset of rains and application of Dithane M-45 + copper oxychloride as soil drench. In India, large scale mortality in *B. nutans* caused by *S. oryzae* was recorded from Orissa State. Jamaluddin et. al: (1988) reported that the pathogen occurred widely in coastal districts of Orissa and caused large scale mortality to planted bamboo affecting the economy of bamboo growers. Out of 4 coastal districts surveyed, the disease was a potential threat in three districts namely, Puri, Cuttack and Baleshwar.

Jamaluddin conducted field trials to control the blight disease in bamboo in 1990. Control burning in the blighted culms was done in March in order to remove the inoculum perennating in the bamboo litter. Subsequently, the affected culms were removed. This was followed by application of fungicides namely Bavistin (0.3%), Fytolan (0.4%) Dithane M-45 (0.4%), Bavistin (0.15%) + Fytolan (0.3%), Bavistin (0.15%) + Furadon 25 gms. About 3-4 litres of solution were sprayed in each culm during June and July. The observations recorded in October showed that all the fungicides were effective in enhancing the number of culms though the effectiveness varied from treatment to treatment and locality to locality. Further, it was observed that in water logged areas the number of culms in each clump was more and infection was also severe. Bavistin in combination with Fytolan or Dithane M—45 was more effective than other treat ments. Rahman (1988) also found copper oxychloride and Dithane M-45 in combination to be effective against the disease.

A good number of fungi are reported to infect stem and leaves. *Fusarium pallidoroseum* attacks culms of *B. arundinacea* and *T. oliveri* whereas *Colletotrichum gloeosporioides* and *Curvularia* are reported to infect stem of *B. arundinacea.* Mostly, the foliar pathogens occurring in the plantations are the same as in nurseries.

DISEASES OF POPLARS

Nursery Diseases

Among the diseases on poplars Set rot, *Rhizoctonia* leaf web blight and *Rosellinia* white root rot occur in nurseries. Most of the foliage diseases described here occur both in nurseries and plantations.

Set rot : Rot of cuttings in poplars caused by *Botayodiplodia palmaram* is one of the major disease problems in nurseries which results in poor sprouting and thus affects planting programme. It has been recorded on *Populus deltoides*, P. *ciliata*, P. *xeuramericana*, and *P. yunnanensis.* Serious damage to *P. deltoides* has been reported from Kurukshetra Forest Division, Haryana Sanjay Van, Tarai Central Forest Division, Uttar Pradesh. The pathogen is soilborne and attacks the cuttings under water logged or too dry soil conditions. Fungicidal dip treatment in 0.5 per cent solution of a mercurial fungicide containing methoxy ethyl mercury chloride with 6 per cent mercury controls the disease.

Rhizoctonia Leaf Web Blight : The disease is caused by *Rhizoctonia solani* anamorph of *Thanatephorus cucumeris* and has been recorded in serious form at New Forest, Dehra Dun. It also occurs in the nurseries at Lacchiwala. At New Forest, two biotypes of the pathogen have been identified, one producing typical dark brown sclerotia on the infected plant parts and leaf litter whereas the other does not produce sclerotia in nature. It is the latter biotype which is more prevalent and damaging to the foliage. The blighted leaves get webbed or cemented by the fungal hyphae at the point of contact and are shed prematurely. The disease can be kept under check through sanitation and cultural practices. Regular weeding is necessary in view of the grasses and other weeds such as *Bidens biternata* and *Agerartum haustonianum* which are susceptible to the diseases incidence and are known to contribute to increased disease incidence and severity (Mehrotra, 1991).

Rosellinia white root rot ; It is an importent root disease of poplar caused by *Rosellinia necatrix.* The disease has been recorded on *Populus deltoides*, *P. nigra* and P. *ciliata.* Besides, the pathogen attacks willow. The infected seedlings show white mycelium covering the entire root surface but later the fungal mat turns greyish to smocky grey. The fungus first spreads over the root surface, then colonizes the bark and ultimately

spreads along the cambial layer. The infected plants wilt and eventually die. The fungus also produces sclerotia and white to black mycelial strands on dead root surface. The latter also extend from the roots to the adhering soil. The disease has been found in serious form in some nurseries in Himachal Pradesh where seedling mortality varied from 10-30 per cent. The disease can be effectively controlled by uprooting and destroying the diseased plants. The infected area should not be planted with poplars for one season and the soil be treated with carbon-di-sulphide or 5 per cent carbolic acid. Drenching of soil around the affected plants with 0. 1 per cent Bavistin has also been found to control the disease (Singh and Singh, 1986).

Bipolaris Leaf Blight : The disease caused by *Bipolaris maydis* has been recently reported in P. *deltoides* (C3 clone) from Punjab, Haryana and Uttar Pradesh and is the cause of great concern in view of its fast spreading and the extent of damage it causes to the foliage in a brief spell during humid months. The infected leaves dry up and shed prematurely. The pathogen is already known to attack maize plants and cuase heavy damage to the crop. This is a classic example of a pathogen of an agricultural crop having been transferred to a forest tree species raised in close proximity of the agricultural crop under agro forestry. In view of high vulnerability of poplars to the disease and heavy rains worsening the disease situation no effective and economically viable chemical control of the disease has been possible. Clones of P. *deltoides* resistant to the disease should be developed to replace the susceptible clones.

Policia Blight Of Poplars : *Policia elegans* is known to cause leaf blight in poplars and an outbreak of the disease has been recently recorded from Jammu & Kashmir State. The infected twigs become curved into the characteristic crooks and leaves become black brittle and crumpled followed by defoliation. An assessment of the disease carried out has revealed 100 per cent incidence on *Populus ciliata* and P. *nigra*. Though plant of all ages are susceptible to the disease, young plants show susceptibility as evident from severe attack of foliage resulting in premature defoliation, the disease intensity was light to moderate in *P. ciliate P. nigra*. in view of heavy early defoliation and repeated attack of young foliage by the pathogen, resistant clones have to be developed. However, pending development of resistant clones spraying with effective fungicides is recommended.

Foliage Rust : Three leaf rusts i. e. *Melampsora ciliata*, M. *populnca* and *M. larici populnca* are known to attack foliage of poplars and cause premature defoliation to varying extent. *M. ciliata* is an indigenous rust which infects indigenous *Populus ciliata* in nurseries, plantations and natural forests, Besides, it also attacks *P. alba*, *P. deltoides*, *P. nigra*, P. *suaveolans*, *P. trichocarpa* and *P. yunnanensi* in nurseries and plantations in Uttar Pradesh and Himachal Pradesh. The rust produces orange yellow uredinia plastering the entire leaf surface followed by orange-red to brown telia. Urediniospores are pale orange yellow and stalked whereas teliospores ear light brown to brown. The diseases develop rapidly under high humid conditions. *M. populnca* attack leaves of P. *alba*. The rust is uncommon and has been reported from Jammu & Kashmir only. However, in case of severe rust infection the seedlings usually succumb to the disease.

M. larici populnea, an exotic has been recently detected on *P. deltoides* by Pandey (1992) from New Forest, Dehradun This exotic rust is already known to cause heavy damage to the poplars in Australia and New Zealand and its detection on *P. deltoides* is the cause of great concern. An extensive survey of poplar nurseries and plantations is called for in order to know to what extent the pathogen has spread over in the country. Immediate steps should be taken to eradicate and destroy the susceptible clone (65/27) of *P. deltoides* so that the fungus fails to cause any serious disease problem in the coming years. Also nurseries should be regularly monitored to know whether or not any other clone is susceptible to the rust. Import of 65/27 clone should be stopped forthwith and cuttings from the diseased area should not be used to raise seedling crop in disease free areas.

Cladosporium leaf spot : The disease is caused by *Cladosporiuu humile* and it has been recorded in a serious form causing premature defoliation in *P.*ciliata, P.*nigra* and *P alba* in nurseries and plantations in Himachal Pradesh, Uttar Pradesh and Jammu & Kashmir. Early defoliation not only affects plant growth but also

makes them vulnerable to attack by other pathogens. Integrated control of the disease involving the following measures : I. disposal of litter by burning, 2. chemical treatment of cuttings by dipping them into 0.3% suspension of Dithane M-45, and 3. spraying of Dithane M-45 (0.35%) at the time of opening of buds and subsequently at three weeks intervals for three months has been recommended. Besides cuttings for propagation should be collected from disease free areas (Khan et al,. 1990).

Other fungal disease recorded on poplars are powdery mildew of *Populus alba* caused by *Uncinula salicis* from Kulu, Himachal Pradesh, powdery mildew of *balsamifera* by *Uncinula adunca* from Kashmir valley, J. & K. leaf spot of *Populus* spp. by *Sphaceloma populi* from all over northern India, leaf blister of P.*ciliata*,P. nigra and P. ×*eurmericana* by *Taphrina aurea* from Shillaroo and Sawra, Himachal Pradesh, leaf spot of *P.* × *euramericana* by *Myrothecium roridum* from Dehradun, Leaf spot P. × *euramricana* by *Alternaria alternata* from Tarai region, Uttar Pradesh, leaf spot of P. *nigra* by *cercospora jamuensis* from Jammu region of J. & K.,leaf spot of *P. alba* by *Cladosporium matrtianoffianum* from Kashmir valley, J. & K, *Coniothyrium deviatum* on drooping leaves of P. *ciliata* from Mussorie, Uttar Pradesh, leaf spot of P. × *euramericana* by *Phyllosticta adjuncta* from solan, Himachal Pradesh, *Titasporina tremulae* on leaves of P. *ciliata*, *Nectria cinnabarina* on branches of P. *ciliata* from Kashmir valley.

PLANTATION DISEASES :

Brown root rot of poplars : The root rot disease caused by *Fomes noxius* has been recorded for the first time on poplars in reforested stands in Tarai Central Forest Division, Uttar Pradesh The diseased trees are killed outright. Mortality in 1976 and 1981 plantations of *Populus deltoides* (C-3, D-67 and C-48 clones) ranged form 7.8—12 per cent which incurred a significant loss to the State Forest Department.

The detailed study on the mode of infection and establishment of the pathogen has revealed that the fungus infects the trees through tractor blade injuries which have been recorded to the extent of 16-48 per cent in agro forestry plantations. The fungus does not spfda erreely in the soil. However, lateral spread of the disease is through root contact.

The fungus has been found to exist in old mixed plantations. It also produces abundant fruit bodies on stumps of poplars left over after removing the diseased trees. The disease can best be managed by avoiding injuries during tractor ploughing, raising new poplar lines in between old lines and isolation of diseased patches by semicircular trenches (Singh and Singh, 1986).

Canoderma root rot: This is an important disease of poplar plantations caused by *Canoderma lucidum*. Clones of P. *deltoides* and P. × *euramericana* have been found highly susceptible to the disease. Heavy mortality in P. × *euramericana* has been reported from Phillaur (Punjab) and Tarai Central Forest Division, Uttar Pradesh and in P. *deltoides* from Dehradun Forest Division, Uttar pradesh. The disease severity can be reduced appreciably by planting poplars at a spacing of 4.5 × 4.5 m instead of at 1.5 × 1.5 m. Digging of isolation trenches of the size 0.3m wide and 0.7m deep to isolate the diseased plants and mixed cropping with *Ailanthus* and *Semul* being resistant to the disease are recommended to check spread of the disease in plantations.

Pink disease of Poplars : The disease has been recorded in poplar plantations. Stem and branch cankers are most common on the infected plants. Cirdling of stem and branches invariably results in death of the plant part above the girdled portion. Development of epicormic branches from the portion below the girdled regions is a normal feature. The girdled branch may be further attacked and killed. The repeated killing and development of epicormic branches results in bushy growth of the affected plants which fail to attain any growth. The disease may be controlled by spraying a mixture of Dithane M-45 (0.2%) and Bavistin (0.1%) during humid months.

Sun scald cankers : Formation of cankers on the southern side of the stem of several clones of P. *deltoides* and P. × *euramericana* has been recorded from plantations raised in Tanda and Pipalparao Ranges of Tarai Central Forest Division, Uttar Pradesh. These cankers sometimes extend longitudinally to the

entire length of the stem. Decay fungi usually establish on such cankers and cause wood decay sometimes resulting in snapping of trees at the decayed region. The trees in plantations can be protected from insolation injury by applying a thick suspension of quick lime in water on the stem up to 2-3 m from ground level as white wash.

DISEASES OF EUCALYPTUS

Nursery Diseases :

Damping off : The disease commonly occurs in forest nurseries causing death of seedlings. The disease is unpredictable and seedling mortality varies from nursery to nursery and season to season. Heavy mortality of seedlings occurs at high temperature and soil moisture. *Fusarium* and *Rhizoctonia* the two facultative parasites inhabiting the soil are usually associated with the disease. The disease can be controlled through cultural practices and use of fungicides which may be used either for seed dressing and or applied as oil mix or soil drench. Thiram/Dithane M-45, Blitox and Bavistin have been found effective in controlling the disease.

Seedling blight of Eucalyptus : It is one of the most prevalent nursery diseases in the country. It is caused by *Cylindrocladium quinquiscptatum* and *C. scoparium*. The pathogen attacks the leaves causing blight and subsequent defoliation whereas infection of the stem and twigs results in wilting. The disease is highly damaging causing heavy mortality under warm and high humid conditions, Abundant sporulation of the fungus on the infected plant parts helps in rapid transmission of the disease. Mortality of seedlings to the extent of 100 per cent has been recorded in several nurseries in and around Doon Valley. The disease situation is equally grim in southrn and north eastern states.

The disease can be controlled by the application of Dithane M-45 and Bavistin in combination. Also outplanting of the seedlings soon after a few monsoon showers may help minimise the disease incidence. It has been observed that the disease becomes more severe when outplantings are delayed and the seedlings are retained in nurseries upto July and mid-August. It is the microclimate and stock of seedlings together which help the disease spread fast and damage of the seedling stock in a brief spell of two to three weeks following repeated incessant rains for a couple of days with a brief interruption of sun shine.

Leaf spot : Three foliar pathogens e. g. *Alternaria alternata*, *Phaeoseptoria ecalypti* and *Cercospora eucalypti* causing leaf spot in eucalyptus have been recorded from dfferent nurseries in the country. *A. alternata* is highly damaging to the foliage during humid months albeit the disease continues during winter months too. P. *eucalypti* attacks the leaves after rains and continues throughout winter months. The fungus sporulates abundantly almost plastering the lower leaf surface particulary in shady locations with copious dew formation. C. eucalypti is of minor importance though it occurs widely, Foliar application of fungicides such as Dithane M-45 and Bavist in either singly or combination depending on the disease situation can control the disease effectively.

PLANTATION DISEASE

Pink disease of Eucalyptus : The disease caused by *Corticium salmonicolor* is a very serious one recorded in Industrial plantation circle in Kerela State where it caused almost complete devastation and led to plantation failure. Warm and highly humid conditions were attributed to disease flare up to serious proportion. The tree species viz , *E. grandis*, *E. tereticornis* and *E globus* which are widely planted in the country are highly susceptible to the disease both in Kerela and Karnataka states. *Eucalyptus* show susceptibility to the disease at a very early age. The disease appears sporadically during the second year but becomes epidemic in the two subsequent years when the entire plantation may become affected under ideal conditions for disease development. The young plants may show repeated die-back and mortality while those which have escaped infection during the early age, may at a latter period become infected resulting in development of cankers. Gum exudation normally occurs from resultant cankers. In such trees girdling by cankers is not complete, and the main leader continues to grow and the crown appears healthy. The record of disease incidence as given in Table shows that it ranged from 54.5-94.1 per cent in different plantations and mortality recorded varied from 25—100 per cent. In view of serious disease situation further planting of *Encalyptus* had to be stopped.

The pathogen is known to occur on the host in four growth forms : (1.) Pustule, (2) Cobwed, (3) Necator and (4) Pink incrustation. The pink disease is so named because of pink incrustation the fungus develops on the stem which represents the perfect state of the fungus.

In India, *C. salmonicolor* occurs naturally and not damaging to many hosts on which the fungus is recorded. it has a very wide host range woody plants which include *Acacia ieucophloea*, *Albizia falcataria*. *Aleurites montana*, *Anacardium occidentale*, *Artocarpvs heterap-rllus' Azadi achta indica*, *Butea mauosperma*, Cassia *siamea*, *Casuarina equisetifolia*, *C. montana*, *E. ucaly. ptus alba*, *E. camaldulensis*, *E, globus*, *E. saligna*, *E. mn ltiflora*, *E. tereticornis*, *E. tessellars*, *E. trabuta*, *Crevillea*, *robusta*, *Hevea brastliensis*, *Leucaena glauca Mangifera indica*, P*odpcarpos gracilior*, P*opulns Sppsalix daphnoides*, *Tamarindus indica* and *Tectona grandis*.

Of these tree species *Hevea brasiliensis* and *Eucalyptus* spp. show high susceptibility to the disease. *Eucalyptus* being an ezotic to India shows no resistance to this indigenous pathogen in high rainfall areas of Karnataka, kerela and Goa and the *Eucalyptus* plantations raised in these states have completely failed.

Management of the disease has been worked out. Pink disease in rubber is effectively controlled by application of Bordeaux mixture. Such a curative treatment is justified for a greatly valued crop like rubber. However, for a crop like *Eucalyptus* such a measure is not economically viable. It is, therefore, recommended that in disease hazardous areas the resistant tree species preferably indigenous to the states should be planted to provide green cover. It is in view of this an experiment was conducted to screen the indigenous tree species by planting them in such areas and based on our studies the following tree species have shown resistance to the disease and they may be safely planted : *Albizia falcataria*, *A.moluccana*, *Bischofia jaoanica*, *Erythrina Indica*, *Euodia lunu-ankenda*, P*terocymbium tinctorium* and *Terminalia myriocarpa*. *Besides Eucalyptus torelliana* and *E.deglupta* also appear promising. Also search should be made to detect some individuals of the susceptible *Eucalyptus* species which remain healthy, free from infection in such areas. Such individuals may be further tested for inherent resistance by raising progenies from them and screening them against infection to provide material for developing a stock resistant to the disease for future plantations.

In view of the experience from *Eucalyptus* plantation failure in southern states it is emphasized that suitability of sites and choice of species be given utmost consideration in future plantations as they govern the success of plantations. Before undertaking large scale plantations it is advisable to grow the tree species (particularly exotics) in an area on experimental basis to test their performance and susceptibility to the diseases. It is only when they are found growing healthy, free from diseases, they may be planted on a large scale. This will help in averting plantation failure and loss of precious time and heavy expenditure involved in raising plantations.

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